University of Michigan
Campus Sustainability Integrated Assessment

Final Report

August 22, 2011

A partnership project of the

Graham Sustainability Institute and the Office of Campus Sustainability

IMPORTANT NOTE ABOUT THIS DOCUMENT

This report was prepared as a navigable electronic resource. Simply place your cursor over a page number in the Table of Contents and click to go directly to the referenced page. Similarly, in the tables of Potential Actions starting on page 10, place your cursor over the Phase 2 Team Report page number and go directly to the referenced page in the appropriate appendix to read more about a specific campus sustainability idea. To return to your previous location in the document, simultaneously press "Alt" and "←" on your keypad. Text access for the visually impaired has also been enabled.

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Please direct any questions to: GrahamInstitute-IA@umich.edu

Executive Summary

The Campus Sustainability Integrated Assessment (CSIA) was led through a partnership between the Graham Sustainability Institute and the Office of Campus Sustainability. It was launched in January 2010 with endorsement from the University of Michigan (U-M) Sustainability Executive Council, chaired by President Mary Sue Coleman.

The CSIA directly involved more than 500 U-M students, faculty, and staff representing 101 organizational units and 27 academic programs to advance campus sustainability by: establishing goals and targets; developing strategic frameworks; identifying research and learning opportunities; educating the campus community; and, sharing publicly what we have learned.

During two phases, seven faculty-led and student-staffed teams focused on: *Buildings*, *Energy*, *Land & Water*, *Food, Transportation*, *Purchasing & Recycling, and Culture.* In Phase 1, the Analysis Teams conducted literature reviews, benchmarked peers, and assessed U-M practices. During Phase 2, the teams conducted more detailed analyses on potential actions that included costs, benefits, technical guidance, evaluation of uncertainties, and implementation timeframes.

Following Phase 2, an Integration Team reviewed all team reports and developed this final report with recommendations. The report organizes all ideas and contributions under four themes: *Climate Action, Waste Prevention, Healthy Environments, and Community Awareness*. Accompanying the themes are *Guiding Principles* to guide our long-range strategy, *2025 Goals* that are time-bound and quantifiable, and *Potential Actions* that provide a menu of possible options for achieving the goals.

CSIA Recommendations

THEME	GUIDING PRINCIPLE	2025 GOALS
Climate Action	We will pursue energy efficiency and fiscally-responsible energy sourcing strategies to reduce greenhouse gas emissions toward long-term carbon neutrality.	Reduce greenhouse gas emissions *(scopes 1&2)* by 25% below 2006 levels. Decrease carbon intensity of passenger trips on U-M transportation options by 30% below 2006 levels.
Waste Prevention	We will pursue purchasing, reuse, recycling, and composting strategies toward long-term waste eradication.	Reduce waste tonnage diverted to disposal facilities by 40% below 2006 levels.
Healthy Environments	We will pursue land and water management, built environment, and product sourcing strategies toward improving the health of ecosystems and communities.	Purchase 20% of U-M food in accordance with U-M Sustainable Food Purchasing Guidelines by 2025. Protect Huron River water quality by: • minimizing runoff from impervious surfaces *(outperform uncontrolled surfaces by 30%)* • reducing the volume of land management chemicals used on campus by 40%
Community Awareness	We will pursue stakeholder engagement, education, and evaluation strategies toward a campus-wide ethic of sustainability.	*There is no stretch goal recommendation for this theme. However, the report recommends investments in multiple actions to educate our community, track behavior, and report progress over time.*

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Leadership Letter

August 22, 2011

One of society's greatest challenges is balancing human activity with environmental responsibility to preserve the health of our planet for future generations. For more than 100 years, the University of Michigan (U-M) has worked steadily to protect the natural environment. As new threats such as climate change and invasive species have entered the scene, the U-M community has worked diligently to steward precious natural resources while providing exceptional opportunities for teaching, learning and research focused on sustainability.

The U-M has developed a far-reaching sustainability initiative that spans education, research, operations and engagement. This presidential initiative leverages numerous strengths and relies upon a collaborative organizational structure to ensure effective coordination of sustainability efforts across our campus – no small task considering the massive scale and decentralized nature of this great University. As part of this coordination effort, the Graham Sustainability Institute and the Office of Campus Sustainability are charged with linking academic and operational efforts to use our physical campus as a living-learning lab for sustainability.

The subject of this report – the Campus Sustainability Integrated Assessment (CSIA) – represents a significant step in this unique academic-operations partnership. Through the CSIA we leveraged the expertise of faculty, the enthusiasm of students, the experience of staff members, and the valuable perspective of external partners. The outcomes are new frameworks and goals to significantly advance sustainable operations at the University of Michigan-Ann Arbor.

While the University has made impressive progress in energy efficiency and resource conservation over the last several decades, an important result of the CSIA is that those efforts will now be structured and stretched through quantitative and time specific goals. The goals are framed by aggressive guiding principles under the themes of *Climate Action, Waste Prevention, Healthy Environments and Community Awareness*.

An overarching focus of this effort was to foster a campus-wide culture of sustainability, and we believe we are now well on our way to making this a reality. Throughout the CSIA process, we have been inspired by the broad and deep engagement across the U-M campus community. More than 500 individuals contributed to the CSIA, with 193 participating formally as a team or committee member, or as an advisor with specific content expertise. We wish to thank everyone for their ideas, time, and energy to advance campus sustainability at Michigan. We hope everyone will find a way to stay connected and encourage others to become involved. Only through sustained engagement and support can we be Leaders and Best in this all important area.

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Professor and Director, Graham Institute

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Office of Campus Sustainability

Introduction

Background

In October 2009, University of Michigan (U-M) President Mary Sue Coleman elevated the University's commitment to sustainability in teaching, research, operations and engagement by creating the Sustainability Executive Council. One of the first actions of the Council was endorsing a Campus Sustainability Integrated Assessment (CSIA) to identify long term stretch goals for sustainable operations on the U-M Ann Arbor campus, including the Athletic Department and the Health System. This report provides a comprehensive summary of the CSIA process and outcomes.

The geographic scope of the CSIA spanned the five Ann Arbor campuses (South, Central, Medical, North and East Medical)[1], which include 3,070 acres of land and 377 buildings comprising 31.4 million square feet. In 2009, these buildings and their 79,174 occupants consumed 6.4 trillion BTUs of energy and 1.2 billion gallons of water. Additionally, greenhouse gas emissions (GHG) from U-M buildings totaled 263,181 Metric Ton CO_2 Equivalents. The magnitude of energy consumption, water usage and GHG emissions generated by the U-M suggests that aggressive sustainability goals for University campus operations could have significantly positive environmental, fiscal, and health impacts.

The CSIA builds on a long history of sustainability commitments in U-M campus operations, such as implementing cogeneration technology at the Central Power Plant in the 1960s, adopting the EPA Green Lights and Energy Star programs in the 1990s, and more recently establishing LEED (Leadership in Energy and Environmental Design) Silver certification as the standard for new non-clinical construction projects where the construction value exceeds $10M. While past commitments have moved the U-M campus forward, more can always be done, and the CSIA was pursued with this in mind.

Methodology, Purpose and Structure

As a means of undertaking this complex project, the Graham Institute and Office of Campus Sustainability employed a highly effective applied research framework known as Integrated Assessment (IA). IA is a process that synthesizes natural, social, and economic information for particularly challenging problems. Among the many strengths of IA is that it brings together perspectives from government, academia, nonprofit, and community stakeholders to support informed decision making. [2]

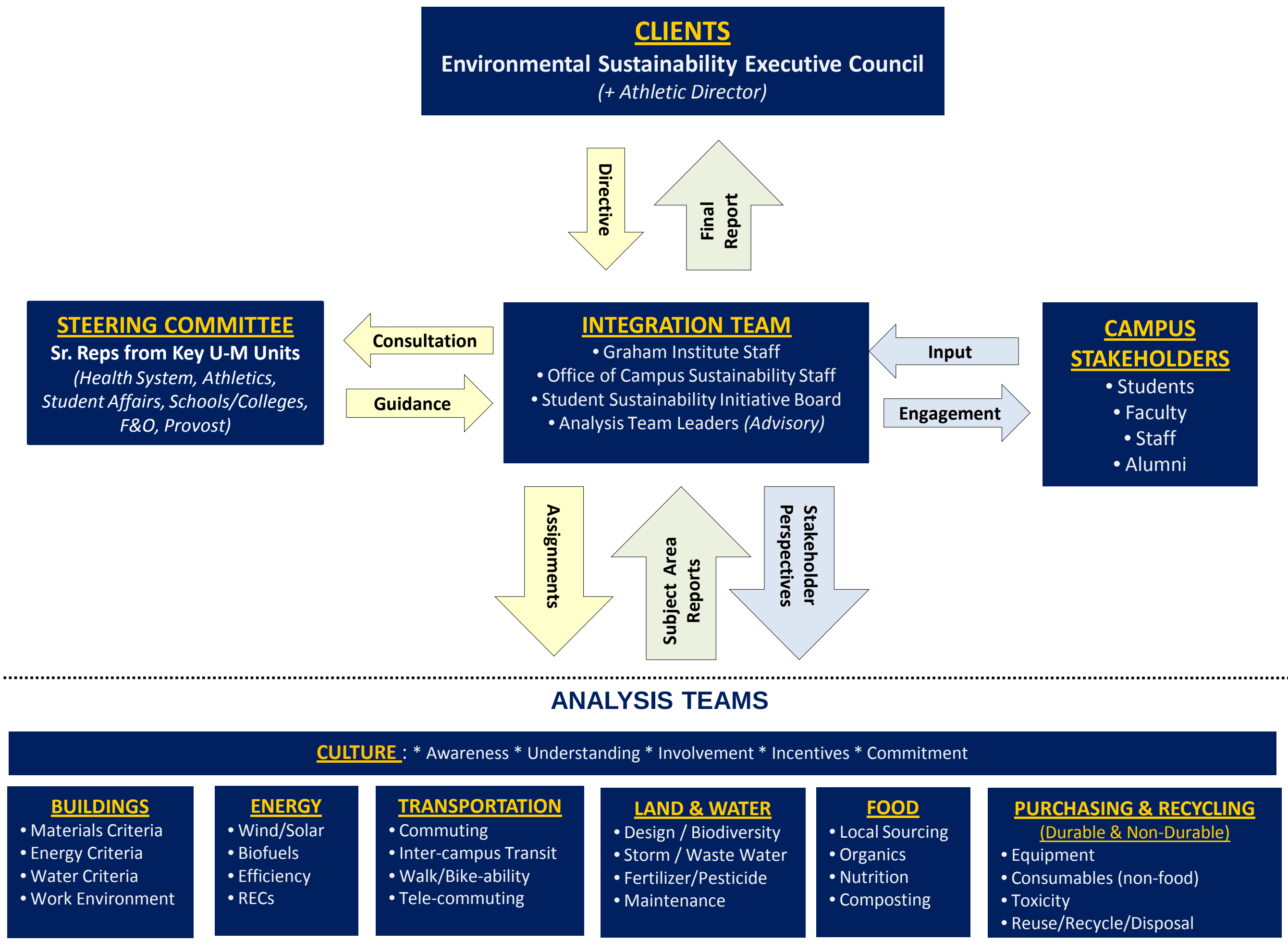
The purpose of the CSIA was to collaboratively develop practicable ideas to guide efforts that will help solidify the U-M as a global leader in campus sustainability. It involved students, faculty, and staff throughout the U-M community to:

- Establish broad goals and specific targets for U-M campus sustainability efforts.
- Develop frameworks to help guide U-M's overall campus sustainability strategy.
- Identify opportunities to use the U-M campus as a sustainability learning laboratory.
- Identify potential demonstration projects to foster campus sustainability research and learning.
- Educate the U-M community on sustainability issues and help change culture as appropriate.
- Publish a final report to share what we have learned as a community.

[1] A map illustrating these campuses is located in Appendix A.

[2] Integrated Assessment (IA) and other key terms are defined in Appendix B. Additional information on IA, including a methodology overview, process benefits, and additional resources can be found at: http://www.graham.umich.edu/ia/ .

The operational structure and process for the CSIA are depicted in the schematic below. A complete description of these project components and an activities timeline can be found in Appendix C of this report. A listing of project milestones is in Appendix D.



Process

During Phase 1, seven faculty-led and student-staffed Analysis Teams focused on: ***Buildings, Energy, Land & Water, Food, Transportation, Purchasing & Recycling, and Culture.*** While conducting literature reviews, peer benchmarking, and assessing U-M practices, Analysis Teams also consulted with U-M operations personnel to gain institutional perspectives regarding their areas of study. At the conclusion of Phase 1, the Analysis Teams submitted comprehensive reports and suggested ideas for further study in Phase 2. The Integration Team reviewed the reports and conducted multiple meetings with the Analysis Teams to identify areas of intersection across these ideas. This review resulted in a priority list of proposed sustainability ideas that required further analysis during Phase 2.

During Phase 2, the Analysis Teams were charged with conducting more detailed analyses that included costs, benefits, technical guidance, uncertainties, and reasonable implementation timeframes for potential actions. It is important to note that during Phase 2, the Analysis Teams were not charged with specifically recommending long term goals for sustainable campus operations – this was the work of the Integration Team in collaboration with the Steering Committee, Analysis Teams, and key operations staff members at the conclusion of Phase 2. A complete list of the Phase 2 focus areas and how they align with institutional priorities can be found in the Interim Report located at: http://graham.umich.edu/ia/campus-ia.php, where all CSIA-related reports can be found. The Phase 2

Analysis Team reports are also included in Appendix E of this document.
To ensure all contributions from the CSIA are retained, the Office of Campus Sustainability created and maintains a log of all ideas generated through Phase 1 and Phase 2, and they will be reviewed on an ongoing basis to identify priority projects for implementation. The information generated by the CSIA has already become a useful resource for several campus units and academic courses such as *Sustainability and the Campus* in which students conduct a substantial, hands-on group campus sustainability project in conjunction with a U-M sponsor.

This final CSIA report contains the recommendations developed by the Integration Team, and informed by the Phase 2 Analysis Team reports with additional input from U-M operations staff. The report outlines four high level themes – ***Climate Action, Waste Prevention, Healthy Environments, and Community Awareness***. Within each theme are proposed goal categories and potential actions that cut across all of the Analysis Team research areas. This menu of potential actions requires additional engineering and cost analyses to determine which should be implemented, at what scale, and whether alternative options are preferable. Working with all of this information, the Integration Team developed a set of proposed *2025 goals*, which are firm targets for the U-M that are time specific and quantifiable. The goal recommendations are presented immediately after the theme overviews.

A hallmark of this two year process was deep and broad community engagement that powerfully informed and shaped the CSIA. This included seven faculty led Analysis Teams staffed by 77 student research assistants who completed over 10,000 hours of work, close involvement of dozens of operations staff members, nearly 200 comments and ideas submitted by the campus community, several town hall events that drew several hundred unique participants, as well as focused workshops involving other academic institutions, businesses and local community organizations. Appendix F provides a listing of faculty, staff, students and external partners involved in the CSIA. Appendix G provides a summary of all comments and ideas received throughout the process along with a response from the appropriate Analysis Team, and Appendix H provides links to additional U-M sustainability resources.

Climate Action

Global climate change is considered by many to be the defining issue of the 21st Century. The CSIA Climate Action theme addresses the potential consequences associated with global climate change, and the University's need to develop a long-term sustainable energy plan. Climate action is of considerable importance because the majority of the energy used by the University requires the burning of fossil fuels, which generates greenhouse gas (GHG) emissions.

Historically, the U-M has worked to reduce its GHG emissions through energy conservation programs, the use of renewable energy technologies, and by providing alternative transportation options to the campus community. Examples include: the Planet Blue Operations Team program – a nationally recognized approach to achieving energy conservation through technology upgrades in campus buildings and the engagement of building occupants; a solar water heater installation on the Central Power Plant roof to preheat water entering the natural gas-powered water heaters; the campus bus fleet that transported more than 6.5 million passengers in 2010; and, the University sponsored van pool program that serves commuters from more than 30 municipalities. The success of these and other efforts is demonstrated by the 22 percent decrease in per capita energy use since 2004.

By developing a practical approach to achieve a responsible carbon reduction goal, the U-M can fulfill its operational responsibility of sustainable energy use while meeting its academic research goals as a world-class institution of higher education. Potential actions proposed in this theme area address all categories of GHG emissions – scopes 1, 2 and 3 – and are supported by ideas from the Energy, Buildings, and Transportation Teams.[3] Ideas listed under the Climate Action theme are organized into two goal categories; reducing absolute greenhouse gas emissions; and, decreasing the carbon intensity of U-M sponsored transportation options[4].

[3] *Scope 1 emissions* are *GHG* emissions occurring from sources that are owned or controlled by the U-M. *Scope 2 emissions* are GHG emissions generated in producing the electricity purchased by the U-M. S*cope 3 emissions* are all other indirect GHG emissions resulting from U-M activities (e.g., commuting, air travel for U-M activities, transporting purchased goods).

[4] *Carbon Intensity* can be defined as the total level of GHG emissions resulting from trips on U-M sponsored transportation options divided by the number of individual passenger trips on those options. *University-Sponsored Transportation Options* include U-M sponsored alternatives to personal vehicle transportation, including on campus and off campus options.

Potential Actions to Reduce Greenhouse Gas Emissions

Potential Action *(organized by team report in no order of priority)*	**Source/Team & Report Page**[5]	**Summary Notes**
Small renovation building projects (costing less than $10 million)	**Buildings 17**	1) create an action plan to prioritize and implement sustainable building practices; 2) develop in-house capacity for energy modeling; 3) expand thermal scanning during design and construction phases; 4) provide annual training to update AEC staff about small renovation sustainable building practices; and, 5) promote projects to increase talent recruitment/retention and use as a collaborative learning tool across disciplines.
High energy demand equipment replacement	**Buildings 22**	Identify equipment with a high energy demand that is lagging in efficiency with the goal to accelerate replacement of these systems. Initiate a study that investigates the feasibility and effectiveness of setting up a fund for these upgrades.
Cost-benefit analysis for building upgrade packages	**Buildings 32**	As the scope of building upgrades expand, cost analyses should help establish comprehensive budgets for sustainable building projects.
Plant Blue Operations Teams	**Buildings 33** **Energy 38**	Given projected campus growth, existing operations will have to reduce GHG emissions by more than 10%. The work of the Planet Blue Operations Team serves as a model for achieving these reductions.
Biomass sourcing	**Energy 8**	Biomass power was identified by the Energy Team as a cost-effective option for reducing GHG emissions. Further analysis is needed to determine the availability and price of biomass before pursuing these facilities.
Syngas fuel source feasibility studies	**Energy 8**	The Energy Team recommends a detailed engineering assessment to determine the feasibility of using syngas as a fuel in combustion turbines at the Central Power Plant.
Biomass (North Campus)	**Energy 12**	A central combined heat and power plant (CHP) is an efficient and cost-effective way to meet North Campus' energy needs. Using biomass at this plant would provide likely cost savings and large GHG emissions reductions.
Geothermal (North Campus)	**Energy 18**	Geothermal heating and cooling system options are explored in the Energy Team report with three potential North Campus resource sites discussed.

[5] Please note: These page numbers refer to the Analysis Team Report page numbers found at the bottom of the individual team reports. The page numbers for this final report and table of contents are found at the top right of the page. The links in these tables will take you to the correct page of the final report.

Geothermal pilot project (Central Power Plant and Stadium)	**Energy 20**	A geothermal pilot project would help gain expertise for future installations and strategies for steam production at the Central Power Plant. A geothermal heat pump at the Stadium to provide heating, cooling, and to supply hot water could be considered.
Parking lot photovoltaics (PV)	**Energy 23**	The Energy Team report provides technical guidance, estimated costs, and annual reduced carbon emissions for pole-mounted PV on targeted campus parking lots.
PV rooftop demonstration	**Energy 26**	In evaluating the capacity of PV on campus, the Energy Team identified a list of buildings as potential candidates for solar rooftop demonstrations.
Solar thermal (pre-heat) Power Center	**Energy 27**	A solar thermal system can be used to preheat water to be used in steam generation. The Energy Team's report estimates costs, benefits, and technical guidance of this technology.
Solar thermal (DHW boost)	**Energy 27**	Hot water for the Central Campus Domestic Hot Water (DHW) loop is generated at the Central Power Plant. A solar thermal heat source can save energy by reducing the need for additional booster heaters along the loop. The Energy Team's report estimates costs, benefits, and technical guidance of this technology.
Wind turbines	**Energy 30**	Wind is a proven, cost effective, renewable source of clean energy. Since no campus locations are suitable for wind energy, turbines would be located off campus in the state of Michigan.
Renewable energy credits (RECs)	**Energy 31**	The University can continue to reduce its GHG emissions and carbon footprint by increasing RECs purchased.
Natural gas turbines at central power plant	Integration Team	A July 2009 feasibility study indicated that the addition of two 15MVA combustion turbines to the Central Power Plant could address future requirements for steam and electricity demand while reducing overall campus carbon emissions. This action was generated during the project's Integration Phase following the completion of team reporting.

Potential Actions to Decrease Carbon Intensity of U-M Sponsored Transportation Options

Potential Action *(organized by team report in no order of priority)*	Source/Team & Report Page	Summary Notes
Hybrid passenger vehicles	**Energy 32**	Hybrid vehicles offer improved fuel economy and as a result can reduce GHG emissions and fuel costs. The Energy Team's analysis considered benefits and challenges of purchasing hybrid passenger vehicles.
Hybrid campus bus	**Energy 32** **Transportation 39**	Hybrid buses offer improved fuel economy and as a result can reduce GHG emissions and save on fuel costs. The Energy and the Transportation Teams' analysis considered the benefits and challenges of purchasing hybrid buses.
Bicycles	**Transportation 15**	A series of biking ideas are made by the Transportation Team including a master plan, bike service center, intercampus bikeway network, and bike sharing system.
AA connector/rail	**Transportation 39**	Integrating town-to-campus movements within the high capacity corridor is being considered in the Ann Arbor Connector Study co-sponsored by U-M, the Ann Arbor Transportation Authority (AATA), and the Downtown Development Authority.
Bus ridership Increase	**Transportation 39**	The Transportation Team investigated the idea of integrating U-M transit with AATA to shift low ridership lines to AATA and increase route ridership.
Optimize bus routes	**Transportation 39** **46**	Seek ways to integrate on campus routes that go further into the community and minimize commuting transfers.
AATA, U-M transportation route pilot	**Transportation 46**	U-M routes with especially low ridership and AATA overlap could be targeted to pilot AATA integration (e.g. Mitchell-Glazier route).
Optimize courier service	**Transportation 53**	Consolidating courier services through Mail Services could create gains in efficiency of money and resources.
No idling policy	Integration Team	In February 2000, Plant Operations issued a Policy Guide addressing unnecessary idling of University vehicles. During the project's Integration Phase, it was suggested that this policy be adopted university wide.
Expand existing alternate transportation options	Integration Team	Parking & Transportation Services manages an alternate transportation program, and are researching ways to improve and expand. This action was generated during the project's Integration Phase following the completion of team reporting.

Waste Prevention

In 2009, the U-M celebrated 20 years of recycling on the Ann Arbor campus. What started out as a grass roots movement coordinated by U-M students and staff has evolved into part of the institution's culture and campus life. Recycling success stories include: implementation of the Student Move Out program, an annual event that has generated more than 140 tons of donations for local charities; the Stadium Recycling Program, which collects 30 tons of cardboard and plastics annually; and, the popular public E-Waste event held each spring in partnership with the Ann Arbor Public Schools.

Sustainable waste management involves more than just recycling. The U-M sponsors a number of innovative programs designed to promote waste reduction and product reuse. Since 1998, residence halls have been collecting pre-consumer food waste for composting. In 2010, $2 million worth of used equipment was resold through the Property Disposition Office. The Office of Occupational Safety and Environmental Health also manages a Chemical Redistribution program that reduces the amount of chemical waste generated by research and teaching labs on campus.

With a current recycling rate of 33%, the U-M still diverts more than 10,000 tons of solid waste to landfill facilities annually. Opportunities to decrease the amount of waste the U-M generates include the recent implementation of single stream recycling, expansion of the current composting program, and improvements to the purchasing process. Participation of the campus community will be necessary if the U-M is to take full advantage of these opportunities. The U-M encourages public participation by providing education, clear direction, and ensuring the necessary infrastructure is operating efficiently. The Waste Prevention theme addresses the amount of waste generated through campus activities and how that waste is managed. This includes the entire cycle, including what materials are considered for purchase, how these materials are used on campus, and, what happens to them at the end of their useful life. This theme is supported by ideas from the Food, Purchasing & Recycling, and Buildings Teams. The potential actions listed under the Waste Prevention theme are organized under one goal category – reducing waste tonnage diverted to disposal facilities.[6]

[6] *Waste Tonnage Diverted* is defined as the reductions in the aggregate amount of waste that goes to disposal facilities. *Disposal Facilities* are defined as landfills, combustion, transfer, and storage facilities.

Potential Actions to Reduce Waste Diverted to Disposal Facilities

Potential Action *(organized by team report in no order of priority)*	Source/Team & Report Page	Summary Notes
Program for material reuse and recycling of building components	Buildings 24	Help reduce waste through a new program, cost assessments, and materials database for the management of construction and demolition debris from small renovation projects. Create a virtual warehouse/website for reused and recycled materials.
Pre and post consumer composting	Land and Water 12 Food 4 Purchasing and Recycling 29	The use of compost as fertilizer and topsoil reduces the need for chemical fertilizer, supplemental water and pesticides and the amount of organic waste going to landfill and incinerators, which decreases the amount of methane emitted during the decomposition process.
Food Waste Audit pilot project	Food 5	A regular trash audit will enable U-M to better understand how much waste in each building is going to the landfill and evaluate waste reduction efforts. The Food Team recommends starting an annual audit of a few buildings and incorporating 10% of campus buildings each year.
Bottled water reduction	Food 10, 14	Shifting from bottled water to municipal water will prevent the production of 600,000 plastic bottles per year and their disposal in landfills. A phased implementation plan for bottled water reduction focuses first on providing convenient access to refill stations, reusable containers, and container cleaning facilities.
Tray-less dining	Food 17	Tray-less dining is a method to reduce food waste. Tray-less dining does not have to be a ban of all trays. Moving trays to a less visible location can also achieve desired results. This action could pay for itself by reducing food waste and procurement costs.
Improvements to Property Disposition	Purchasing and Recycling 9	While the Purchasing and Recycling Team ultimately recommends major organizational restructuring to Property Disposition, their report provides a number of incremental suggestions to improve its effectiveness including advertising, new software, loading dock construction, and holding seasonal outlets to clear inventory.
Single stream collection	Purchasing and Recycling 22	Single-stream collection will increase current recycling rates. While most of the infrastructure is already in place, additional education and promotion will be necessary to engage the University population and ensure buy-in.

Zero-waste sporting events	**Purchasing and Recycling 26** **Food 9**	Since U-M's athletic activities have such high visibility and engage so many people on and off campus as participants or spectators, zero-waste sporting events are a great opportunity for U-M to take a significant step towards sustainability.
Campus composting facility siting	**Purchasing and Recycling 29**	Investigate potential campus composting sites and educate students about proper composting techniques.
Office supply reuse program	**Purchasing and Recycling 30**	The team recommends a phased approach for revising the Office Supplies Program because their analysis shows it is currently not cost or environmentally effective.
Environmentally preferable purchasing	**Purchasing and Recycling 39**	A successful policy will create a set of basic requirements for university departments as well as outline future goals for the evolution and development of sustainable purchasing.
Green products assessment	**Purchasing and Recycling 40**	The Purchasing and Recycling team identified tools that can be used to evaluate green products. For example, a Green Products Assessment questionnaire was developed by students in ENVIRON/RCIDIV 391 class.
M-Marketsite	**Purchasing and Recycling 44**	This idea focuses on: 1) increasing percentage of orders placed to better manage data collection on ordering behavior; 2) optimizing the user interface to improve communications between users and the Procurement Department; and, 3) increasing visibility of environmentally preferred products.
Chemical redistribution	Integration Team	The Chemical Reuse program allows labs to obtain chemicals and solvents free of charge, with OSEH storing unexpired and unused surplus chemicals in a repository for redistribution. This program is expected to save U-M both purchasing and waste disposal costs by reducing the overall volume of hazardous waste generated.
Green chemistry program	Integration Team	The Green Laboratory Operations for Sustainability (GLOS) Recognition Program promotes sustainable operations in U-M laboratories. The Sustainable Laboratory Practices Working Group partners with laboratory faculty and staff to evaluate existing lab practices in the area of source reduction, product substitution, purchasing, micro-scale techniques, chemical reuse, recycling, neutralization and disposal. This action was generated during the project's Integration Phase.

Healthy Environments

The U-M enjoys a unique location within the Huron River watershed, offering the campus community opportunities to experience and enjoy bountiful natural areas. The Healthy Environments theme is, therefore, concerned with the health of both ecosystems and communities, and recognizes the University's responsibility to preserve and protect our local environment for future generations of students, faculty, staff and visitors.

For many years, the U-M has maintained a comprehensive Storm Water Management Program Plan designed to protect the Huron River basin from impacts associated with storm water run-off. Storm water not absorbed into the ground after rain events travels along the surface, picking up oil, pesticides and other pollutants, discharging them into local surface waters. The U-M has implemented Best Management Practices designed to reduce storm water runoff impacts including: the installation of a 1 million gallon detention basin beneath the Life Sciences Institute parking structure; the North Campus Wetland Basin that manages runoff from 90 acres of campus property; a porous pavement parking lot near the West Quadrangle dormitory; and, three green roofs located on the Ross Business School.

In addition to protecting the water quality of our community, the U-M supports the preservation and conservation of open space. For example, the University directly manages extensive natural preserves for research, learning and recreation. In addition, the U-M contributes to farmland preservation through local food sourcing. This is important because Michigan is the second most agriculturally diverse state in the country, but has lost more than 100,000 acres of farmland since 2002.

The Healthy Environments theme is supported by ideas from the Land & Water, Food, Buildings and Transportation Teams. The potential actions listed under the Healthy Environments theme are organized under three goal categories: increasing U-M food purchases from sustainable sources; reducing land management chemical usage; and, minimizing storm water runoff from impervious surfaces.[7]

[7] *U-M Food Purchases* represent food purchased by the University of Michigan (this excludes third-party vendors operating on campus). *Sustainable Sources* includes locally sourced food (i.e., food grown and processed in Michigan or within 250 miles of Ann Arbor) and other categories such as third party certifications, organic practices, humane treatment of animals, hormone and antibiotic free, free-range poultry and eggs, grass-fed or pasture raised meats, and sustainable fisheries. *Impervious Surfaces* are paved or hardened surfaces that do not allow water to pass through. This includes materials used for most roads, rooftops, sidewalks, pools, patios and parking lots. *Storm water Controls* are best management practices to decrease storm water runoff to the Huron River such as native plantings, green roofs, pervious parking lots, and river buffers. *Land Management Chemicals* refers to all chemicals (e.g., herbicides, pesticides, fungicides, fertilizers, de-icers) applied on U-M grounds.

Potential Actions to Increase U-M Food Purchases from Sustainable Sources

Potential Action *(organized by team report in no order of priority)*	Source/Team & Report Page	Summary Notes
Sustainable food forager position	**Food** **20**	This new campus position would assist with sustainable food purchases, find new local sources of food, and help implement and oversee the Sustainable Food Purchasing Guidelines.
Local/sustainable food labeling system	**Food** **25**	This action combines complexities of sustainable food production into one standard that would help increase sustainable food purchasing.
Campus farm/garden	**Food** **30**	Expanding garden space on U-M property will increase opportunities for students, faculty and staff to learn about key food-related sustainability issues.
Sustainable Food Purchasing Guidelines	**Food** **27** Integration Team	Guidelines identify existing sustainable practices in foodservice operations, increase transparency and customer options, and demonstrate a commitment to a more sustainable food system for the campus and hospital systems. While this action was discussed in the Food Team report, it was further explored and pursued during the IA's Integration Phase. Draft guidelines have now been created and are pending university approval.

Potential Actions to Reduce Land Management Chemical Usage

Potential Action *(organized by team report in no order of priority)*	Source/Team & Report Page	Summary Notes
Low/no-chemical use zones in a phased approach	**Land and Water Team** **11**	Reduce the use of chemical herbicides, pesticides, fungicides and fertilizers on all campus grounds in a phased approach.
Snow and ice removal strategies – permeable and heated paving	**Land and Water Team** **12**	Reduce reliance on chemicals used on campus grounds with ice and snow during the winter months.
Expand composting as a fertilizer alternative	**Land and Water Team** **12**	Reduce the need for artificial fertilizers by incorporating greater use of campus compost in landscape management practices.
Landscape management strategy for native vegetation and lawn reduction	**Land and Water Team** **16**	Increase the use of native plants and the presence of native plant communities in traditional lawn and tree campus landscapes.

Potential Actions to Minimize Storm Water Runoff

Potential Action *(organized by team report in no order of priority)*	Source/Team & Report Page	Summary Notes (in addition to the Land and Water Team's analysis and reporting, these actions are described in U-M's 2010 Storm Water Management Program Plan) www.oseh.umich.edu/pdf/guideline/SWMP2010.pdf
OSEH May 2010 Storm Water Management Program Plan (SWMPP) **(*Note: plan is under implementation*)**	Integration Team	The Storm Water Management Program Plan (SWMPP) is prepared as a requirement of the University's National Pollutant Discharge Elimination System Storm Water Discharge Permit. The SWMPP describes measures, procedures and practices that U-M will utilize to minimize the discharge of pollutants from campus into the storm water drainage systems and adjacent receiving waters. In accordance with the Permit, the SWMPP is required to include the items that follow in this table.
Landscape management strategy to increase stormwater disconnections	**Land and Water Team 13**	The Land and Water Team identified additional opportunities to address storm water runoff quality, quantity, and time of concentration including replacement of impervious surfaces and increasing native plant cover for stormwater management.
Convert impervious to pervious surfaces	**Land and Water Team 14**	Create a phased impervious cover replacement policy for walkways and parking lots, and all game courts with pervious surfaces.
Construction and post construction stormwater best management practices	**Land and Water Team 15**	The Land and Water Team report identifies best management practices to reduce and retain stormwater runoff and protect runoff quality by establishing soil and vegetation protection zones, sediment traps, compost berms, and many other ideas cited in their report.
Vegetated filter strips and buffer zones	**Land and Water Team 23**	Designate U-M property existing within 100' of the Huron River and 50' from a stream or other body of water as a vegetation and soil protection zone.
Convert traditional, impervious building roofs to green roofs	Integration Team	Increase implementation of green roofs, which filter rainfall as part of a natural storm-water management system and last longer than conventional roofs. U-M currently manages three green roofs, two on the Ross School of Business building and one on the Kresge Library.

Community Awareness

The University engages the campus community and encourages students, faculty and staff to become involved in making the campus more sustainable. For example, the U-M sponsors an annual EarthFest event on the Diag to showcase and promote the wide range of activities and programs comprising the U-M Sustainability Initiative. In addition, Planet Blue Operations Team open house events inform building occupants of the program's objectives while empowering them to join the University's sustainability efforts. The CSIA process demonstrated that active participation of the U-M community is necessary to shape a successful campus sustainability strategy, and it will continue to be important as the U-M strives to reach the goals recommended in this report.

Promoting the culture shift required to instill sustainability related values in a community of 80,000 people is an extremely challenging task, especially since much of the University population is transient by nature. When students come to the U-M, their primary focus is earning their degree and other interests are often secondary due to the responsibilities associated with college studies. The U-M hosts many visitors, all of whom leave a unique environmental footprint. Sporting events, libraries, museums, and the U-M Health System bring in millions of people on a temporary basis and it is difficult to significantly expose these guests to sustainability ideals in the short time they are on campus. On the other hand, the number of guests provides a unique opportunity to present our sustainability principles to a very large and diverse audience.

The Community Awareness theme focuses on better understanding and shaping sustainability knowledge and behaviors throughout our campus community. The theme goes beyond campus operational efforts and ties closely to educational components of the broader U-M Sustainability Initiative. Key actions within the Community Awareness theme are critically important for driving progress toward the quantifiable stretch goals. The potential actions listed under the Community Awareness theme are organized under one category – cultivating a culture of sustainability on campus.

Potential Actions to Cultivate a Culture of Sustainability on Campus

Potential Action *(organized by team report in no order of priority)*	**Source/Team & Report Page**	**Summary Notes**
Survey transportation trends	**Transportation 54**	An annual or biannual community survey of transportation trends will help analyze community transportation patterns.
Survey courier service needs	**Transportation 54**	Campus Mail could carry out a survey of departments to assess the total need for courier services. The survey would help develop an appropriately sized program and also inform the level a savings or efficiencies to be gained.
Survey student & staff interest in bottle water reduction/elimination	**Food 13**	Determine the campus community's preference for bottled vs. tap water and the feasibility of reduction strategies.

Water/food sustainability education Programs	**Food** **15, 17, 21**	Incorporate water/food sustainability education into student orientation activities.
Recycling incentive programs	**Purchasing and Recycling** **24**	Integrate incentive and engagement programs to increase recycling rates through participation in events like Recyclemania, Terracycle, and RecycleBank.
Training for sustainable purchasing program	**Purchasing and Recycling** **46**	Implement a Sustainable Purchasing Policy and educate the campus community on responsible purchasing, linking it to potential cost savings when possible.
Cultural metrics	**Culture** **3**	Expand indicators tracked and reported to include cultural elements; data would be collected as part of survey design or STARS reporting process.
Alumni Surveys	**Culture** **21**	Work with the alumni association to potentially develop and administer ongoing surveys of U-M alumni.
Cooperative Institutional Research Program (CIRP) survey of incoming U-M first year students	Integration Team **Culture** **11**	Work with the Student Affairs to include sustainability questions for incoming students - run for three years starting in 2012.
Student Longitudinal Survey	Integration Team **Culture** **13, 15**	Work with ISR to design and administer longitudinal survey of U-M students to assess change in awareness, commitment and behaviors.
Faculty/Staff Longitudinal Survey	Integration Team **Culture** **17, 20**	Work with ISR to design and administer longitudinal survey of U-M faculty/staff to assess change in awareness, commitment and behaviors.
U-M Sustainability / Planet Blue Communications and Reporting	Integration Team **Culture** **19**	This action includes all promotional and reporting materials for the U-M Sustainability/Planet Blue initiative (i.e., not just operations). Examples include the Annual Sustainability Report, website, printed materials, etc.
Sustainability representative program for faculty, staff and students	Integration Team	This action builds off proposals developed by the Voices of the Staff Environment team and the Student Sustainability Initiative. It is a partnership of units across campus and would be informed by faculty with expertise in behavior change. (Note: a pilot program has now been established. For more info, see http://sustainability.umich.edu/news/u-m-launching-planet-blue-ambassador-program-fall)
AASHE STARS	Integration Team	Join AASHE's Sustainability Tracking Assessment and Rating System (STARS) Program for transparent reporting of sustainability performance measures. Implementation of this action to be covered through staffing at Graham and OCS.

Policy and Planning Considerations

The primary objective of the CSIA was to collaboratively develop stretch goals for sustainable operations and an array of potential actions to foster progress toward those goals. However, the Analysis Teams also identified several policy and planning ideas for the University to consider going forward. While all ideas developed through the CSIA warrant further study, those presented below have an added degree of complexity, because they are not discreet projects with clear paths for decision making and implementation. The multifaceted and complex nature of these policy and planning ideas requires additional time, analysis, and discussion to assess their merits and feasibility.

Policy / Planning Consideration	Related Theme	Source/Team & Report Page	Notes
Net present value modeling for building renovations	Climate Action	**Buildings 10**	Consider the use of Net Present Value modeling for approval of buildings renovations under $10 million and Planet Blue energy conservation measures.
Campus parking policy	Climate Action	**Transportation 2**	Create a parking policy to ease parking shortages, facilitate commuting by multiple modes, and decrease construction of new structures while reducing environmental impacts. The policy could address: 1) increasing parking-rate differentiation; 2) reducing parking subsidies by 2015; and, 3) shifting from monthly or annual parking payment.
Bike master planning, service center, rentals, and sharing program	Climate Action	**Transportation 15**	Create a comprehensive plan for bicycle improvements and transportation that ensure the most efficient use of resources. A service center, rental, and sharing system can significantly expand the accessibility of bicycle transportation and affordable services.
Pedestrian facilities and travel	Climate Action	**Transportation 28**	Plan and implement land use changes that put more diverse services within walking distance of the campus community, especially on North Campus. In the short term, enhance the safety and comfort of pedestrians throughout campus by improving and expanding pedestrian facilities.
Land use on North Campus	Climate Action	**Transportation 28**	Target a greater mix of land use on North Campus to put more destinations within walking distance and increase access to commercial destinations and enhance pedestrian travel.
Transit policy that integrates AATA with University routes	Climate Action	**Transportation 40**	Create a transit policy to promote seamless transit mobility both between the Ann Arbor campuses and between campus and surrounding areas. Improving efficiencies in existing alternative transportation is critical to increase use.

Campus airport transportation	Climate Action	**Transportation** **47**	Work with local and regional transit providers to enable an affordable, convenient link to Detroit Metro Airport via mass transportation.
Construction code of conduct	Waste Prevention	**Buildings** **25**	Develop a construction code of conduct to address indoor air quality to mitigate human health related problems and effects on surrounding environments resulting from renovations.
Phased approach for bottled water reduction and policy for elimination	Waste Prevention	**Food** **13**	Include a description of education efforts, surveys, expansion of fountains and refill stations, and other steps leading toward a policy of bottled water elimination by 2020 (except for emergencies)
Taskforce for sustainable procurement	Waste Prevention	**Purchasing and Recycling** **36**	Establish a Taskforce for Sustainable Procurement. With a goal of increasing environmental benefits and decreasing costs over time.
Vendor code of conduct	Waste Prevention	**Purchasing and Recycling** **41**	Expand the existing Code of Conduct to incentivize vendors to meet U-M standards for sustainability.
Life Cycle Analysis (LCA)	Waste Prevention	**Purchasing and Recycling** **50**	Conduct an annual LCA to help measure the institutional environmental footprint in addition to metrics in the Annual Environmental Report.
Sustainable Sites Initiative	Healthy Environments	**Land and Water** **5**	Adopt standards set forth in the Sustainable Sites Initiative as campus standards for landscape planning, design, and management.
Impervious cover replacement policy	Healthy Environments	**Land and Water** **14**	Create a phased impervious cover replacement policy to replace half of paved walkways, parking lots, and all game courts with pervious material.
Landscape policies for climate change	Healthy Environments	**Land and Water** **19**	Increase capacity of campus environments to respond to uncertainties of climate change by maintaining natural areas that increase carbon sequestration, manage and purify stormwater, etc.
Landscape policies for regional connectivity	Healthy Environments	**Land and Water** **19**	Increase connections between the campus and regional landscapes with greater habitat connectivity.
GIS systems integration and analysis	All	**Buildings** **42**	Develop and maintain detailed GIS of the Ann Arbor campus as a tool for monitoring, performance tracking, and modeling to reduce environmental impacts and improve quality of campus planning.
GIS pilot project	All	**Buildings** **46**	Develop comprehensive GIS model for a portion of the Ann Arbor campus as an academic-operational collaboration to document and input existing campus conditions and develop analysis tools.
Campus information resources	All	**Buildings** **42**	Link existing U-M information resources (e.g., annual Space Management Survey and the Plant Operations GIS) to create a model of the physical and environmental conditions of the campus.

CSIA Recommendations

Following the completion of Phase 2, the Integration Team reviewed all potential actions proposed by the Analysis Teams. The Phase 2 reports were also sent to key U-M operations staff for review and comment. Based on this input, the Integration Team organized all ideas under four high level themes - ***Climate Action, Waste Prevention, Healthy Environments, and Community Awareness.*** Next, the Integration Team developed *Guiding Principles* for each theme to guide long-range strategy through changing circumstances. Finally, time specific and quantifiable *2025 goals* were recommended.

A baseline year of 2006 was selected for goal setting because the Office of Campus Sustainability possesses reliable data from that point. While this baseline predates the addition of major campus expansions such as the North Campus Research Complex and the new C.S. Mott Children's Hospital and Von Voigtlander Women's Hospital complex, the footprint of these campus additions were factored into goal baselines. A target year of 2025 was established because this will allow sufficient time for complex work toward achieving the goals. Because innovations and opportunities are likely to change during this time period, the goals will be reviewed every five years to assess progress and adjust as needed. Finally, while these goals do not reflect an exhaustive list of all potential sustainability measures the U-M will pursue, they represent a broad, impactful, and measureable agenda to guide University campus sustainability efforts for the next several years.

CSIA recommendations were presented to U-M executive officers in the Summer of 2011 and initial financial analyses and possible scenarios were constructed for internal review. Final decision on the recommendations will be made by the Sustainability Executive Council. Decisions regarding specific actions to be implemented in pursuit of adopted goals will be determined by operations staff and University leadership. Below is a comprehensive list of the CSIA recommendations.

Definition of Terms

- ***Guiding Principle*** – Broad philosophy guiding long-range strategy through changing circumstances
- ***2025 Goal*** – Time-bound, quantifiable objective aligned with each guiding principle

CLIMATE ACTION

Guiding Principle: ***We will pursue energy efficiency and fiscally-responsible energy sourcing strategies to reduce greenhouse gas emissions toward long-term carbon neutrality.***

2025 Goals

1) ***Reduce greenhouse gas emissions*** *(scopes 1 & 2)* ***by 25% below 2006 levels.***
2) ***Decrease the carbon intensity of passenger trips across U-M sponsored transportation options by 30% below 2006 levels.***

WASTE PREVENTION

<u>Guiding Principle:</u> ***We will pursue purchasing, reuse, recycling, and composting strategies toward long-term waste eradication.***

<u>2025 Goal</u>

Reduce waste tonnage diverted to disposal facilities by 40% below 2006 levels.

HEALTHY ENVIRONMENTS

<u>Guiding Principle:</u> ***We will pursue land and water management, built environment, and product sourcing strategies toward improving the health of ecosystems and communities.***

<u>2025 Goals</u>

1) ***Purchase 20% of U-M food in accordance with U-M Sustainable Food Purchasing Guidelines by 2025***
2) ***Protect Huron River water quality by:***
    a. ***minimizing the runoff impacts from U-M's impervious surfaces*** *(outperform surfaces with no stormwater controls by 30%); and,*
    b. ***reducing the volume of land management chemicals used on campus by 40%.***

COMMUNITY AWARENESS

<u>Guiding Principle:</u> ***We will pursue stakeholder engagement, education, and evaluation strategies toward a campus-wide ethic of sustainability.***

- *There is no recommendation for a specific, time-bound, quantifiable stretch goal related directly to the Community Awareness theme. However, the CSIA recommends investments in the following actions to educate our community, track behavior, and report progress over time:*
    - *<u>Awareness and Education Programs</u>* – Establish Planet Blue Ambassadors program involving students, faculty and staff in modeling and teaching sustainability practices to the U-M community; establish Planet Blue Student Fund to give students a leadership role in developing and engaging in campus sustainability projects.
    - *<u>Longitudinal Surveys</u>* – Work with ISR's Survey Research Center to develop a high-quality assessment tool and conduct annual surveys of students, faculty and staff to track awareness/behavior over time and identify opportunities for performance improvement.
    - *<u>Reporting and Communication</u>* – Establish a new industry standard by including cultural metrics (tracked via surveys) as part of the annual campus sustainability reporting efforts; sign on to the AASHE STARS program to report sustainability performance externally in a manner that is consistent across all universities.

Conclusion

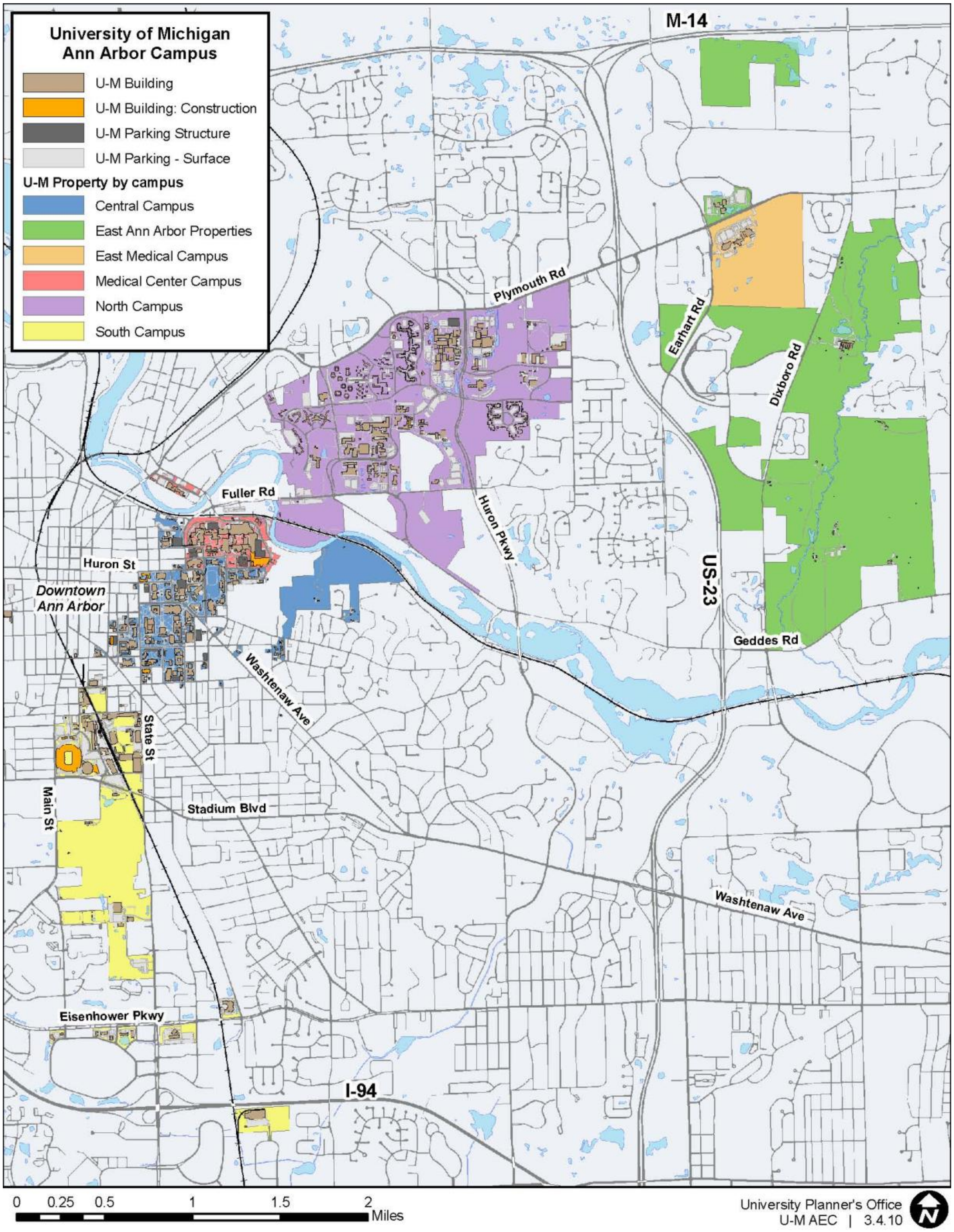
The Campus Sustainability Integrated Assessment sought to leverage University of Michigan strengths in research, education, operations and engagement to advance the sustainability of our campus. After two years of intense work, the result is a set of guiding principles, goals, and potential actions to significantly advance sustainable operations at the University of Michigan-Ann Arbor. The recommendations offer a holistic framework to help foster organizational transformation. The time is right to act on these recommendations and call upon all members of the campus community to play an active role in U-M campus sustainability efforts.

This project established a powerful new model for advancing U-M campus sustainability by formally connecting operational and academic efforts. While it made the CSIA process more challenging, a critical feature was the active involvement of students, faculty, staff, and other stakeholders in examining possibilities and making recommendations for buildings, energy, transportation, land and water, food, purchasing and recycling, and campus culture. In leveraging the expertise, enthusiasm, and experience of hundreds of U-M stakeholders, the CSIA achieved an all-important objective – broad and deep community engagement.

While we are encouraged by the outcomes of this complex project, we are also very interested in evaluating the effectiveness of the process that led us here. Therefore, we are working to engage a group of U-M masters' students to complete an overall evaluation of the CSIA. This evaluation will focus on perspectives of key stakeholders, examine initial progress toward the goals, and identify any immediate changes in campus culture and process. The project team will identify effective performance measures, select appropriate data collection tools, and analyze the strengths and weaknesses of different evaluation strategies. Through an examination of stakeholder perspectives, we expect the project will also help guide future campus sustainability initiatives.

Talented individuals are well-positioned to take on the challenge of implementing the 2025 goals. This will require support from both University leadership and the campus community. Fortunately we have operations staff ready and engaged, faculty focused on sustainability research and teaching, and students who continually demonstrate their interest in and commitment to a diverse set of initiatives and activities. We are confident that we can meet the challenges of our time in ways that are ambitious and achievable while also effectively stewarding the financial resources that will allow the University to continue achieving its mission – *to serve the people of Michigan and the world through preeminence in creating, communicating, preserving and applying knowledge, art, and academic values, and in developing leaders and citizens who will challenge the present and enrich the future.*

Appendix A: IA Geographic Scope



Appendix B: Definition of Terms

2025 (Stretch) Goal – A time-bound, quantifiable objective aligned with each guiding principle.

Association for the Advancement of Sustainability in Higher Education's (AASHE) Sustainability Tracking, Assessment Rating System (STARS) - A transparent, self-reporting framework for colleges and universities to measure their sustainability performance.

Carbon Intensity - The total level of GHG emissions resulting from trips on U-M sponsored transportation options divided by the number of individual passenger trips on those options.

Disposal Facilities – Landfills or combustion, transfer, and storage facilities.

Greenhouse Gas (GHG) - Gases that trap heat in the atmosphere and often attributed to burning fossil fuels to create usable energy.

Guiding Principle – A broad philosophy guiding long-range strategies through changing circumstances.

Impervious Surfaces - Paved or hardened surfaces that do not allow water to pass through. This includes materials used for most roads, rooftops, sidewalks, pools, patios and parking lots.

Land Management Chemicals - All chemicals (e.g., herbicides, pesticides, fungicides, fertilizers, de-icers) applied on U-M grounds.

LEED (Leadership in Energy and Environmental Design) - An internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using sustainable strategies (energy savings, water efficiency, CO_2 emissions reduction, etc.).

Life Cycle Analysis - A technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave.

Potential Actions – An analysis-driven menu of possible options for achieving stretch goals.

Renewable Energy Credits (RECs) - Tradable, non-tangible energy commodities in the United States that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource.

Scope 1 emissions - GHG emissions occurring from sources that are owned or controlled by U-M.

Scope 2 emissions - GHG emissions generated in producing the electricity purchased by U-M.

Scope 3 emissions - All other indirect GHG emissions resulting from U-M activities (e.g., commuting, air travel for U-M activities, and the transport of purchased goods).

Single Stream Recycling – A recycling method that refers to a system in which all paper and containers are mixed together in a collection truck and separated for reuse at a materials recovery facility rather than sorted into separate commodities (newspaper, cardboard, plastic, glass, etc.) by the resident.

Stormwater Controls - Best management practices to decrease stormwater runoff to the Huron River such as native plantings, green roofs, pervious parking lots, and river buffers.

Sustainable Food – U-M food purchases that include locally sourced food (i.e., food grown or processed within 250 miles of the Ann Arbor campus) and other categories such as organic, MSC (Marine Stewardship Council) certified, fair trade, antibiotic free, cage free, grass fed, shade-grown, etc. See Appendix H for more of these specific definitions.

Sustainable Sites Initiative - Voluntary national guidelines/performance benchmarks for sustainable land development, management practices, design, construction and maintenance.

Syngas Fuel - The name (from synthetic gas or synthesis gas) given to a gas mixture that contains varying amounts of carbon monoxide and hydrogen. Examples of production methods include steam reforming of natural gas or the gasification of coal or biomass.

U-M Food Purchases - Food purchased by the University of Michigan (this excludes third-party vendors on campus, such as Wendy's, Pizza Hut, Amer's, etc.).

University-Sponsored Transportation Options - U-M sponsored alternatives to personal vehicle transportation, including on campus and off campus options.

Waste Tonnage Diverted - Reductions in the aggregate amount of waste that goes to disposal facilities.

Appendix C: Project Components and Timeline

Analysis Teams

- Students at all levels – and from all areas – of the University were involved in the majority of the data gathering, analysis, and report preparation. Through Phase 1 and Phase 2 of the CSIA, 77 students completed more than 10,000 hours of Analysis Team work. Students in ENV 391: Sustainability and the Campus, also contributed to the CSIA.

- The work of each team was led by faculty members with expertise in the respective focus areas and informed by appropriate U-M operations personnel.

- Analysis Teams worked through the Graham Institute and Office of Campus Sustainability to coordinate data requests and gather input regarding relevant activities/initiatives within major University units (e.g., Student Affairs, Health System, Athletics, Schools & Colleges, Business & Finance, etc.).

- All involvement of U-M Business & Finance (B&F) personnel and associated requests for operations data were coordinated through the Office of Campus Sustainability, so as to minimize disruptions to normal job duties of B&F personnel.

- Each Analysis Team produced a comprehensive report covering their specific areas of study that include ideas or options for goals and targets for the University to pursue.

- Team Leaders:

Team	Faculty Lead	Primary Affiliation
Building Standards	Geoffrey Thun	Taubman – Architecture
Energy	Greg Keoleian	SNRE – Sustainable Systems
Water & Land	Stan Jones	SNRE – Landscape Architecture
Food	Larissa Larsen	Taubman – Planning
Transportation	Jonathan Levine	Taubman – Planning
Purchasing & Recycling	Olivier Jolliet	Public Health – Env. Health
	Brian Talbot	Ross School of Business
Culture	Bob Marans	Institute for Social Research

Integration Team

- The team was staffed by Graham Institute, Office of Campus Sustainability, Student Sustainability Initiative, and select other operations representatives. All Analysis Team leaders were also members of the Integration Team.

- Responsibilities included:
    - Scoping, staffing, and coordinating the Integrated Assessment effort.

    - Identifying U-M operations personnel and faculty members to guide Analysis Team work.

- Meeting with all Analysis Team leaders approximately every 4-6 weeks to ensure work progressed satisfactorily with coordination across teams.

- Working with each Analysis Team to ensure products met guidelines and deadlines.

- Developing comprehensive interim and final reports that:
  - Synthesized and integrated work from each Analysis Team
  - Identified themes and opportunities for achieving campus-wide efficiencies (i.e., can ideas from various areas be combined for better use of limited resources)
  - Proposed broad goals and standards for sustainable campus operations
  - Prioritized proposed goals for Environmental Sustainability Executive Council consideration.

Steering Committee
To ensure that the IA process facilitated an appropriate balance between meeting the U-M's day-to-day operational demands and supporting the IA Analysis Teams, the IA process was advised by a Steering Committee that:

- Consisted of senior representatives from key operating units

- Meet approximately every 6 weeks to discuss the IA activity

- Provided the Integration Team with broad-based, high-level input to effectively design and execute the IA process

- Ensured the project is proceeding in an effective manner

- Identified whether process modifications are required to execute the project effectively or if additional resources are to be requested of the Environmental Sustainability Executive Council

- Committee Members:

Faculty / Staff Member	Unit Represented
Tony Denton	Health System
Loren Rullman	Student Affairs
Rob Rademacher	Athletics
Brad Canale	College of Engineering
Knute Nadelhoffer	College of Literature, Science, and the Arts
Phil Hanlon/Martha Pollack	Office of the Provost
Hank Baier	Facilities and Operations
Don Scavia	Graham Sustainability Institute
Terry Alexander	Office of Campus Sustainability

Project Timeline

Timing	Activities
July – October 2009	• Met with representatives from key units across campus to solicit input for properly scoping the project and gain the necessary buy-in to move the project forward
November – December 2009	• Discussed and gained support for proposed study at Environmental Sustainability Executive Council meeting • Ironed out logistics • Recruited faculty and negotiated contract terms • Recruited students
January 2010	• Finalized Analysis Teams and meet to begin scoping project work • Provided each Analysis Team with a specialized summary of relevant U-M data based on area being studied • Developed a general framework for all Analysis Teams to follow • Analysis Teams began conducting research efforts • Convened 1st Steering Committee meeting • Communicated process with unit leaders and issued data request survey • Hosted first campus Town Hall event
February – March 2010	• Analysis Teams continued research efforts and identified data gaps • Analysis Teams developed follow-up data requests • Integration team facilitated administration of data request and response process between Analysis Teams and key units (e.g., Student Affairs, Health System, Athletics, Schools & Colleges, B&F) • Convened second Steering Committee meeting • Convened second and third meetings with all Analysis Team Leads
April – May 2010	• Formed a review panel of key operations staff members to consider Phase 1 draft recommendations • Held second campus Town Hall event at which Analysis Teams presented draft recommendations in focus group sessions • Analysis Teams completed initial analysis and drafted Phase 1 reports

June – July 2010	• Integration Team worked with Steering Committee, Team leads and others to:
	  o Review the reports from each Analysis Team
	  o Solicit additional information, where needed
	  o Draft an interim report that cut across and integrated content from the team reports and identifies priority areas for Phase 2 analysis
	• Hosted meeting and public forum with external contacts to learn from experiences at other institutions and gather input on emerging theme areas

Timing	Activities
August 2010	• Began scoping Phase 2 work plans • Confirmed faculty leads for Phase 2
September 2010	• Received endorsement from Steering Committee for Phase 2 • Developed strategies for involving key staff from F&O and other units as team members in Phase 2 • Worked with Analysis Team faculty leads to develop Phase 2 work plans that matched Phase 2 focus areas • Identified the student composition for teams in Phase 2, including re-hiring and hiring new students to begin work in September
October - November 2010	• In collaboration with Steering Committee, OCS, Analysis Teams, etc., pursued a more detailed analysis of options, focusing on the priority areas resulting from Phase 1 efforts. Phase 2 efforts featured more "hands-on" involvement and leadership from F&O personnel to ensure that potential goals are technically and financially achievable. • Held third campus Town Hall event • Held joint Integration Team and Steering Committee meeting to discuss draft Phase 2 recommendations
December 2010	• Each Analysis Team prepared a final Phase 2 report for their area that articulated: o Achievable goals based upon sound use of available technology to achieve/maintain prominence in the focus area o Forecasts of likely environmental, social, and economic benefits weighed against the cost of implementation o Technical guidance for cost effective means of implementation, taking into account possible risks and payback periods to assist decision making process o Evaluations of uncertainties and concerns
January – February 2011	• Integration Team began work to synthesize and integrate the Phase 2 reports of each Analysis Team, and to propose a set of cross-cutting campus operational sustainability goals that are practicable and informed by the campus community • Met with Steering Committee to review operations staff input on Phase 2 reports and discuss plans for final integration work • Prepared initial list of stretch goals
March – May 2011	• Refined recommended goals and target dates • Met with Integration Teams to present recommended goals • Presented goal recommendations to key executive officers
June - August 2011	• Prepared final integration report and developed plans for moving forward including communicating results to the campus community
Fall 2011	• Public announcement of IA results and U-M goals

Appendix D: Project Milestones

Ongoing Activity: Meetings Involving Staff from OCS, Graham Institute and Student Sustainability Initiative.
Timing: Bi-weekly or weekly meetings
Description: A core group of the Integration Team met regularly to discuss project planning and logistics. Overall, discussions focus on ensuring the project is proceeding in an effective manner with meeting planning, report review, information flow, and key collaborations being part of the focus.
Outcome: Ongoing communications of the Graham Institute and OCS

Ongoing Activity: Integration Team Meetings
Timing: Monthly meetings
Description: The Integration Team was staffed by the Graham Institute, OCS, Student Sustainability Initiative representatives, and faculty leading each of the Analysis Teams. This team's role was to scope and coordinate the IA effort along with communicating activities happening across the teams. The Integration Team worked to ensure the IA progressed and that team products meet the deliverable goals. These monthly meetings provided a forum for the team leads to ask questions and discuss interests, progress, concerns, areas of team overlap, and define next steps.
Outcome: Monthly planning meetings

Ongoing Activity: Steering Committee Meetings
Timing: every 4-6 weeks
Description: The IA process was advised by a Steering Committee to ensure the project includes an appropriate balance between meeting the U-M's day to day operational demands and supporting the IA Analysis Teams. The Steering Committee consisted of senior representatives from key operating units on campus who meet to provide the Integration Team with high-level input to design and execute the IA process.
Outcome: Regular planning and review meetings

Ongoing Activity: Comment and Ideas Online Submission
Timing: throughout Phase 1 and 2
Description: A Campus Sustainability Idea Submission Form was posted throughout the project on the Graham Institute's website to solicit comments and ideas about ways to improve sustainability efforts on campus. This call for ideas was part of the project's effort to actively involve U-M students, faculty, staff and other stakeholders.
Outcome: 189 comments and ideas were submitted in Phase 1 and 2. A summary can be found in Appendix F.
Related Link: http://www.graham.umich.edu/news/article.php?nid=211

PHASE 1

Pre- Activity: Campus IA Internal Scoping Meetings
Timing: July – October 2009
Description: Graham Institute and Office of Campus Sustainability (OCS) representatives met with key units across campus to solicit input and gaining the necessary buy-in to move the project forward. The proposed project was also discussed at Environmental Sustainability Executive Council meetings to gain support.
Outcome: CS IA Plan draft with project organization schematic depicted
Related Link: http://www.graham.umich.edu/ia/campus-ia.php

Pre-Activity: Faculty Recruitment
Timing: November - December 2009
Description: Graham staff identified and prioritized a list of faculty for each of the seven Campus IA focus areas using the Graham Institute's faculty directory (the directory identifies faculty who are interested in or working on sustainability topics). Meetings were held with faculty to describe the history of campus sustainability efforts so far and determine their interest and availability in working on the project. Their involvement was presented as an opportunity to both provide service to the University and advance their research goals. The project framework, partners, and general timeline was discussed and each faculty was asked to identify their level of commitment over the next year and desired student staffing needs.
Outcome: Seven faculty leads were chosen. A listing can be found in Appendix F.

Activity: IA Phase 1
Timing: January – May, 2010
Description: In Phase 1, Analysis Teams collected and evaluated data and produced comprehensive reports for seven selected areas, including energy, buildings, transportation, land and water, food, purchasing and recycling, and culture. Faculty members with relevant expertise lead the analysis teams, which were staffed by four to six students per team. Phase 1 reports were submitted by each team in the end of May and set the stage for additional analysis and more specific recommendations to be worked on in Phase 2.
Outcome: Seven Analysis Team reports
Related Link: http://www.graham.umich.edu/ia/campus-reports.php

Activity: Student Recruitment
Timing: January 2010
Description: The Graham Institute created an online application and held a project orientation meeting for 80 interested students. Faculty ultimately picked the students to staff their teams from more than 115 applications.
Outcome: A total 43 students were hired to staff the seven teams. A listing can be found in Appendix F.

Activity: Town Hall #1
Timing: January 28, 2010
Description: Over 300 people attended the first Town Hall to hear from U-M sustainability leaders and also faculty heading analysis teams about how they planned to address specific topics such as energy, land use and human behavior. Comments from students and the public were heard and recorded as part of the meeting.
Outcome: This event gave more than 300 participants an opportunity to contribute ideas and hear about the Campus IA project
Related Link: http://www.graham.umich.edu/news/article.php?nid=241

Activity: Data Request and Response Process
Timing: January – May, 2010
Description: During Phase 1, each team designated a data request lead. Requests were submitted via an online form through the project's CTools site and submissions were routed through the Graham IA database. After review, the submissions were sent to OCS who reviewed and responded to each data request.
Outcome: Data request responses to Analysis Teams

Activity: Town Hall #2
Timing: April 12, 2010
Description: Campus Sustainability IA Analysis Teams presented preliminary findings and proposed action plans for their specific project areas. After these brief reports, attendees were invited to participate in up to two different Analysis Team Breakout Sessions to learn more about the project areas, as well as to offer comments and suggestions for those projects.
Outcome: This event gave more than 150 participants an opportunity to contribute ideas and hear about the Campus IA project
Related Link: http://www.ur.umich.edu/update/archives/100414/townhall

Activity: Campus Sustainability Integrated Assessment review panel meeting
Timing: April 23, 2010
Description: This meeting was designed to be a forum where faculty leading the Analysis Teams could present their findings and get feedback from key administrative and operations staff. Each faculty and student lead had 30 minutes for direct discussion with the review panel. Other student members of the analysis teams attended and observed the review to learn about the work of other teams.
Outcome: Feedback to guide final Analysis Team Phase 1 reporting

Activity: Student survey
Timing: May 2010
Description: The Graham Institute sent a brief survey to all student members of the analysis teams following the completion of Phase 1. Individual identities were not connected to the 23 responses. The survey elicited feedback about students' expectations, compensation, skill building, contributions to the U-M Sustainability Initiative, and overall project communications.
Outcome: 23 student evaluations
Activity: Advisory Meeting with External Contacts
Timing: July 26, 2010

Description: A public forum was held to present an update for the IA, as well as hear from representatives of key corporate and academic institutions who have significant experience with sustainability efforts. The forum provided an opportunity to better understand how other institutions have addressed comparable challenges, as well as to gather feedback from participants who were invited to attend.
Outcome: Feedback from other institutions and partners
Related Link: http://sustainability.umich.edu/news/innovative-sustainability-efforts-explored-forum

Activity: Integration Phase
Timing: Summer 2010
Description: At the conclusion of Phase 1 in June 2010, each Analysis Team submitted a comprehensive report and suggested ideas for further study in Phase 2. The Integration Team reviewed the reports and conducted multiple meetings with the Analysis Teams to identify areas of intersection across recommendations. The Integration Team also received feedback from the Steering Committee and members of the U-M Sustainability Executive Council to help focus team efforts in Phase 2. Using this feedback and five, high level themes as guideposts, the Integration Team selected ideas for teams to focus on their Phase 2 analysis. This selection was based on defined evaluation criteria and articulates the synergies of Phase 1 recommendations into each of the five theme areas. The five themes and recommended foci for each team's Phase 2 efforts were described in an Interim Report, along with a short summary from each team's Phase 1 report.
Outcome: Interim Report
Related Link: http://www.graham.umich.edu/ia/campus-reports.php

PHASE 2

Activity: Student Recruitment
Timing: August 2011
Description: The Graham Institute created another online application to recruit students in Phase 2. The seven faculty leads picked students from approximately 150 applicants to staff their team. In addition to these student researchers, the Graham Institute posted a position announcement to hire one MBA for each of team to lead the Phase 2 economic analysis.
Outcome: A total of 52 students, including seven MBA students, were hired to staff analysis teams. A listing can be found in Appendix F.

Activity: IA Phase 2
Timing: September - December, 2010
Description: During Phase 2, the Analysis Teams were charged with conducting more detailed analyses that included costs and potential benefits, technical guidance, evaluation of uncertainties, and implementation timeframes for key operational activities identified in Phase 1. Their final reports included the following guidance: 1) how recommended actions align with activities of other teams, 2) how team recommendations map to higher level sustainability themes, 4) suggestions for how to prioritize actions, and 5) issues requiring further analysis.

Outcome: Phase 2 Analysis Team reports
Related Link: http://www.graham.umich.edu/ia/campus-reports.php

Activity: MBA Team meetings
Timing: September – December 2010
Description: MBA students were hired for each of the seven analysis teams. Their task was to help their team with guidance on capital costs, operating costs, and payback for potential actions. These seven students met monthly with staff from the Graham Institute to discuss how to communicate their analysis, prioritize team recommendations, and articulate MBA analysis consistently between teams.
Outcome: Economic guidance for Phase 2 team reports

Activity: Operations staff involvement
Timing: September – January 2011
Description: In Phase 2, operations staff were involved in two ways: 1) serving as regular members on analysis teams to provide information and reporting assistance; and 2) reviewing final team reports to provide comments/feedback. The comment period that followed Phase 2 gave staff from each unit a chance to voice concerns and clarify information. Comments were provided as either general feedback on the broad topic of analysis or on a specific recommendation.
Outcomes: Compiled staff comments for each team report

Activity: Town Hall #3
Timing: October 14, 2010
Description: The third Town Hall meeting was held in October 2010. This event gave the campus community an opportunity to hear findings from Phase 1 of the project, a description of activities outlined for Phase 2, and ask questions of the seven Analysis Teams, OCS, and the Graham Institute.
Outcome: 117 people participated in this event.
Related Link: http://www.graham.umich.edu/outreach/ia-meeting.php?nid=717

Activity: Combined Steering Committee and Integration Team Meeting
Timing: November 2011
Description: This meeting was a unique gathering of Steering Committee members and faculty and student leads from the Analysis Teams. The goal of the meeting was for U-M leaders to ask questions and give feedback to the Analysis Teams while also having broad discussions about the project in this diverse and large group setting.
Outcomes: Steering Committee feedback on Phase 2 team investigations and future goal setting

Activity: Data archive
Timing: February 2011
Description: Analysis Team student leads and MBAs were in charge of archiving the information and data gathered as part their team reporting. Data was archived in four categories: 1) spatial data, 2) numerical data, 3) graphical data (photos, figures), and 4) key references (reports, key documents).
Outcome: CTools project data archive

Activity: Student survey
Timing: February 2011
Description: The Graham Institute sent a brief survey to all student members of the analysis teams following the completion of Phase 2. Individual identities were not connected to the 39 responses. The survey elicited feedback about students' expectations, compensation, skill building, contributions to the U-M Sustainability Initiative, and overall project communications.
Outcome: 39 student evaluations

Activity: Action identification/prioritization
Timing: December – February 2011
Description: As part of their Phase 2 reporting, each team created a prioritization matrix to illustrate their list of potential actions within the context of an economic, environmental, and social ranking framework. Each team's matrix provided guidance to the Integration Team's goal setting process. In addition to these matrices, a "Deep Dive" of each Phase 2 Analysis Team report identified whether team ideas were in one of three categories: 1) potential actions, 2) policy considerations, or 3) proposed goals. The Integration team's assessment led to a list of potential actions based on environmental and social benefits, financial costs, and potential for making progress toward the goals.
Outcome: A list of potential actions for each theme/goal area that leads back to Phase 2 reports

Activity: Goal setting
Timing: January – April 2011
Description: After Phase 2, staff from the Graham Institute and OCS worked to articulate potential actions within a framework that includes a list of guiding principles and stretch goals. Weekly meetings were scheduled to discuss, revise, and agree upon goal statements and framework terms, which are defined as:

- *Guiding Principle* – a broad philosophy guiding long-range strategies through changing circumstances
- *2025 (Stretch) Goal* – a time-bound, quantifiable objective aligned with each guiding principle
- *Potential Actions* – an analysis-driven menu of possible options for achieving stretch goals

Outcome: Goal framework

Activity: Proposal to key members of the Steering Committee and Executive Council
Timing: May 2011
Description: The Integration Team summarized the goal framework in a proposal informed by recommendations from the Phase 2 Analysis Team reports and input from U-M operations staff. The proposal outlines four high level sustainability themes - *Climate Action, Waste Prevention, Healthy Environments, and Community Awareness.* Accompanying each theme is a guiding principle that outlines U-M's long term aspirational vision for the theme area. Below the guiding principle are proposed 2025 goals (i.e., stretch goals), which are firm targets that are time specific and quantifiable. Under each goal is a list of potential actions and scenarios that U-M could pursue to achieve the goal.
Outcome: Campus Sustainability IA Goal Recommendations Proposal

APPENDIX E. I. : Phase 2 Buildings Team Report

UNIVERSITY OF MICHIGAN
CAMPUS SUSTAINABILITY INTEGRATED ASSESSMENT

BUILDINGS ANALYSIS – PHASE II REPORT

February 25, 2011

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I. EXECUTIVE SUMMARY

During Phase II of the Integrated Assessment, the Buildings Team focused on developing a set of recommendations in response to the charge identifying three areas of highly specific investigation prioritized by the IA Steering Committee, and emerging from Phase I of the IA Process:

> *1. Develop a detailed action plan for prioritizing and implementing sustainable building practices on renovation projects costing less than $10 million, [C, H, M, E, CA].*
>
> *2. Assess the viability and develop a plan for expanding the scope of Planet Blue buildings teams to include a broader range of environmentally-responsible upgrades, [C, H, CA].*
>
> *3. Assess the viability, complexity and resource requirements associated with developing and maintaining GIS-based database for U-M's building inventory and real estate holdings to facilitate simulations and predictive capacity in design planning and evaluation activities, [C, E].*

As a means to structure this work, the Buildings Team specifically focused on the development of recommendations that aim to transform existing *practices* and *processes* on the U-M Ann Arbor campuses as opposed to the development and identification of particular projects or incremental improvements. The intention behind this approach is to foster methods for paradigm transformation within the U-M community culture towards the uptake and implementation of systemic sustainable design practices within the built environment. Some of the emerging recommendations may require changes to existing policy, some may require departmental expansion, and some will require risk in adopting new technologies and methods for planning and monitoring campus planning and growth – all seemingly radical actions. The basis for the development of these recommendations is however, far from radical. During Phase II the Buildings Team utilized most of its available time and resources developing detailed process diagrams for each of the three territories of investigation in close consultation with related departments of Architecture Engineering and Construction (AEC), Planet Blue, Facilities & Operations, and the Office of Campus Sustainability in order to develop a close understanding of staff and department interactions and existing procedures, funding models and protocols, and the degree of existing interdepartmental coordination within the highly decentralized physical holdings and structural autonomy of individual departments and units.

We anticipate that the ideas advanced in this report may be met with a range of support and resistance relative to modifying existing cultural practices, economic costs, and barriers to implementation; however, we have framed each recommendation in such a way as to facilitate departmental discussions regarding the 'principles' embodied in the recommendation as opposed to a 'quantifiable target' with the hopes that further discussion and reflection around the intentions of each recommendation would allow U-M staff to develop an independent framework for implementation, evaluation and improvement over time as opposed to setting time based targets that lie beyond the control, authority, or insight of Buildings Team.

Four key concepts structure this report's content, and can be summarized as embodied within the following projective recommendations proposed by the Buildings Team for consideration:

1. *Given the often contradictory nature between simplified economic payback models and the implementation of sustainable building initiatives, and in the context of the University's mandate as an institutional leader in sustainable practices,* ***careful consideration should be given to evaluate appropriate methods of payback analysis on a project-by project basis, including close consideration of intangibles in undertaking small projects at U-M, renovation and systems upgrades under $10 million, and within the Planet Blue Program****.*

2. *Given that AEC is responsible for the design and execution of 75% of campus-wide renovations under $10 million,* ***U-M should build upon and enhance existing in-house personnel capacities and departmental practices to meet the leading edge of professional sustainable design practice.***

3. *Given the proven success of the Planet Blue program in achieving performance goals and raising awareness around sustainable energy upgrades on campus buildings,* ***U-M should expand Planet Blue as a model for instigating additional pilot and short-term projects for environmental sustainability initiatives across the campus. In addition, the existing Planet Blue program should be expanded to include water conservation, material selection, indoor air quality mediation, and post-occupancy evaluations.***

4. ***Develop a comprehensive approach to the expansion of GIS-based tools, methods, and practices that may be utilized to pursue predictive sustainable planning, long term tracking, monitoring, and evaluation of systems, and establish a database to support applied research initiatives with respect to the built environment across the U-M Ann Arbor campuses.***

A detailed action plan follows that outlines specific prioritized sub-recommendations in parallel with an assessment of recommendation motives, impacts, costs (where their identification falls within the scope of this report) and barriers to implementation. Where possible we have classified sub recommendations in terms of short, medium and long term application, rather than identifying specific dates for completion, as we recognize that the duration and uptake of any such recommendations is contingent upon U-M Administrative processes and cultural uptake within individual departments. The Building's Team strongly encourages the university to provide special funding considerations to establish these programs when necessary, and that units work with the Office of Campus Sustainability to create long-term plans to finance their continued operation beyond this initial period of support.

II. INTRODUCTION

1.0 Phase II: An Operations Focus

During the preparation of the Buildings Team Phase I Report, a broad range of issues pertaining to the design, execution and ongoing maintenance of the built environment with respect to sustainability objectives were evaluated and indexed across 38 peer institutions. From this evaluation, a range of recommendations were developed with the intention of capturing both general targets for sustainable building that would guide institutional practices at U-M, as well as developing a framework for institution-specific goals aligned with U-M objectives. These goals emphasized not only general energy reduction, but also prioritized human health and well-being relative to building practices, the development and use of sustainable building projects as 'testbeds' to foster new opportunities for research at U-M, and the use of sustainable building projects as communication devices to enhance community awareness, generate donor interest, and publicize U-M efforts in the area of sustainable development. The recommendations were clustered around the following foci:

1. *Establish a Design Review Committee as a form of peer review to assess the quality of proposals for construction throughout the University.*
2. *Through the adoption of LEED v3.0 Silver plus 30% better than ASHRAE 90.1 energy performance as the standard for all building projects, maintain the ongoing goal of out-performing this baseline, addressing ideas for research and study outlined herein.*
3. *Develop a framework for directing building development that recognizes the unique challenges and opportunities associated with a distributed campus of diverse composition, including distinct ecological and urban contexts.*
4. *Assess and create targets for reduction of non-renewable energy for the University that correlates energy use with dynamic building occupancy. Set short term goals to be achieved by 2015, with the long term goal of carbon neutrality.*
5. *Prioritize renovations across University buildings based on need for improvement of environmental performance.*
6. *Position the University of Michigan campus as a 'living laboratory' with the goal of expanding current curricula and advancing student initiatives of research that engages the built environment.*

At the direction of the Integration Team, the Buildings Team focused on three highly specific domains of inquiry relative to the broad set of issues identified in the Phase I effort with specific areas for investigation reiterated here:

1. *Develop a detailed action plan for prioritizing and implementing sustainable building practices on renovation projects costing less than $10 million, [C, H, M, E, CA].*
2. *Assess the viability and develop a plan for expanding the scope of Planet Blue buildings teams to include a broader range of environmentally-responsible upgrades, [C, H, CA].*
3. *Assess the viability, complexity and resource requirements associated with developing and maintaining GIS-based database for U-M's building inventory and real estate holdings to facilitate simulations and predictive capacity in design planning and evaluation activities, [C, E].*

The Buildings Team recognized in the charge above an explicit mandate to focus its Phase II efforts on *in house* operational practices, as opposed to targets for overall institutional targets related to the design and construction of the built environment.

2.0 Overview of Phase II Methodology: Systems Intervention

Due to the nature of the Phase II focus, and recognizing that efforts within related divisions of U-M's operations have been focused on measures to improve energy performance across buildings' holdings for several decades, the Buildings Team's work began with a detailed evaluation of existing practices at U-M and processes within related departments: Architecture Engineering and Construction (AEC), Planet Blue, Facilities & Operations, and the Office of Campus Sustainability. The intention of this approach was to understand working methods, decision making frameworks, implementation practices, and performance evaluation methods, with the goal of trying to ensure that recommendations generated by the Team would relate directly to existing practices at U-M, and that the potential for their consideration and implementation would be maximized. Where the proposed recommendations contained in this report propose to alter or enhance existing staff practices, they are made with the recognition that significant efforts to advance sustainable building practices within staff operations are already mandated, some of which have been recently implemented, and others with are currently being developed.

In order to better understand the various conditions described above, the Buildings Team began by mapping the processes relevant to each recomendation in order to identify the systemic context within which our work was to operate. (See Appendices B, C, & D) Close discussions with staff conducted across a series of meetings facilitated by OCS were required in order to properly understand the relations between specific operational tools and prototcols (ie: the FCA database and Capital Project Initiation) relative to funding mechanisms for renovation work on campus (General Fund, Unit funding, deferred maintenance funding, Planet Blue funding). Members of the Buildings Team accompanied Planet Blue personnel to multiple meetings an visits to the sites of ongoing projects in various stages of completion in order to facilitate a deep understanding of the specific practices and context of the Planet Blue implementation program across its various phases.

Following the principles outlined by Donella H. Meadows in her seminal text "Places to Intervene in a System",[1] we have prioritized recommendations that in the estimation of the Buildings Team, are most likely to foster long term systemic impacts and aim to shift institutional paradigms. Further, we have taken the position that, given U-M's role as a public university and research center, the amplification of existing departmental and staff talent would be a focused priority for our recommendations. During the discussions with staff, it is accurate to state that the ideas and suggestions to achieve improved performance with respect to the implementation of sustainable design measures in small buildings and renovation projects were met with positive response. However, we consistently heard that while the various proposals were of interest and would have impact, they would also unfavorably extend project timelines and overburden existing staff capacity. We were also reminded on several occasions of the vast diversity of project types that fall within the purview of "Renovations Under $10 Million", which could include the replacement of a single boiler component at one scale, or extend to a small building addition with a complex set of envelope, mechanical, electrical and daylighting considerations an another. Since a structure already exists to evaluate the appropriateness and potential for impact embodied in an individual project prior to determining the means to best approach the project, the construction of a highly flexible framework for ongoing operations will have the greatest relevance for identifying and implementing sustainable solutions.

Consistent with the reporting framework developed by the Integration Team, we have used the short-form formats of **[C, E, M, H, CA]** to identify throughout the document, the five key sustainability theme areas: *Climate; Human Health; Ecosystem Health; Materials Footprint; and Community Awareness* identified by the Integration Team to guide Phase II work and its alignment with U-M priorities.

3.0 Overarching Phase II Observations

3.0.1 Payback

Throughout the Phase II Process, the Buildings Team met and discussed potential improvements, metrics, standards and processes with staff members responsible for implementing sustainable building design measures at U-M. During these conversations, a consistent two-part message was expressed with respect to impediments to advancing sustainable practices. The first part consistently pointed to the extended timelines associated with such practices. Whether it was a discussion regarding the protocols of evaluation systems such as LEED, the additional demands of commissioning practices for buildings, time requirements for detailed energy modeling or financial evaluation, or the research time required to source appropriate products and coordinate systems for a specific design, cost related to additional staff time and client demand for fast project turnaround was continually identified as an impediment. The second impediment most commonly cited was the financial instrument most often utilized to evaluate the value of a systems upgrade when assessing sustainable design options: Payback Period. The utilization of payback is based upon the financial assumption that any given sustainability measure would produce measureable reductions in operating costs (most typically associated with energy use reduction, and the current costs of energy), wherein the payback period represents the time for the capital outlay to match resulting savings. This impediment is widely recognized as a barrier to institutional ability to incorporate sustainable design measures into campus design:

> "*many campus sustainability directors are frustrated by what they regard as a double standard in campus budgeting: A climate-mitigation project, such as energy-efficient building design, is subject to strict payback requirements. That is, in a certain period of time, it must pay back capital costs with savings it achieves in operations costs. But other projects competing for budget money are considered with no reference to payback.*"[2]

During the Buildings Team's close investigation into the territory of small capital practices at both AEC and Planet Blue, the issue of payback was identified as a significant limiting factor in defining which projects would be undertaken and which would not. Further, it was observed that a strict "simple payback model" with an eight (8) year period is currently utilized for most products on renovation projects (this excludes fenestration which has a maximum payback of 10 years, membrane roof insulation at 12 years, and all other insulation with a maximum payback of 30 years). As a result of this observation, we have developed two recommendations described in *Section III. A. Capital Project Approval Guidelines for Small Construction Projects* to evaluate this practice, and recommend more nuanced methods for calculating payback based on net present value and the use of expected value, a tool that allows for the consideration of intangible benefits in financial calculations.

3.0.2 Architecture, Engineering and Construction (AEC)

U-M's Architecture, Engineering and Construction department plans and manages the design and construction of new facilities, additions, renovations, utilities, and infrastructure improvements. By managing the design and construction of campus projects, AEC assures that all projects will be constructed in accordance with University and State of Michigan criteria for quality design including economics of construction and operation.[3] This in-house design, construction and management department with over 200 staff members plays a critical role in the development and execution of all construction projects on campus and is composed of highly trained and skilled staff members. Given the Building Team's charge to evaluate recommendations pertaining to the design and implementation of sustainable projects under $10 million, in house staff methods and practices are of specific interest. Whereas larger projects (over $10 million) now are to be undertaken to meet the standards for LEED Silver +30, metrics assigned to small projects are less demanding, focusing primarily on compliance with energy code through existing energy conservation measures. Further, a large percentage of small projects are designed and executed by AEC staff without the use of outside consultants. Last, the size and capacity embodied within AEC is an anomaly amongst peer institutions, many of whom have streamlined their internal design and construction departments opting to outsource the bulk of work to private consultants. The Building's Team sees this situation as a unique opportunity to support the efforts stated in AEC's Sustainability Master Plan and to forward U-M's goal of being *Leaders and the Best*. Given the control over project methods, processes and execution that is possible as through AEC's position, we have developed a series of recommendations to capitalize upon the potential of AEC as a leader in sustainable building design practice as outlined in *Section III.B. Building Renovations Under $10 Million.*

3.0.3 Planet Blue

The Buildings Team understands that the motto "Planet Blue" is currently being used for the larger sustainability work at UM. For the purposes of this report, "Planet Blue" will specifically refer to the Planet Blue energy conservation initiative, part of the Environmental and Energy Initiative (EEI), an outcome of the President's Environmental Task Force which was started in 2003. The "Leading Up to Planet Blue" timeline compiled by the Buildings Team helps to illustrate the context from which we understand Planet Blue was created (see Exhibit C.2.4.i in Appendix C). Historically, the University's approach to energy management in existing buildings has been ahead of the work of most of the peer institutions reviewed as part of the Phase I work. In their 2010 "Kill-A-Watt Leadership Program Report," the University of California-Berkeley supports this position:

> *"Of the external peer institutions reviewed, University of Michigan's environmental and energy initiative — Planet Blue — stood out as one of the most successful campus-wide energy reduction initiatives with a focus on changing occupant-controlled behavior. Our external case study team analyzed web content and interviewed U-M personnel to understand the development of the Planet Blue initiative, the process followed by the Planet Blue teams, and the initiative's successes."* [4]

Currently, nineteen out of twenty-five peer institutions researched have instated aggressive programs in the last ten years to update lighting, plumbing, and HVAC systems and have tracked significant financial savings tied to these improvements. Three of these institutions have adopted LEED standards for Existing Buildings, Operations, and Maintenance (EBOM) as a way to track their improvements and insure continued performance.[5]

> *"Planet Blue Operations Team is a campus-wide educational and outreach campaign with a mission to: Actively engage the University of Michigan community to conserve utilities and increase recycling thereby saving money and benefiting the environment.*[6]

Given that the University of Michigan has served to be a role model for implementing successful Energy Conservation Measures, the Buildings Team believes that U-M has the opportunity to continue to set a high standard of excellence for environmentally responsible initiatives of a much larger scope through the expansion of the Planet Blue program, and adoption of its operational model as a means to execute a wider range of projects on campus. Detailed recommendations are outlined in *Section III.C. Planet Blue Programs and Practices.*

3.0.4 GIS Systems Integration at U-M

As the University of Michigan strives to reduce environmental impact and improve the overall health and quality of its buildings and campus, accurate monitoring of existing systems as well as detailed analysis of environmental impact for informed decision making will be critical to understanding and improving the sustainability performance of the campus as a whole. Developing and maintaining a highly detailed Geographic Information System (GIS) of the Ann Arbor campus could be an extremely valuable tool for both performance tracking and projective modeling. A geographic information system "integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information."[7] GIS provides the capacity to tie large amounts of information to physical locations, representing multiple attributes of a building or object as they change over time. These attributes can then be analyzed in various combinations to understand causes and effects, which permits better-informed decision making.

GIS systems have a high capacity for storing and organizing large amounts of data in a clear and logical format. These systems are ideal for documenting and understanding layered and complex networks such as buildings and infrastructure. The University of Michigan already documents a broad range of information related to buildings and infrastructure. Spatializing this information would increase its legibility and usability, and could render visible certain conditions and opportunities for improvement that were not clear before. While linking all of the existing data resources and standardizing on-going data input will require an initial investment of time and finances, existing methods within AEC and Facilities and Operations can be modified to reduce initial work load. The existing Space Survey already has a clear and well established data structure that would make a very strong foundation for a campus building model. Upgrading the new building documentation requirements from two-dimensional CAD plans to complete three-dimensional Building Information Models (BIM) will allow for the rapid integration of new construction projects into the overall campus model. The Medical School has already demonstrated the value of a GIS platform as a planning and coordination tool; the University at large has the opportunity to test the software's capabilities for reducing the campus's climate impact and material footprint. Detailed GIS-related recommendations are outlined in *Section III.D. GIS Systems Integration and Analysis in Planning and Monitoring at U-M.*

A. CAPITAL PROJECT APPROVAL GUIDELINES FOR SMALL CONSTRUCTION PROJECTS

A.1.0 Considering Net Present Value [C, E, M]

A.1.1 *Consider the use of Net Present Value Modeling for Approval of Building Renovations under $10 Million and Planet Blue Energy Conservation Measures*

A.1.1.1 Recommendation and Background

The Net Present Value (NPV) of a project is the sum of its future cash flows or expense savings, less its initial cash outflow - discounted to reflect the time value of money. Because organizations are capital constrained, capital today is worth more than its equivalent in the future. Cash flows or expense savings in the future are worth less than their equivalent cash flows today. Organizations face trade-offs between their capital investment decisions. Capital invested in one project may forego the availability of capital funds for others. Rational capital budgeting decisions should then consider the foregone investment opportunity of one project *over* the other opportunities available. The *cost of capital* for investment decisions therefore takes into consideration the rate of return available to an organization on alternative projects, the current and expected inflation rate, and the risk premium on the given project. An NPV analysis for capital projects forecasts the future cash flows and discounts them at the assumed *cost of capital*. The sum of these discounted future cash flows, less the original investment is the project's NPV, or the project's value in real terms. NPV best approximates the real return on investment for capital projects by providing a more thorough sensitivity analysis than undiscounted models such as simple payback.

*Net Present Value (in dollars) = S(CF**[1]**t1, CFt2, CFt3… CFtn) – Investmentt0*

Simple Payback Period (in years) = Investmentt0 /(Net Annual Savingst1:n)

A.1.1.2 University of Michigan Current Practices and Cultures

In accordance with the University of Michigan *Special Instructions to Designers* (SID) Document, renovation projects and energy conservation measures are evaluated using the *simple payback criteria* – typically benchmarked to a maximum expected payback period of eight years for systems with an expected life span of 20 years or more. Units seeking approval for a project proposal must estimate the expected initial investment and the expected annual cost savings (less any expected incremental maintenance costs). Projects that pay back within the eight-year project time frame will be approved, contingent on current period budgetary limitations. The Planet Blue program operates under the same metric of an eight year payback when determining which Energy Conservation Measures to deploy when they are evaluating a building. This prescription recognizes that certain projects may exist with "longer than the maximum payback period, in order to exceed ASHRAE 90.1 by 30%" or other University design guidelines.[8]

Staff members within AEC and Planet Blue seek out and approve projects that meet the University's eight-year simple payback criteria. Units submit project proposals detailing the expected initial capital cost and expected annual savings of the project to calculate the simple payback in years. Proposals articulate future cost savings based on current energy and labor prices. Volatility of future University energy rates, utilization changes, and other factors that may affect the expected cash flow in future periods are not considered in this model. The simple payback period model provides decision makers within the University an excellent base case to discuss project proposals. However, the simple payback offers little information for decision makers with which to *value and evaluate, rank,* or *perform sensitivity analyses* on those projects. Interviews with AEC and Planet Blue personnel provided insight into their recognition of the inherent limitations, but also benefits of the current practice.

A.1.1.3 Peer Institutions and References

The Buildings Team recommends that AEC and Planet Blue staff employ Net Present Value analysis to evaluate and approve both Renovations under $10 Million and the Energy Conservation Measures that are the foundation of Planet Blue's building improvement work. While the team recommends this policy for units at the University of Michigan independently, peer institution capital budgeting policies also substantiate this fundamental policy change recommendation. The Buildings Team encountered marked variability in peer institution capital budgeting approval policies and standards. Additionally, the Team noted that many institutions are reevaluating their current practices because of the fundamental limitations of simple payback to evaluate and approve sustainability projects.

Accelerating Campus Climate Initiatives, a publication by the Rocky Mountain Institution, outlines barriers Universities and other organizations face as they attempt to develop sustainability programs and initiatives.[2] The authors find that "many campus sustainability directors are frustrated by what they regard as a double standard in campus budgeting: A climate-mitigation project, such as energy-efficient building design, is subject to strict payback requirements. That is, in a certain period of time, it must pay back capital costs with savings it achieves in operations costs. But other projects competing for budget money are considered with no reference to payback".[9] The publication discusses in great depth the advantages and disadvantages of the various capital project approval guidelines, several of which will be discussed later in this document. Recognition that payback is often a significant barrier in relation to sustainability capital projects prompted the investigation into current and future peer institution policies, a few case examples of which have been outlined below.

Harvard University's sustainability initiative is a $12 Million endowment that seeks to undergo projects to reduce the institution's current environmental footprint and generally increase the overall sustainability of the campus. Capital projects that meet a 9% or higher Internal Rate of Return (IRR) are approved. The IRR is the discount rate at which the Net Present Value of the project is $0. Therefore, projects that generate positive time valued cash flows at an assumed cost of capital of 9% or higher will all be approved. While the payback in years is also important for capital project approval, ultimately the discounted payback determines approval. Harvard University also considers each project's Return on Investment (ROI); the current median ROI for sustainability initiatives is 27%.[10]

Northwestern University is developing a payback model that incorporates the 'interactivity with other measures' into the valuation process. No information was available to ascertain whether the University had adopted a more sophisticated or time discounted payback policy, but their recognition of the limitations of simple payback on sustainability-based initiatives lends support to the recommendation for a reevaluation of the policy at the University of Michigan.[11]

Stanford University also recognizes the limitations of undiscounted payback models and utilizes "life cycle cost analysis rather than simple payback to evaluate design decisions in building what is envisioned to be a 100-year facility."[12] Life cycle costing considers the whole cost of project over its entire anticipated useful life. Stanford University maintains a detailed handbook – *Guidelines for Life Cycle Cost Analysis*- for its land and buildings capital project initiatives. Their model uses strict present value analysis to calculate payback, with detailed analysis of the yearly change in savings and expenses.[13]

While highlights of peer institution policies should in no way be indicative of best practices or provide the sole rationale for the AEC and Planet Blue at the University of Michigan to modify their current design policies, these cases should provide support for the recognition of the limitations of simple payback models on sustainability based initiatives.

A.1.1.4 Benefits and Costs

The fundamental benefit of NPV over simple payback is the sophistication and detailed presentation of the expected costs and benefits of a given project. Simple payback models utilize the initial cost of the project, netted against the future cost savings that will be generated in nominal terms. NPV performs that same fundamental analysis, but with consideration given to the fact that those future cost savings are worth fewer dollars in real terms today. Capital outlaid today could have been utilized on a different project – perhaps with a higher net return in real dollars. Similarly, capital projects foregone leave an opportunity for those funds to be invested at the organization's average return rate. The 10 year annualized return on investment at the University of Michigan is approximately 9%, even considering the impacts of the financial crisis during 2008 and 2009.[14] Finally, at the most basic level, cash flows in the future are worth strictly less in real terms because of the effect of inflation.

Net Present Value also considers the variability in cash flows over the expected life of a project. Like life cycle costing, consideration should be given to future changes in utility rates, relevant expected changes in maintenance costs, and any other expected cash flows foreseeable over the life of the proposed project. Simple payback fails to consider these variances. Accordingly, the limitations on the assumptions of activities, costs, and savings in the future deem the method inappropriate for evaluating projects which are inherently based on a high initial investment and gradual payback over their expected useful lives. Although sustainability initiatives and projects today predominantly require a larger initial cash outlay, they do generate significant cash savings over their useful lives. Requiring projects to pay back in nominal terms in eight years is a reasonable initial check for the potential benefits of a project, but the policy provides no means with which to determine the overall return of that project, rank that project against other proposals, or to produce a sensitivity analysis on the assumptions of that project to most effectively make that investment decision.

For a case study that demonstrates the functional differences between simple payback modeling and NPV, please refer to "Case Study 1" in the Buildings Team's Appendix A that includes an analysis of three sample ECM's provided by Planet Blue and the ECC.

Sustainability initiatives and other capital projects often have large initial capital investments, but longer expected useful lives that generate real cash savings over that period. The University of Michigan AEC Department and Planet Blue should utilize Net Present Value and sensitivity analysis to evaluate the real costs and benefits of a project proposal under various assumptions of useful life, costs of capital, expected energy costs, and yearly variances in required maintenance of a particular proposal in order to best evaluate, approve, and rank (when applicable) renovation projects under $10 Million as well as Energy Conservation Measures.

A.1.1.5 Barriers and Uncertainties

The Buildings Team recognizes that certain barriers and uncertainties may encumber a transition between policies. Incorporation of uncertainties in modeling assumptions is a significant practical and cultural barrier to enacting such a policy. Individual units may be subject to different assumed costs of capital (variances in investment opportunity costs), and the expected increase in energy costs across the University is difficult to accurately predict in all cases. Incorporating such uncertainties into this model then presents a logistical problem of determining which departments are charged with generating and disbursing such assumptions. Such a process could be time consuming, expensive, and inherently bureaucratic. Further, such a process change could provoke cultural resistance from units that submit project proposals.

A.2.0 Expected Value [H, CA, L]

A.2.1 Where appropriate, (AEC) and Planet Blue staff should consider intangible factors into Payback Modeling for building renovations under $10 Million and certain Energy Conservation Measures.

A.2.1.1 The Expected Value of Intangible Costs and Benefits

The qualitative rationale for sustainability includes economic, environmental, and energy measures capable of broadly agreed-upon measurement. While Net Present Value analysis predicts economic sustainability in the form of cash savings from sustainability initiatives, many of the inherent benefits of sustainability derive from certain intangible goals of the implementing institution. In particular, the University of Michigan recognizes the broad magnitude of the true benefits of sustainable initiatives and operations. Yet in many cases assigning a true monetary value to those benefits is difficult because the improvement in welfare cannot be readily viewed on a regular account statement such as an energy or water bill. That does not however imply that those intangible benefits do not return value to the University.

Environmental economics and sustainability center on the effectiveness by which an institution may most effectively build a case around its project initiatives while giving consideration to all the costs and benefits of that particular project – those easily quantified and those which are more closely hidden. Sustainability initiatives that seek broad, triple bottom-line, and synergistic effects across units or divisions, must consider all of the potential values and costs within that *system* to adequately assess the potential *impact* of that project.

Total Economic Value = Direct-Use Value + Indirect-Use Value + Non-Use Value + Intrinsic Value [15]

The *Direct-Use Value* of a project is the sum of the values of the goods or services provided directly to the user. This is the most readily quantifiable factor in a project, often measured by the direct cost of supplying that project, or the user's willingness to pay.

The Indirect-Use Value of a project is the benefit derived external to the intended use of a project, often the benefits associated with an entity's perception of the value to other systems. This factor captures many of the synergistic effects of a particular change or process across other elements within the system.

The *Non-Use Value* considers many of the softer, qualitative values of a given initiative. Such values may include cultural or reputational benefits which cannot immediately be assigned a direct or indirect-use value.

The *intrinsic value* is any residual value not captured in the other three categories. Intrinsic value implies that projects or initiatives (and their impacts) have value subsequent even to the value applied to them by their users. This measure will not be used in this model.

Examples of the *Direct*, *Indirect*, and *Non-Use value* of particular sustainability initiatives will be highlighted throughout this section. Valuation of these factors may be completed through many different methods. The Buildings Team recommends that, where applicable, project proposals incorporate the *Expected Value* of the direct, indirect, and non-use values of all quantitative and qualitative factors that may apply to any given initiative.

*Expected Value = (Incremental Benefit – Incremental Cost) * Probability Factor* [16]

A.2.1.2 University of Michigan Current Practices and Cultures

Consistent with the President Coleman's sustainability initiatives at the University, the Business and Finance Departments' 2011 stated goals emphasize the importance of sustainability at this institution. The Strategic Framework cites 'innovation, collaboration, health, safety, and the environment' as the core driving values for FY 2011 under a stated goal of 'Best in Class Leadership.' The framework outlines several distinct goals including wellness, environmental sustainability, and capital project implementation as critical initiatives for pursuing this strategic course.[17] In pursuing these objectives, consideration of the broad, systems impacts of certain behaviors is critical.

The Buildings Team's recommendation for the incorporation of intangible costs and benefits into the decision making process for renovation and ECM project proposals does not materially change current University of Michigan staff practices and cultures. The incorporation of expected value of intangible costs and benefits for certain applicable projects is a procedural recommendation which will more accurately quantify in numeric terms current staff decision making behaviors, and include these factors in decision making structures.

Individuals charged with decision making within the AEC and Planet Blue consider the broad economic, environmental, and social impacts of project proposals during the evaluation process. In fact, the University is currently developing a sustainability checklist to benchmark projects and ensure that decision makers take advantage of all opportunities for sustainability. Further, "[the AEC] is currently developing a methodology to allow the evaluation of intangible benefits in a systematic manner."[18] Finally, certain University protocols such as the *Special Instructions to Designers (SID)* document and the University's *Capital Project Guidelines* emphasize the importance of considering the total impact of a project. Submitted project proposals must contain a statement of purpose that outline not only the quantitative costs and savings of the project, but also certain qualitative rationalizations for approval.

While current staff practices emphasize the importance of considering intangible costs and benefits into the evaluative process, decision makers are for the most part limited by the strict eight-year payback requirement for capital projects and ECMs. The eight-year payback does not incorporate any factors beyond cost into its model. Thus, under the current policy, AEC and Planet Blue projects that would fail to pay back in nominal terms within eight years will typically be declined, even if they have other qualitative impacts beyond the scope of simple economic value. Though a project may have vast synergistic effects and intangible benefits to the Michigan community, simple payback could delay its implementation until the annual cash savings increase enough to warrant approval.

A.2.1.3 Benefits and Costs

Most sustainability capital projects have significant incremental upfront costs, but return true benefits over their useful life. These benefits include the readily quantified direct use values, but also those indirect and non-use benefits associated with sustainable construction practices. By assigning an expected value to those intangible costs and benefits at the presumed probability of occurrence, decision makers may assign an expected dollar value to a project. Such a valuation can provide a meaningful framework to base discussion during the evaluation process.

In relation to renovations and ECMs, the Buildings Team identified several intangible benefits of sustainable building practices for users. Sustainable building practices may employ construction practices that improve "indoor environmental quality, improved occupant controllability of systems, greater connectivity between indoor and outdoor environments, and increased availability of natural day lighting and ventilation".[18] Improvements upon these metrics may or may not generate real cash savings over the project's useful life. While these renovation projects therefore may not be able to pay back in cash terms, the intangible benefits associated with these sustainable construction practices provide real qualitative benefits to users.

The Buildings Team identified and investigated three unique intangible factors that contribute to overall community well being. In particular, sustainable construction practices will have real impacts on student and faculty health, student and faculty productivity and satisfaction, and talent attraction and retention. Within the Integrated Assessment reporting framework, sustainable construction has material effects on *Climate*, *Ecosystem Health,* and *Material Footprint*. Incorporation of the intangible factors into the evaluative process allows for consideration of *Human Health*, *Community Awareness*, and *Learning/Research Opportunities* intangible benefits into the valuation model.

In order to best illustrate the economic benefits of utilizing expected value calculations for decision-making, the Buildings Team performed an economic analysis of certain sustainability projects. Please refer to Appendix A for a thorough example of the economic benefit calculations that consider variables such as *Reduced Absenteeism*, *Staff Productivity*, and *Development* as indirect-use values, and the variables *Community Public Health*, *Satisfaction*, and *Talent Recruitment and Retention* as non-use values.

A.2.1.4 Barriers and Uncertainties

While there is no strict barrier prohibiting the utilization of the expected value model to quantify intangible benefits of green construction projects, the true barrier is a disinclination to incorporate uncertain and difficult to measure aspects into any financial calculation. The variables discussed in the case study were constructed by the Buildings Team and have no implications on the true University environment. Decision makers within the University will be reluctant to incorporate these values into their evaluative procedures for that very reason. Determining the correct input assumptions and therefore, output values for the model is near impossible (else it would already be done in practice).

Yet, the inclusion of these metrics enables a rough quantification of true impact. While decisions already focus on the qualified benefits of these attributes, assigning a numeric value to each allows the project under consideration to be more intensely scrutinized or ranked, beyond the potentially limiting criteria of strict financial payback. Because payback is often prohibitive for sustainability initiatives due to significant upfront costs, valuation of intangible impacts allows more projects consideration. This model in no way asserts that a project should be approved if it does not meet the payback threshold. Rather, it asserts that a thorough, quantitative analysis of the other, intangible project benefits provides a more meaningful set of criteria with which to best base investment decisions. The Buildings Team believes that, where applicable, renovations under $10M and certain Energy Conservation Measures should utilize expected value modeling to incorporate intangible benefits into the decision making process.

A.3.0 Summary of Capital Project Approval Guideline Recommendations

Given that the economic rationalization for sustainability is often the most significant barrier to successful implementation of sustainability initiatives within an organization, all substantive recommendations must be rationalized within the framework of a complete reexamination of the concept of 'value.' As such, careful consideration must be given to the appropriate method for payback analysis (and the applicable parameters) on a project-by-project basis. While payback in nominal terms provides an excellent base case for certain objectives, in many cases, the benefits associated with those objectives exist far beyond the required cash payback period, and outside the scope of what is readily quantifiable. The recommendations that follow rationalize the importance of sustainability within the framework of NPV and expected value.

B. BUILDING RENOVATIONS UNDER $10 MILLION

B.1 University of Michigan AEC Development and Expansion [C, E, M, H, CA]

B.1.1 The office of Architecture, Engineering and Construction (AEC) at the University of Michigan should take steps toward becoming the leading university building services office with regards to sustainable practices among the University's peer institutions, and become a sustainable design leader among architecture and engineering firms nation-wide. This goal can be achieved in part through strategic expansion of in-house staff, skills development and training specific to capital renovation projects under $10M.

Specific recommendations for AEC staff expansion and training:
1. Develop *in-house capacity* in order to create comprehensive energy models for appropriate small renovation projects with an end goal of implementing ASHRAE + 30% as a baseline metric where appropriate.
2. Expand in-house commissioning practices to include design-phase commissioning for appropriate small renovation projects. SID-G currently only mandates construction-phase commission for small capital projects.[8]
3. Develop in-house capacity to conduct thermal scanning on applicable small renovation projects during both design and construction phases in order to provide valuable feedback to designers and engineers for evaluating scope of a new renovation project and the effectiveness of execution.
4. Provide annual training sessions to update all relevant AEC staff with the latest sustainable building technologies and practices *specific* to small renovation projects so that all staff involved in the design and execution of small renovation projects will remain industry leaders in sustainable construction practices. This training would be considered comprehensively within AEC, and evaluated on an annual basis to ensure ongoing escalation of specific sustainable design and construction skills across staff compliment.

B.1.1.1 <u>Recommendation and Background</u>

For large capital projects, an outside architecture firm is typically hired as the prime consultant, with additional sub-consultants to undertake design and administration of the work as required.[19] Unlike large capital projects, the AEC provides in-house professional design services for approximately 75% of small renovation projects under $10M total construction cost. Exhibit B.1.1.i in Appendix B is a process diagram mapping the Buildings Team's understanding of the current practices and workflows within AEC for such projects. Therefore, the AEC has significantly more control over small renovation projects, and the quality of projects and implementation of sustainable design measures is directly tied to the capacities of AEC staff. The Buildings Team sees this situation as an asset in facilitating the improvement of performance and associated transformation of related policies regarding the sustainable practices applied to renovation projects. While the Buildings Team recognizes that goals of sustainability are integral to current AEC practices as well as the development of future practice, demonstrated by the on-going development of the *Sustainability Master Plan*, further improvement in the training of existing staff in addition to strategic expansion of in-house capacity through new hires where appropriate, will provide significant and direct impact on the sustainability of small renovation projects.

According the *Special Instructions to Designers Section D* (SID-D), the sustainability requirements specific to renovation projects between $2M and $10M construction are limited in scope.[8] Limitations in available AEC staff capacity often preclude implementation of more stringent sustainable practices on small capital projects. Clients are generally unwilling to take on the additional costs and longer time frames for implementing robust sustainability measures for these small projects. For example, achieving an energy performance goal of ASHRAE +30% requires significant staff and/or consultation resources to create the necessary energy models, and under current practice, it would seldom be cost-effective to implement on renovation projects under $10M. By expanding appropriate staffing and training within AEC, a long term strategy could be implemented that makes it feasible to draw from expanded in-house capacity to implement additional sustainability measures for small capital projects. Given that the majority of the design services for small capital projects are already handled in-house, expansion of in-house personnel could make such a recommendation more feasible. Additionally, expansion of in-house capacity would also reduce the AEC's dependence on outside consultants to implement sustainability or performance measures, thus effectively reducing costs associated with implementing sustainability measures and streamlining the associated processes over the long term.

The Buildings Team is not recommending that a LEED standard be adopted for all capital renovation projects under $10M. While there exists precedent for taking such action at the institutional level, (for example, the New York City Local Law 86 requires that all city government capital projects over $2M construction costs achieve LEED Silver or higher)[20] the Buildings Team instead suggests that augmenting AEC may provide a more material impact on the sustainable design performance of smaller projects rather than adopting a static set of guidelines to follow. The blanket categorization of small projects includes a diverse set of project types and scope, ranging from fairly comprehensive renovation projects, to the replacement of a single building system component, to extremely small renovation works of a very limited scale. As such, it will be important to give careful and individual project consideration when determining the appropriate scope of sustainable design measures based on the particular characteristics of an individual project. While LEED checklists for renovation projects should certainly be consulted, a larger, sustainability-minded staff within the AEC would generate sustainable practices that best fit unique conditions at the University and thus create a bigger impact on campus than adopting a LEED standard. The Buildings Team recognizes that the AEC values flexibility in their approach to implementing sustainability measures for renovations under $10M construction costs.

The Buildings Team recognizes that adopting measures 1-3 would significantly lengthen the design process for projects that are typically expected to be fast-tracked. As a result, the Buildings Team recommends that these measures only be adopted for projects that have at least a $2M construction cost and a multisystem complexity, matching the threshold set in the NYC Local Law 86. Achieving ASHRAE +30% energy performance is known to be significantly difficult for most renovations. However, where projects involve renovation of whole building systems or the addition of new spaces, working towards these energy goals should be considered.

Furthermore, the team recognizes that such sustainability measures may not be appropriate for all capital renovation projects between $2M and $10M, and thus believes that though these measures should be considered mandates, dispensation for certain project specific exemptions at the discretion of the AEC and client unit should be considered.

B.1.1.2 Benefits and Costs

The Buildings Team strongly believes that enhancing the AEC Office's core-competencies in energy modeling, commissioning, and thermal scanning practices will have a meaningful impact on the sustainability of capital renovation projects under $10M and, over the long term, will achieve significant reductions in greenhouse gas emissions and create observable improvements in the health and well -being of University stakeholders. SID guidelines regarding sustainability measures for small capital projects can be reevaluated in a cost-effective manner with the new model of project design and delivery. With expanded capacity and resources, ASHRAE +30% may be implemented as the baseline standard for small capital renovation projects with appropriate scope of work, a measure that will effectively and feasibly reduce greenhouse gas emissions for small renovation projects through overall impact and application of enhanced building performance measures. The University of Michigan already recognizes the success of this baseline metric in reducing energy demand and greenhouse gas emissions as it is required for capital project over $10M. By increasing in-house staff capacity, fewer consultants would be hired across various project types, providing a more long-term cost saving measure and contributing to the financial feasibility of implementing more robust sustainability measures for small capital projects. Additionally, approaching sustainability goals through increased staff and training has non-cost-based social and community benefits. Initiating a hiring cycle in the AEC of the University of Michigan will assist an industry struggling significantly at the local, state, and national levels. Additional training would provide AEC staff with a broader range of skills with which to build a more successful and broader professional career. Existing company support for individual professional development could prioritize training focused on sustainable technologies. Finally, an improved AEC will certainly result in improved design of small renovation projects, thus enhancing the overall campus life and well-being.

The Buildings Team believes that the AEC at the U-M has the potential to become a cutting edge entity both across peer institutions and within the architecture industry through the expansion of in house capacity and an augmented emphasis on sustainable building practices. These green construction practices for small capital projects directly affect the overall quality of our climate, ecosystem health, human health, material quality and re-usability, but such practices also have indirect implications on community awareness and the educational community.

The development of the AEC as a leading architectural operation may have material implications on the University's financial performance through the value of such an initiative in terms of external perception of U-M's commitment to sustainable agendas. The measurement of impact of such a publically visible and legible initiative is of course difficult to quantify, and returns us to the issues discussed in *SECTION A.2.4* around the expected value of intangible factors into the cost/benefit analysis for the payback of this particular recommendation. Benefits of augmenting current capacity and training may also have direct implications on the University's ability to attract and retain high caliber individuals who might otherwise seek out employment opportunities in the private sector. There is a quantifiable benefit associated with the value of employing the 'Leaders and Best,' as opposed to hiring experts for specific projects. Further, retaining institutional knowledge and creative abrasion will contribute positively to project proposals and decision making in the future. Additionally, maintaining a highly specialized AEC within the U-M could increase sustainability-focused donations to academic units. While large capital projects may seek private funding, private donors are currently unlikely to directly fund small renovations. However, donors increasingly value an emphasis on individual departments' commitment to sustainability, and ensuring that even small projects emphasize sustainable building criteria could have quantifiable impacts on the ability of the units to campaign for capital.

As discussed in *SECTIONA.2.4* the inclusion of all of these factors is subjective and difficult to quantify. Nonetheless, employing expected value criteria, it is possible to articulate an estimated financial benefit to the University outside of strict cash saved. As the Buildings Team recommends that training and hiring be done in phases, it will be possible to observe incremental changes on these metrics, and undertake a short term pilot program the results of which could be evaluated prior to making any larger commitment to consider staff expansion. An initial pilot program might work within AEC's existing or slightly augmented Professional Development budget with existing staff. University decision makers may analyze academic unit specific gifts on an annual basis, changes in staff applications, hiring, and turnover, and other key performance metrics. This recommendation is a long term strategic recommendation that must be consistently evaluated in order to best align with the University's sustainable vision.

The Buildings Team constructed a hypothetical case study quantifying the potential costs and benefits associated with employing in-house capacity within the AEC instead of external consultants. In the Couzens Hall renovation project, thermal Scanning inspection costs were $50/hour. Thermal scanning was conducted 8 hours a week for 26 weeks costing $10,400 and produced a yearly energy cost savings of $2,238 with a payback of 4.6 years.[21] If the AEC trained in-house staff-person earning $45,000 a year to conduct thermal scanning and invest in the equipment, the process would approximately cost $30/ hour ($20 an hour direct labor x 1.5 to include overhead). We utilize the same number of direct labor hours for the in-house staff member for ease of comparison, though billable hours would likely be lower as compared to the external consultant who would include hours for administrative and travel expenses. For the same project, the total cost would be reduced to $6,240, thus lowering the payback period to 2.8 years. This case supports the argument for the AEC to adopt fixed costs through new hires over using outside consults if it were adopted across multiple projects and project types. This model has not quantified the intangible benefits of goodwill to the University and institutional knowledge through maintaining staff members.

B.1.1.3 Barriers and Uncertainties

While the Buildings Team recommends the expansion of AEC, it does recognize certain barriers and uncertainties to such an expansion. First, the AEC has limited resources from which to draw funds to hire new staff and provide additional training to existing staff. Second, additional commissioning and energy modeling implies longer turnaround times for project delivery. Clients of the small capital renovations project usually expect timely project delivery given the scale of these smaller projects. Expanded energy modeling and commissioning practices would add both time and costs to be incurred by the client for these projects. Most likely, there is not a willingness among all academic units to adopt sustainability measures in which they must absorb some of the added costs and lengthened project delivery. Further, for process and personnel based recommendations, it is hard to gauge a specific pay-back period, and it is difficult to predict the actual effectiveness and competency of new staff. Finally, the ability to recruit appropriate staff remains an unknown risk.

The scope of this analysis was limited by the availability of AEC budgets and expense reports. The Buildings Team was unable to acquire information regarding the relative annual expense proportions of various capital projects under $10M. Further inquiry indicated that the vastly varied nature of individual projects precluded AEC staff's ability to provide typical estimates on the occurrence of expenses, in order to further refine thinking around this matter.

B.2.0 Project Initiation [C, E, M, H, CA]

B.2.1 Adopt a synergistic project initiation process for renovation projects under $10M in which sustainability goals are foregrounded in the initiation processes of capital projects that are currently primarily* program *driven. The Buildings Team recommends that U-M utilize the Facilities Conditions Assessment (FCA) database as additional leverage to initiate new renovation projects under $10M construction as well as initiate a study that investigates the feasibility and effectiveness of setting up a fund specific to a system-wide upgrade of particularly large and energy inefficient equipment across the entire campus.

B.2.1.1 <u>Recommendation and Background</u>

Under current U-M practices, the initiation of all capital projects, including small renovation projects under $10M, is driven by program demand. The FCA database is only tied to post-occupancy deferred maintenance regimes, drawing resources from an independent fund from which equipment upgrades and building modifications can be undertaken based on a list of condition evaluations and prioritization criteria, one of which is energy performance. FCA projects are organized, ranked, and executed according to a set of priority ratings.[22] However, the FCA database is policy neutral, meaning it is not a comprehensive capital plan for building renewal. The database does not include costs related to programs and/or the reconfiguration of building space.[23] As a result, a formal link does not exist between the valuable information maintained in the FCA database and the initiation of small renovation projects. A unit-driven small renovation project may incorporate some FCA-listed deferred maintenance projects, but a high number of listings on the FCA database does not necessarily initiate a renovation project. The reason for this disconnect is in part a result of the different sources of funding for capital projects and maintenance/modification projects.

The Buildings Team recommends that program needs and the FCA database foster a dynamic relationship in which both act together to initiate renovation projects under $10M. Essentially, the Buildings Team recommends that the FCA database does *not* maintain a policy neutral status. The Team believes that the FCA database could be better integrated in the project initiation processes so that the items in the database not only act as an integral lever to the initiation of a small capital renovations, but also that the sustainability standards for the systems upgrades/replacements may be aligned with the related renovation project, as opposed to being limited to the repair and replacement of existing equipment and systems. Such a system could be beneficial even when projects undertaken from the FCA database are not explicitly energy related. For example, if a Unit learns that a large maintenance procedure is taking place for life safety or health concerns, the Unit could opt to contribute additional funding to enhance the sustainable performance of the updated system.

Additionally, this relationship can work in the other direction; decisions regarding program expansion can be informed by the FCA database. Within individual Units, pressure often exists to accommodate program expansion or facilities alteration within existing spaces. For many program types, the pressure to accommodate program changes can result in the renovation of existing space whose characteristics are discordant with new uses, or which generate undesirable outcomes in terms of existing spatial characteristics' capacity to effectively house new programs, either creating conflicts in terms of scope of work required, or in terms of systems conflicts between surrounding and new uses.To help mitigate this risk, units and AEC should consult the FCA database as a resource that can inform the appropriateness of adopting a new program for a space given the nature and condition of infrastructure in place and whether or not it can sustainably support the new program.

Recommended New Procedures (Medium Term):

-All items on the FCA database should take into consideration any relevant corresponding program driven renovation projects anticipated in the next 10 years

-Design of renovations, under new guidelines stemming from AEC expansion, should integrate *all* relevant FCA database flagged items into the design of the renovation.

-Replacement/upgrades of the equipment flagged to be repaired or replaced by the FCA database should meet the sustainability standards comparable to new project design guidelines (such as ASHRAE +30%) and the renovation project as a whole.

-If the FCA database contains a significant amount of flagged items relevant to a renovation project, the project as a whole should be prioritized based on the need to improve the environmental performance of the systems related to the space.

-When inquiring after the feasibility of program change or expansion, the AEC and academic unit should align their wants and needs against the data in the FCA database to make sure program change is appropriate given the condition and type of equipment or infrastructure in place. Opportunities to level program expansion should be coordinated with necessary building upgrades, and opportunities for base building improvement.

-Funding of the FCA database projects should be reconsidered in order to implement new procedures. *(see study proposal below)*

Recommended Study (Short Term):

The Buildings Team recommends that a study be undertaken to identify primary equipment systems with a high energy demand that are particularly lagging with regards to energy efficiency with the end goal of accelerating a university wide replacement of these systems. As the FCA database is not prioritized to focus on replacing equipment according to which systems are the biggest energy consumers, particularly boiler and chiller systems, this study would address the appropriateness of retooling prioritization of the FCA database. This study should have an end goal of examining the feasibility of establishing a fund to specifically handle and accelerate these University-wide upgrades. Instead of thinking of system upgrades on a building to building basis, approaching reductions of greenhouse gas emissions associated with large in-efficient mechanical equipment on a system wide level will provide the most impact, giving the FCA database a broader stance within the university as a means to promote and execute sustainability goals.

B.2.1.2 Peer Institutions and References

Adopting a more integrated project initiation approach for renovation projects is a practice employed at U-M's peer institutions and other entities. The University of Pennsylvania encourages responsible stewardship of all existing University buildings through a synergistic approach to renovation projects:

> *"Each renovation project, therefore, should include an investigation of all aspects, systems and features impacted by the specific intervention. Conditions discovered during project evaluation, design or construction that are in need of improvement cannot be ignored. Even in cases where budgetary or schedule constraints necessitate only a partial remediation, any building deficiencies brought to light are to be examined and documented so that they may be addressed at a future time. Such proactive management reflects the University's commitment to maximizing the efficiency of its built environment. In working to sustain its existing capital investments, the University proves the principle that the greenest building is the one you do not have to build."*[24]

Additionally, New York City's Local Law 86 mandates certain requirements consistent with need-based renovations. For example, if a boiler replacement project goes over a specified benchmark cost ($2M), then that project must meet their specified LEED standard for any capital project over $2M, despite the fact that this individual replacement is not a program driven renovation project.[20]

B.2.1.3 Benefits and Costs

A synergistic approach to the initiation of renovation projects will more efficiently and holistically address lagging performance "weaknesses" throughout the existing University building stock (as is currently part of the FCA practice), as well as assist in realizing the broader potential impact of small renovation projects in advancing sustainable agendas across campus. Instead of addressing sustainability issues with existing buildings through disconnected channels, either through equipment upgrades initiated by the FCA database, or through incorporating sustainable measures into the design and execution of renovation projects initiated by the program needs of a unit, the Buildings Team believes that a fully integrated approach to project initiation will have a significant impact on the sustainability of the campus as a whole.

Though measuring specific impacts related to such process oriented recommendations is difficult, it is our belief that this policy shift will result in greenhouse gas reduction across all renovation projects, both above and below $10M construction costs (as a result of the aggregate impact of such reforms and improvements). The FCA database is a very valuable resource, and by ending its policy neutral status and initiation of further study into re-working the allocation of its current funding, the FCA can assist in achieving comprehensive sustainability goals for renovation projects across the university. Further, employing the FCA database as a benchmark against expected useful life and depreciation of fixed assets could prove a financially relevant tool to evaluate the performance of projects.

B.2.1.4 Barriers and Uncertainties

The FCA database currently has a limited range of influence. The program is flagged as policy neutral and explicitly does not provide a comprehensive capital plan for building renewal. As a result, making major changes to the role of the FCA database and further integrating it into the project initiation process would require reconsideration of existing institutional policies. Furthermore, because the funding is separated, individual Units do not have incentives to consult or coordinate renovation requests with items on the FCA database even if an item on the list pertains to something in a Unit's building stock. In order to address this existing condition, we recommend that a procedure based assessment be undertaken by U-M staff to evaluate the potential benefits of such a synergistic approach across a sample group of related projects across the next 3 academic years, in parallel with the rollout of pilot projects described in B.2.1 above.

This process oriented recommendation certainly raises questions of the ability to make major institutional policy changes in a timely fashion. Furthermore, uncertainties surround the financial maneuvering required to coordinate FCA database and associated funds with funding required to support program driven capital renovation projects; however, the study would help answer these financial questions. Implementation of this overall recommendation is a medium to long-term strategic recommendation, requiring a phased implementation.

B.3.0 Construction and Materials [C, E, M]

B.3.1 Develop an internal policy and program for the management of construction and demolition debris (C&D) from small renovation projects emphasizing source reduction, recycling, and pollution prevention, in tandem with requirements to minimize construction based pollutants to both indoor environments and adjacent ecological systems during the construction process.

B.3.1.1 Recommendation and Background

The University should develop systems to mitigate and ultimately avoid construction materials waste, utilizing a construction waste recycling process on all small building renovations to effectively separate and recycle recoverable waste materials generated during construction and remodeling. Construction waste poses a significant burden to landfill loading and operation, making up 26% of all non-industrial waste in the United States (44% of that coming from renovations). Additionally, construction waste from sources such as solvents or chemically treated wood can result in soil and water pollution both onsite and en-situ.[25] Through the implementation of a recycling and reuse program, excess materials could be reused in University projects, transported to local recyclers for resale, or donated to local non-profit organizations (such as *Reuse Ann Arbor*). The Buildings Team recommends that the University evaluate and develop internal specifications for a definitive minimum waste and debris diversion criteria for utilization on small projects. Criteria such as "divert from landfill disposal a minimum of 75% of the non-hazardous construction waste generated at the jobsite"[26] would be created and applied to all applicable construction work.

The Buildings Team also recommends that the University employ a construction code of conduct to address indoor air quality (IAQ) to mitigate human health related problems resulting from renovations, and to mitigate the detrimental effects on the surrounding ecosystem. This code of conduct should address all implications of the site location, specifying appropriate procedures to avoid disruption of the surrounding site environment with either noise or air quality issues. Furthermore, efforts to reduce pollutants emitted during the construction phase should be made through using construction equipment with cleaner diesel fuel. This initiative should include using filters for both construction vehicles and material delivery trucks, as well as acquiring construction equipment that runs on low-level sulfur diesel fuel. Perhaps most critically, formal policies should be developed to address a standard set of requirements and procedures for the mitigation of internal air quality (IAQ) to active areas of work and study adjacent to, and connected through mechanical systems, during the execution of construction processes occurring during periods of building occupancy in parallel with construction activity. While such guidelines are explicitly defined in related standards such as the LEED program,[26] the Building's Team recommends that special evaluation and selection of criteria be undertaken by U-M given the sensitive nature of related issues for staff, faculty and students comprising the University community. Guidelines for both construction and demolition debris management and air pollution mitigation during construction are currently under development through the Sustainability Master Plan at the AEC, but at the time of this document's publication a draft was not available for review.

The above recommendations are short to medium term actions requiring focused study beyond the scope of this report. Specialized training regarding proper deconstruction of existing building projects so as to preserve the desired resources for recycling would be required for related U-M staff. Each project would need a pre-deconstruction study to determine which resources would be desirable and feasible to recycle and to decide the best procedure to extract those materials. Decisions would have to be made on whether materials are sent to local recyclers or would remain in possession of the University for future projects. Further, AEC documents and policies will require revision in the short term to include agreed-upon best practices as determined by the required construction code of conduct. The deconstruction evaluation process, as well as the sorting, storage, and sale of recovered materials could include collaboration with existing community entities such as the ReUse Center and Recycle Ann Arbor.

Finally, with the large turnover of small building renovations across the University, the creation of a virtual warehouse and information web site with guides to deconstruction and materials reuse and computer based deconstruction feasibility tools could expand and encourage the sourcing of reused and recycled materials at U-M. Many environmental and social benefits can be realized by reusing building materials, including reducing the consumption of new resources, minimizing landfill waste and pollution, creating value-added markets from waste materials, and expanding community benefits and workforce development skills. The University should, whenever feasible, emphasize the deconstruction of building projects as opposed to demolition in order to take advantage of any potentially reusable materials removed from those deconstructions, excluding toxic materials.

In order to assess what format of engagement in reuse streaming is most appropriate to U-M, a cost assessment regarding the anticipated capital and operating costs relative to material reuse savings should be undertaken in the near term. In the event that the institution can justify participation in the storage of materials internally, then consideration of the creation of a materials warehouse, either within underutilized existing warehouse space, through the expansion of the Property Disposition program, or through the creation of a new facility, to become the default repository for any retainable construction material. The virtual warehouse of all available retained materials should be updated continuously and allowed access by all design teams working on University building projects for consideration and innovation using reused and recycled materials. When designing building projects, if desired materials cannot be obtained through the University's inventory, then looking to local recyclers to obtain reused and recycled material should be done. Similarly, those materials collected from deconstruction projects that cannot be used by the University should either be donated to local non-profit organizations or sent to local recyclers as methods to divert as much construction and demolition debris from disposal to landfills and incineration facilities to protect the local ecosystem.

This is a long term recommendation, with evaluation and goal-setting with respect to performance to be undertaken by U-M staff in the near term. Setting up both a virtual warehouse would require an inventory analysis of all current construction materials within the University's possession followed by an ongoing tracking of material flow. Establishing a physical warehouse for storage of construction materials salvaged from projects would require more time. First, a study of available space on campus by AEC to determine appropriate location would be required and then a thorough plan for storage and tagging of materials to properly sort and record material inventory would be applied to ensure efficiency and organization of the system.

B.3.1.2 Peer Institutions and References

While the University of Michigan employs leaders in design and construction, the University currently lags behind other peer institutions and other entities as it pertains to post-construction reuse and recycling. The Environmental Building News reports that building construction accounts for nearly 30% of all raw material consumption in the United States. Furthermore, nearly one-third of the waste in U.S. landfills comes from building construction and demolition debris, according to the U.S. Environmental Protection Agency.[27] Reports from The Buildings Materials Reuse Association find that organic materials such as wood, which represent a significant amount of overall construction and demolition debris, eventually breakdown and produce methane, a greenhouse gas many times worse than carbon dioxide. For every ton of wood reused, 60 pounds of greenhouse gases are prevented by eliminating the need to harvest and mill new lumber. Recognition of these adverse environmental effects gives rise to certain LEED Credits for sustainability initiatives post-construction. LEED Materials and Resources (MR) Credit 9 aims to divert 70% of waste (by volume) generated by facility alterations and additions from disposal to landfills and incineration facilities, applied solely to base building elements permanently or semi-permanently attached to the building itself.[26] LEED for Schools MR Credit 3 advocates reusing and recycling building materials and products to reduce the demand for virgin materials and reduce waste, thereby lessening the impacts associated with the extraction and processing of virgin resources. These LEED requirements seek to use salvaged, refurbished or reused materials at a threshold of at least 5% or 10%, based on cost, of the total value of materials on the project.[26] Finally, LEED IEQ Credit 1.5 for Existing Buildings specifies containment control strategies that include protecting the HVAC system, controlling pollutant sources, interrupting pathways for contamination, enforcing proper housekeeping and coordinating schedules to minimize disruption.[26]

Peer Institutions have taken several steps to take advantage of the opportunities available in materials reuse and recycling. The University of Chicago requires that at least 50% of construction and demolition debris, as measured by weight, produced on site be recycled. Additionally, signage announcing construction on campus is all fabricated with recyclable materials, and vinyl die cut logos and texts are applied to the painted surfaces.[28] At Emory University, the construction waste recycling levels are at 75%.[29] The Construction Materials Reuse Project in Charlotte County, Florida has made a huge push in effectively managing construction and demolition debris (C&D) through source reduction, pollution prevention and recycling. The Project, initiated in 2000, integrated four elements: a virtual warehouse and information website, an institute for C&D materials recovery, reuse, and recycling, a diversion program at ten different properties to demonstrate commercial viability of deconstruction as part of the demolition process, and marketing for deconstruction and reuse. The project's target was to integrate the critical components needed to create a deconstruction workforce and marketplace for recovered construction materials. The outcomes of the program included trained deconstruction subcontractors, an online warehouse, and a training program.[30]

B.3.1.3 Benefits and Costs

The cost of recycling construction material waste would include setup and maintenance fees, but those fees could be ameliorated over time by the reduction in tip fees at area landfills. Waste hauled to a landfill incurs expensive "tip" fees to cover the cost of burying the material with municipal trash. Facility use fees at recycling sites—sometimes 1/2 the cost of landfill rates—cover the cost of processing the material into a saleable material, such as aggregate or compost. Training will be required for on-site separation, initially requiring some extra effort and training of construction personnel, but once best practices in separation are established, learning curve efficiencies will be realized.

An example of potential cost savings for material recycling is given with one container of concrete – the heaviest of materials – weighing 10-12 tons. This one container of concrete can be recycled for $350, or the container of concrete can landfilled at $65 a ton, for a total cost of approximately $780 per container. This example is for a single unit, thus, scaling this cost savings for an entire construction project shows that there can be significant savings per project mainly due to landfill fees and hauling costs.[31]

The benefits for reusing construction materials include the preservation of forest resources, storm water and soil erosion control, maintenance of biodiversity, sequestration of tons of greenhouse gas, and reduced energy use and pollution from harvesting, milling, and transportation of new lumber. The reuse of treated lumber reduces the pollution associated with its production and disposal. Deconstruction also extends the life of building materials and the University's material footprint, further contributing to the University's sustainable building practices.

Intuitively, deconstruction is more labor intensive than demolition. Significant consideration is required to assess and develop an institutional position on U-M's relation to its construction waste flow. While increased staffing requirements could tap the Southeast Michigan community job market creating new jobs by expanding deconstruction activities, careful assessment of related costs relative to institutional profile will be required, and should include the development of a business case to assess the feasibility of U-M participation in recycling and reuse economies.

B.3.1.4 Barriers and Uncertainties

Barriers associated with this recommendation include the start-up costs to create a materials warehouse, as well as the creation of a virtual warehouse for recovered materials and long term operating costs. Such a new practice would be difficult to immediately implement and would require an institutional commitment based on positive feedback from feasibility analysis. University staff would need to investigate the feasibility of certain spaces and the differential costs and revenues associated with maintaining reusable inventory versus immediate sale. This recommendation is a medium to long term recommendation requiring short term investigation and further analysis. In addition, the success of such a project will also be predicted upon the willingness of labor culture to embrace transformation in demolition practices. The scope of the Integrated Assessment precluded analysis of options given the variability of materials used in construction, facilities or sites currently available, as well as a comprehensive study of local industries.

B.4.0 Building Renovations as Marketing and Educational Tools [CA, L]

B.4.1 Promote sustainable building renovations as marketing and educational tools to augment talent recruitment, retention, and to employ the U-M as a collaborative learning tool across the design and engineering disciplines.

B.4.1.1 Recommendation and Background

The impact that sustainable building practices are having on societal perception today is substantial, and that impact continues to grow at a remarkable rate as demonstrated in the US Green Building Council's documentation of project registration (see figure B.4.1.i in Appendix B). This impact has shifted public interest in sustainable construction from a marginal concern to a mainstream priority. The benefits that the University may receive from committing more resources towards sustainable initiatives, especially focal sectors like campus buildings, reaches far beyond strictly direct financial gains from energy reduction or material costs. The University should evaluate the formalization of intangible benefits resulting from the implementation of sustainable design practices into renovations of buildings less than $10M as a conscious measure in the recruitment and retention of the University's high caliber of faculty, students and staff - crucial participants in maintaining the University's position as a lead research institution in the nation *(see SECTION A.2).* The uptake of sustainable building practices and public dissemination of these practices tied to institutional marketing efforts and materials may help to attract new talent by promoting high quality work environments and through supporting and encouraging sustainable lifestyles across the U-M community.

The impact a completed building project has on its occupants is not defined solely by the project scope and character defined during the design and construction process. Long-term impacts and opportunities for a range of institutional uses beyond the building construct as a capital asset should be considered during its development and preparation as part of the U-M community. The implementation of didactic and marketing content into the design of the building renovations to complement the incorporation of performance based detailing may offer a means to capitalize on the front end expenses incurred through sustainable design and building practices. Examples of such details include the incorporation of interactive signage throughout sustainable buildings to bring focus on sustainable systems, materials, and construction practices and the development of projects with specific systems and features that can be utilized within sustainable course content at U-M.

Sustainable building projects should be used in conjunction with current and new curricula to advance research initiatives, material research, and assessment methods, with the intent to further raise awareness and educate the University community and enhance course offerings and research programs. This can be enhanced by engaging ongoing faculty research agendas and course content in establishing the scope of work on particular projects. Building renovations less than $10M are the most feasible pilot projects to experiment with different designs and technologies in a University setting as these projects typically embody less risk with respect to the inclusion of new technologies and methods as a result of their limited scope. Collaboration with students and faculty teams on the development of agenda for specific renovation projects could offer further enhancement of design and engineering curricula while engaging the University community to tackle a common goal of developing more sustainable building practices.

This recommendation defines short term goals for preliminary study and evaluation primarily linked to the creation of a number of small scale research and implementation studies that would include post execution analysis in the form of social research to evaluate their impact on perception across user groups.

B.4.1.2 University of Michigan Current Practices and Cultures

The Stephen M. Ross School of Business and the Samuel T. Dana Building both incorporate appropriate signage and informational material into the facilities. The Ross School maintains electronic signage highlighting various components of the building's LEED Silver credits such as its green roof, waterless urinals and two-way flush toilets, daylighting, and material inputs. The Dana Building has a prominent display of the LEED Gold Facility, in particular the marginal improvements of the renovation. The building includes waste composting, recycled material inputs, and natural lighting. While both facilities include signage in the final building, marketing materials highlighting the various credits could have been employed at all steps in the construction phase to generate excitement. Similar practices could have been utilized in the renovation and occupancy phases of North Quad, Couzens Hall, and the Law School addition. The Buildings Team believes that educational and marketing efforts need not be limited to large or high profile projects alone, but could be considered as an effective educational strategy across all scales and phases of construction. However, the projected value of such a program is beyond the capabilities of the current team and study period to financially quantify.

B.4.1.3 Peer Institutions and References

The 2010 College Sustainability Report Card found that 69% of colleges and universities incorporate a sustainability message during the admissions and student orientation processes.[32] Furthermore, according to a recent Tandberg survey, 80% of respondents across 15 developed nations would prefer working for a company that "has a good reputation for environmental responsibility" – the figure was 81% in the US.[33] As the education market becomes increasingly competitive, universities will need to maintain a marketable edge in order to continue to attract top talent. Green policy and sustainable design practice can be an important differentiator given the interest in working for an environmentally responsible company stated by workers globally. Santa Clara University for example has made a committed effort to educate and encourage their members to 'go green'. To accomplish the initiative's purpose, renovations' sustainable features are highlighted wherever possible. Signs posted throughout buildings describe sustainable design detail implementation and render a walk through the space an educational experience. Glass panels and montages display the materials used in the building.[34] Accordingly, U-M staff could develop an interdepartmental team to evaluate the potential for specific sustainable design projects in the development of an overarching marketing campaign focused on communicating the University's green activities to potential students and employees; the ability to recruit and retain future talent in an increasingly competitive labor market may in part depend on this. The increasing importance of sustainability to potential students is apparent, and the University of Michigan should take steps to both employ sustainability criteria in its operations, and publicize these efforts. Activities such as the Campus Sustainability Integrated Assessment prompt a marked increase in the legibility of sustainable practice initiatives at AEC and the Office of Campus Sustainability, primarily evidenced through digital media.[18] The Buildings Team has noted the degree to which these efforts have made sustainable initiatives evident to members of the U-M community and general public alike.

B.4.1.4 Benefits and Costs

An evaluation of the benefits and costs associated with this proposed set of practices is particularly difficult to articulate in the context of this report and requires further study.

B.4.1.5 Barriers and Uncertainties

Signage and other marketing materials embedded within the structure of construction budgets represent nominal cost relative to other project components; however, the coordination of a system wide strategy of sustainable communication within U-M may represent significant investment. Further, U-M administration would need to evaluate the relationship of costs assigned to the development of sustainable building stock and budgets historically associated with marketing, talent attraction and retention. Developing project budgets in a new hybridized format inclusive and with the intention of addressing the value associated with sustainable thinking could require new procedures for evaluating fulfillment of the institution's mission. That these domains are typically separated financially and operationally is neither without consequence nor without potential quantification. The Buildings Team would suggest that a subsequent short term application of investigation into the frictions and synergies around this topic may be of value to the University, and should be undertaken in the short term to evaluate its potential.

C. PLANET BLUE PROGRAMS AND PRACTICES

C.1 Planet Blue and U-M Administration [C, E, M, H, CA, L]

C.1.1 To overcome existing limitations due to stringent payback requirements, Develop a highly integrated, nuanced cost and benefit analysis for complex packages of building upgrades that will (i) account for synergies between sustainability measures and (ii) assign values to desired outcomes that may or may not be directly linked to cost savings.

C.1.1.1 Recommendation and Background

As the work in a building begins to include a greater range of environmentally responsible measures, the synergies between scopes of work should be accounted for. Currently, intangible benefits (e.g. talent retention, value of demonstration projects) and some overlooked tangible benefits (e.g. improved occupant health and reduced staff absences) are not accounted for. See *SECTION A.2.0* for a discussion of the evaluation of all broad costs and benefits associated with sustainable projects and capital budgeting.

The Buildings Team recognizes the value of the expedient, simple eight-year payback model currently in place. However, as the scope of building upgrades expands, cost analyses must begin to acknowledge the inherent synergies across building systems and operations, as well as the social and environmental benefits that fall outside the eight-year payback threshold. *SECTION A.1.0* discusses NPV as an evaluative tool to account for some of the synergies of sustainable upgrades, especially in the context of expenses that would otherwise be precluded because of strict financial payback criteria.

C.1.1.2 Benefits and Costs

An integrated cost benefit analysis, particularly with consideration to intangible benefits, would be invaluable to the building industry as it is currently an under-realized area of knowledge. An initiative to establish comprehensive budget consideration of sustainable projects would help to continue U-M's leadership in innovative, new practices toward increasing sustainability measures on campus.

Additionally, the U-M AEC Sustainability Master Plan includes a section titled "Evaluating Sustainability Measures"[18] for which the AEC are currently considering various methodologies that account for both tangible and intangible benefits – this work and its outcomes could be shared with Plant Operations in order to formulate a cost analysis that can help to identify synergies and trade-offs between portfolios of Sustainability Measures for each building.

C.1.1.3 Barriers and Uncertainties

For the purposes of this report, the Buildings Team assumes that the model of Planet Blue will continue to exist in a form similar to its operations today – as a project under Plant Operations, funded annually, and managed in an integrated, team structure. As such, a cost analysis tool that begins to account for more than energy conservation alone will be complicated to implement given the de-centralized organization of the University and its varied funding mechanisms for building projects.

C.1.2 Define a timeline for implementing the Planet Blue program at all U-M buildings so that sustainability measures are consistently applied within the entire U-M community.

C.1.2.1 Recommendation and Background

Planet Blue currently accounts for approximately 90 of the 377 buildings on the Ann Arbor campus. The first three years of the Planet Blue initiative have proven to be highly successful in terms of addressing the original ambitions for the project, as discussed below. The Buildings Team recommends that the successes of the program be extended horizontally into all U-M properties.

Planet Blue initially set an energy reduction goal of 5% energy reduction for a portfolio of 90 buildings. The results to date have significantly exceeded this goal. For the initial five pilot buildings in 2008, a 6% reduction in energy costs was achieved. For FY 2010, energy conservation measures in the Planet Blue program reduced these buildings' overall energy usage by 12%, a value of $3,484,000 at 2010 energy costs. This is particularly significant when compared against Planet Blue's annual budget of approximately $3.5 million. Planet Blue has maintained their annual budget of approximately $3.5M since its formalized inception in FY2007. Funds are appropriated from University General Funds with approximately 60-75% of annual operating expenses consisting of the value-adding Energy Conservation Measures (ECMs). The remaining proportion of the budget is allocated to Planet Blue marketing, staff, and other applicable overheads such as IT, space utilization, and other relevant costs.[35] Although Planet Blue operates as an independent cost center, the efficiency Planet Blue maintains in its strategic process of analyzing and executing prospective ECMs ensures that all expenses borne by Planet Blue are indeed recovered through the expense savings of the ECM to the relevant individual unit.

C.1.2.2 Benefits and Costs

Keeping all buildings and their occupants accountable to Planet Blue protocol and standards would require additional staff time and additional training for an expanded Planet Blue team. An alternative to additional staff is an extended timeline so that the existing team structure could work through a larger portfolio of buildings.

A direct benefit of the expansion of Planet Blue into all U-M buildings is a greater in-house capacity to manage facilities and their operations. This work would also benefit a re-structuring of the FCA database into a more preventative model (*see SECTION B.2.1*). By subjecting each U-M building to an integrated team meeting and building walk-through approximately once every five years, all repairs and upgrades could be combined into a package of work with potential synergies. These synergies might result in shared labor costs, more informed decisions based on a larger picture of the building and increased communications between Plant Operations and building facilities managers.

The Planet Blue model currently requires that an external organization consumes all of the expenses of a sustainability project, while the client unit receives all the benefit in terms of direct cost savings. An expansion of the Planet Blue scope to all facilities will require an additional budget for Planet Blue, but all projects will directly save money for the University. Any expansion of scope will return positive value to the University.

C.1.2.3 Barriers and Uncertainties

Given the de-centralized structure of U-M, this type of expansion would require a top-down directive, similar to the decision to require all new buildings to exceed the ASHRAE 90.1 energy requirements by 30%. It is unclear to what extent the University would be willing or able to put this requirement in place, particularly for the U-M Health System, the Housing Department and Athletics.

C.2 Planet Blue Process [C, E, M, H, CA, L]

C.2.1 Form working groups of key U-M staff and faculty charged with the goal of identifying additional scope opportunities, with associated metrics, in order to expand the set of sustainability measures considered for each U-M building by the Planet Blue Teams.

C.2.1.1 Recommendation and Background

The Buildings Team recommends that the Planet Blue administration utilize the first half of the fiscal year to set methods and metrics for a potential incremental scope expansion to the Planet Blue process. By limiting additional staff and faculty time to the Fall Term (September-December), the Winter and Spring/Summer Terms could be used for piloted implementation of these articulated objectives. For example, during preliminary project analysis, Planet Blue staff would set targets for IAQ and ventilation, in addition to its goals for energy conservation and water management. During the second half of the year, building projects would attempt to incorporate these metrics into performance and evaluation. We further recommend that the faculty time committed to sustainability initiatives on campus be formally recognized as service time applicable to faculty service requirements.

Within these discussions, opportunities for campus-wide initiatives should be considered as well. There may be instances when it would be more efficient, in terms of funding, marketing or both, to implement a specific sustainability measure in all buildings rather than on a building-by-building basis.

Historically, U-M's approach to energy management in existing buildings has been ahead of the work of most of the peer institutions reviewed as part of the Phase 1 work. In their 2010 "Kill-A-Watt Leadership Program Report," the University of California-Berkeley supports this position:

> *"Of the external peer institutions reviewed, University of Michigan's environmental and energy initiative — Planet Blue — stood out as one of the most*

successful campus-wide energy reduction initiative with a focus on changing occupant controlled behavior. Our external case study team analyzed web content and interviewed U-M personnel to understand the development of the Planet Blue initiative, the process followed by the Planet Blue teams, and the initiative's successes."[4]

Currently, nineteen out of twenty-five peer institutions researched have instated aggressive programs in the last ten years to update lighting, plumbing, and HVAC systems and have tracked significant financial savings tied to these improvements. Three of these institutions have adopted LEED standards for Existing Buildings, Operations, and Maintenance (EBOM) as a way to track their improvements and insure continued performance.[36]

"Planet Blue Operations Team is a campus-wide educational and outreach campaign with a mission to: Actively engage the University of Michigan community to conserve utilities and increase recycling thereby saving money and benefiting the environment."

Given that the University of Michigan has served to be a role model for successful energy conservation measures, the Buildings Team feels that U-M has the opportunity to continue to set a high standard of excellence for environmentally responsible initiatives of a much larger scope. Additional sustainability measures could include both tangible and intangible work, for example: water conservation, materials selection and maintenance, sub-metering and related controls, improved indoor air quality and more enjoyable, productive spaces. For each of these topics there are both faculty and staff with knowledge that would help the University define and prioritize additional scope for the Planet Blue teams.

C.2.1.2 Benefits and Costs

Potential marketing benefits are augmented by encouraging staff and faculty to think beyond budgetary limitations and the status quo during preliminary discussions and building analyses - innovation should be prioritized. See *SECTION C.3.0* and *SECTION B.4.0* for additional discussion on the topic of innovative sustainability projects and public relations. The Planet Blue Teams currently use an Opportunity Checklist[37] as a method to record a growing list of possible Energy Conservation Measures for consideration at each building. This is an excellent tool to continue as the scope expands to include additional sustainability measures. In some cases however, we find such a checklist to actually be a limiting factor, precluding discussion of certain opportunities that by precedent have been known to fail to meet strict payoff requirements. Utilizing NPV and expected value of all costs and benefits is critical to providing the fullest rationalization for any sustainability project.

Interaction and contribution by both staff and faculty will strengthen the culture of sustainability on campus by engaging a wider group of active, aware participants. Inter-departmental work of this type will also help to overcome the de-centralized operations of individual units and promote a greater sense of inter-disciplinary work in all priority areas of the University - education, research and operations.

Expanding the scope of Planet Blue will require additional staff time, however, this could be (at least initially) limited to shared support staff. Planet Blue currently employs nine full time staff members, who contribute the largest component to general overhead expenses of the Planet Blue process (approximately 30% of annual budget). Expansion of Planet Blue could require an additional salaried employee, or a reallocation of current labor hours. This would increase annual operating costs, but the expanded scope would provide for additional ECM deployments - resulting in real annual cost savings to the applicable unit.

C.2.1.3 Barriers and Uncertainties

In all of the discussions with staff and faculty the Buildings Team conducted during the Fall 2010 semester, there was a common issue of too many tasks and not enough time. It is not certain that the staff and faculty best qualified to undertake this work would have sufficient time available. Further, the current utilization of simple payback is a strict barrier to broad incorporation of other metrics within the Planet Blue scope.

C.2.2 Take immediate action by prescribing formal sustainability measures and metrics related to water conservation and recycling to the scope of the Planet Blue Building Teams for Fiscal Year 2012.

C.2.2.1 Recommendation and Background

Water and recycling are currently included in the Planet Blue campaign scope, but are not pursued as aggressively as Energy Conservation Measures. The Buildings Team recommends that Planet Blue pursue these topics more aggressively in order to create and test new protocols within the structure and in-house expertise of the existing Planet Blue teams. In line with the previous recommendation, we recommend that the creation of methods and metrics to address water conservation and recycling be completed during the first half of the fiscal year (Fall 2011). Two process diagrams were created by the Buildings Team (see Exhibits C.2.2.i and C.2.2.ii in Appendix C) in order to better understand how the Planet Blue teams work. The “Reporting and Team Structure” diagram includes our understanding of the most pertinent relationships within which Planet Blue operates, and the “Process Mapping” diagram outlines Planet Blue’s chronological scope of work. The creation of these diagrams is based on a number of primary sources, including the Planet Blue website, publications, interviews with staff members and observations gained through attendance at every stage of the seven-step Planet Blue process. (Refer to Appendix F for a list meetings and attendants.) The scope of the Planet Blue Teams can be significantly and productively expanded with limited, precise adjustments to the existing Planet Blue processes which have proven to be highly successful.

C.2.2.2 Benefits and Costs

The Planet Blue buildings teams have, over the past three years, developed highly successful methods of working. Their experience and expertise could be put to work immediately to begin expansion of scope. As the Planet Blue program began without much framework and now works efficiently, we would recommend that this staff be trusted to use some trial and error modes of working in order to get the work underway; the in-house capacity is in place and should be taken advantage of.

Likewise, the Integrated Assessment has produced a group of students that are now aware of and familiar with U-M protocols and priorities. A minimal-cost opportunity exists now to hire one of these students to work directly with the Planet Blue staff as a trial through the Fiscal Year 2012 work to advance this agenda.

C.2.2.3 Barriers and Uncertainties

Fiscal Year 2012 is currently slated as the transition year for Planet Blue; the details of the nature of this transition are currently unclear. The Planet Blue teams have been so singularly focused on the problem of energy conservation that it may be somewhat difficult to introduce additional metrics, especially when it comes to intangible benefits and status quo procedures like the eight-year payback model.

C.2.3 Execute regular post-occupancy evaluations (POE) in each building in order to track seasonal building performance and occupant comfort and improve community awareness within each building.

C.2.3.1. Recommendation and Background

Post-occupancy evaluations are useful indicators of building performance in terms of operations and maintenance as well as design. *"Post-occupancy evaluation involves systematic evaluation of opinion about buildings in use, from the perspective of the people who use them. It assesses how well buildings match users' needs, and identifies ways to improve building design, performance and fitness for purpose."*[18] The Buildings Team recommends that surveys be conducted in buildings that have undergone the Planet Blue process as a routine part of the Planet Blue program.

By gathering data regarding satisfaction, comfort and performance as well as operational logistics from all building occupants, Planet Blue teams are more likely to learn about perceptions and performance of proposed systems implementation. For this reason, evaluations should always include an open suggestion field for miscellaneous comments. We would also recommend that surveys be completed during each season of the year - a cycle of one survey every 1.25 years would accomplish this goal.

The Whole Building Design Guide (WBDG), a noted resource for those working in the sustainability field, includes a section on the topic of post-occupancy evaluations.[38] While there are numerous private businesses that offer to create and implement these evaluations, the Buildings Team recommends that the AEC and Planet Blue act as primary designers of the POE and maintain the survey and results infrastructure in-house. In short, we believe that U-M has the capacity to implement this recommendation without the need to use outside consultants.

The Planet Blue model promotes an integrated approach that brings together staff, faculty and students from various disciplines to collaborate on the work. This approach is highly efficient as initiatives toward environmental sustainability are rarely singular in their potential impacts. A heightened level of awareness is key to the long-term performance of a building that is ultimately beneficial to the climate and human health.

C.2.3.2 Benefits and Costs

Surveys are easily conducted online and once a template has been finalized it can be implemented at every building without modification. With the exception of initial survey creation, the costs related to this activity could be estimated at 10-15 minutes per building occupant to submit the survey online. This information would then be readily available to Planet Blue staff for initial discussions prior to formally engaging building occupants.

In their Sustainability Master Plan, the AEC includes the creation and implementation of post-occupancy evaluations for recently completed projects. They state: “The Team will coordinate with departments such as U-M Interior Design Services (IDS), Plant Engineering (UPE), and Planet Blue in order to complete this task.” The work required to implement post-occupancy evaluations will be shared among a number of departments, and the information resulting from that work will also be shared across departments. This type of activity may be appropriate for research funding and support as well.

Furthermore, occupant surveys distributed and collected on a regular basis would help to increase awareness around the sustainability measures being pursued on campus. Planet Blue was created because the University recognizes the importance of awareness and changing people’s behavior - adding regular evaluations would help to reinforce this goal of the initiative. Further, evaluations are a tool to ascertain information on the importance of various sustainability initiatives to the direct stakeholders of each individual project; stakeholders have different needs for different facilities. Surveys can provide meaningful information to the Planet Blue staff to best meet the demands of a building’s direct users.

C.2.3.3 Barriers and Uncertainties

Division between AEC and Plant Operations, and other departments, may be somewhat of an obstacle. For example, the knowledge gained relative to sustainability measures by Plant Operations as a result of ongoing building maintenance and operations is sometimes undervalued or overlooked altogether by design teams on large projects through AEC. Certain sustainability measures are therefore ignored in later building upgrades by those who recall their previous dismissal. The Buildings Team believes that the knowledge gained from a co-authored occupancy evaluation will help to close the gap between the designers and the operators.

C.2.4 Complete a comprehensive review of the Planet Blue program to discover successes and challenges

C.2.4.1 Recommendation and Background

In 2007, a study completed by the U-M Institute for Social Research (ISR)[39] led to the creation of the Planet Blue program. Since this time, there has not been an equivalent study to evaluate the success of Planet Blue specifically related to community awareness. The Buildings Team recommends that the Institute for Social Research receive funding in order to distribute, collect and compile surveys to the campus community in order to be able to compare awareness with the results of the 2006-2007 study.

Planet Blue follows a long history of energy conservation initiatives, undertaken regularly since the 1980s, while adding key elements of awareness and education. A research study conducted by the Institute for Social Research at U-M found that campus occupants believed that little was being done to address issues of sustainability; this study made recommendations to increase community awareness and align occupant behavior with energy conservation measures which led to the creation of the Planet Blue process. The "Leading Up to Planet Blue" timeline compiled by the Buildings Team helps to illustrate the context from which we understand Planet Blue was created (refer Exhibit C.2.4.i in Appendix C).

C.2.4.2 Benefits and Costs

The costs associated with this study should be less than the cost of the initial study as the surveys have already been crafted, and the Principal Investigator is still highly involved in the work of the Integrated Assessment. Additionally, the development of in-house capacity through the work of the students involved with the Integrated Assessment could help to reduce the amount of preparation time required should those same students by recruited to assist with the follow-up evaluation of Planet Blue.

C.2.4.3 Barriers and Uncertainties

It is not certain that the improvements in community awareness will be as great as we may perceive them to be. A two-page proposal for the evaluation of Planet Blue was submitted to Hank Baier from ISR in Spring 2008 following the pilot launch of the program in five buildings.[40] It is not clear why the proposal was not accepted.

C.3 Planet Blue Model for Additional Pilot and Short-Term Projects [C, E, M, H, CA, L]

Given the proven success of the Planet Blue program, the Buildings Team recommends that U-M use Planet Blue as a model for instigating additional pilot and short-term projects for environmental sustainability initiatives across the campus.

C.3.1 Designate a revolving fund specifically for pilot projects related to innovative sustainability projects on campus.

C.3.1.1 Recommendation and Background

The creation of an energy management budget by the University in the 1980s signaled the importance and priority of the issue of energy conservation. Funding allocations are a highly visible indication of an institution's priorities. As such, the Buildings Team recommends that a revolving fund be created specifically for the creation of sustainability projects on campus, to be managed by the Office of Campus Sustainability.

C.3.1.2 Benefits and Costs

By employing a revolving fund or endowment financial structure managed by the Office of Campus Sustainability, annual budgeting and projecting would be significantly reduced. By maintaining a supposed 'sustainability account' at the University level, decision makers within administration may avoid procedural limitations of certain components of the General Fund allocation process. While the General Fund allocation process is currently a key success factor for the autonomy of the principal units, a fund not limited by the cutoff in the fiscal year can ensure continuity of operations at any given time, and provide for certain larger projects. Further, a separate fund could incentivize specific gift donations to projects that emphasize sustainability.

Funding opportunities would also help to promote innovation. At the University of California-Berkeley, the "Green Fund Grants" are supported by a small student fee paid by each student on campus and subject to student approval. The Buildings Team recommends that U-M consider a similar approach to support a formal fund allocation as discussed above, however, we would suggest that the staff and faculty be asked to contribute an equal amount as the students. A small fee paid by every person in the U-M community will work to reinforce the paradigm shift necessary for making sustainability a priority on campus and will increase awareness around both the issues of sustainability and the measures being taken at U-M to work on it. A greater sense of awareness and commitment may arise from a community that is directly funding projects for the benefit of the whole. A Fall 2010 Graham Institute sponsored undergraduate class investigated the willingness of students to pay an annual 'green fee,' and found very broad support for such a policy.[41]

C.3.1.3 Barriers and Uncertainties

Certain limitations may exist on the ability to maintain an auxiliary revolving fund specific to sustainability initiatives. While such a fund would ensure the longevity of sustainability projects at the University (versus an annual subjective budget allocation), budgeting is inherently political. Further, given the uncertain economic environment in the United States, and in particular, the State of Michigan, students and faculty may push back against the mandate of incremental student fees.

C.3.2 Use the Planet Blue process model to implement innovative sustainability projects identified by working groups of key U-M staff and faculty.

C.3.2.1 Recommendation and Background

Building directly on the recommendation of *SECTION C.2.1*, the Buildings Team recommends that staff and faculty teams identify experimental territory for sustainability pilot projects on campus. Using the Planet Blue pilot study model as an example, it is possible that future pilot studies could have a significant impact on the built environment at U-M.

There are a number of possibilities that deserve serious consideration: additional sub-metering and monitoring in buildings could improve measurement and verification protocol as part of continuous commissioning; the creation of energy models for at least a portion of campus buildings would help to prioritize upgrades as energy modeling accounts for synergies among various measures; and the use of readily available data for sustainability research projects like the health data at U-MHS which could be used to identify building-related sickness as a way of further prioritizing building upgrades.

C.3.2.2 Benefits and Costs

Potential marketing benefits increase by encouraging staff and faculty to pursue innovative, inter-departmental solutions to sustainability issues. Furthermore, interaction and contribution by both staff and faculty will strengthen the culture of sustainability on campus by engaging a wider group of active, aware participants.

As discussed in section C.3.1 above, a revolving fund could provide one means by which innovative pilot projects are tested. Typical modes of funding should also be considered; for example, the National Science Foundation (NSF) has established several grants that in particular support inter-disciplinary research efforts.[42] As the nation's top public research institution, the University has the opportunity to make an enormous impact in the field of sustainability by influencing its researchers to engage in related issues.

C.3.2.3 Barriers and Uncertainties

It is not clear to what extent faculty may be willing to pursue research projects related to sustainability if this is not their primary area of interest, nor to what extent the University can truly have an impact on the research pursued by its faculty.

D. GIS Systems Integration and Analysis in Planning and Monitoring at U-M

D.1 Build upon Existing Capacities (C, H , E, M, CA)

Link existing University information resources, such as the annual Space Management Survey and the Plant Operations Geographic Information System, to create a comprehensive model of the physical and environmental conditions of the campus

D.1.1.1 Recommendation and Background

The Buildings Team recommends that the University of Michigan support the development of and utilize a comprehensive Geographic Information System (GIS) program to link existing resources for information about the Ann Arbor campus holdings, including buildings, infrastructure, landscape, transit, water, and ongoing and future construction or renovation projects.

Having a consolidated view of campus systems, including but not limited to the age, repair history, maintenance needs, upgrade schedules and performance of buildings, infrastructural networks, and landscaped areas would be a valuable tool for tracking and analyzing the development of sustainable operations on the campus, and would inform decisions about future developments or renovations that could help the University achieve its Sustainability goals. Additionally, consolidating multiple resources will streamline data access for staff and campus stakeholders and will capitalize on established data collection methods to keep information accurate and up-to-date.

D.1.1.2 University of Michigan Current Staff Practices and Culture

Plant Operations at the University of Michigan currently maintains a robust GIS platform that accurately represents all of the buried utility lines on and around the Ann Arbor campus. In addition to the electric, gas, sewer, and steam networks, this system also contains information on area floodplains, watersheds, topography, property lines, and other significant physical entities, such as roads and building footprints. Several user groups within Facilities and Operations access this system, including varied utility shops for maintenance coordination, AEC for planning and construction purposes, and the Environmental Protection and Planning Program for information on landscape and utility conditions. Though Plant Operations has not tracked actual time savings since the implementation of this system, members confirm that this platform has drastically increased efficiency. The Plant Engineering department responsible for maintaining the GIS interface is in the process of implementing real-time electrical utility monitoring capabilities into the existing GIS platform. This will allow Plant Operations to rapidly identify any problems or sudden changes in utility draw that may suggest a maintenance need.

In addition to the existing GIS interface housed in Plant Operations, several other departments within facilities and operations track and maintain databases that contain information pertinent to the built environment around the Ann Arbor campus. The Real Estate and Space Information office located within AEC is responsible for maintaining current drawings of all the University's property holdings and complete campus maps. These drawings already provided the base maps the existing GIS interface. The Office of Space Analysis also maintains a highly detailed database of all campus buildings that is updated with information from the Annual Space Survey. This survey provides highly detailed information about each building, including building use, materials, utilities, and the life spans of all installed systems. The FCA database, discussed earlier in the *Renovations Under $10 Million* section also acts as a source for information on building maintenance requirements and the health and operation of building systems. Additionally, an organized inter-department effort within Facilities and Operations called BRIEFS is in the process of linking all of the major information resources for campus buildings. Their goal is consolidate disparate sources to insure that all departments have the most current information and to insure the fastest response time possible in the event of an emergency. Refer to Exhibit D.1.1.i in Appendix D for a network map of existing information infrastructure as the Buildings Team currently understands it.

All of these existing systems demonstrate the strength of the University's information infrastructure. Valuable information related to the composition and performance of the built environment is already being tracked across the campus and has been for many years. This information has been well utilized to demonstrate success in the University's commitment to energy reduction over the years. With some initial organization, investment, and research, this data can be used in an even more valuable way, to not only track the existing conditions and resources on the campus but to analyze future scenarios and contribute to informed decision making to meet the University of Michigan's Climate, Ecosystem Health, and Human Health goals.

D.1.1.3 Peer Institutions and References

The University of Oregon Infographics Lab houses and maintains the University's complete campus GIS network.[43] This model unites data from multiple resources and departments, including several utility systems (including electric, water, gas, steam, sewer, and telecommunication), transportation, tunnels, soil, vegetation, building data at a room-by-room resolution, and emergency and safety networks. This consolidation of information allows the Infographics Lab to generate consistent maps and tools for several audiences among the students, faculty, and staff. Through a single point of contact, University administration has a complete view of the workings of the Eugene campus and can make thoroughly informed decisions on planning, construction, transportation, and ecosystem health. Though operating as a research laboratory within the University, the Infographics Lab is a valuable resource to University administration and staff, insures the ongoing maintenances of campus information, and provides learning, research, and employment opportunities to students interested in Geographic Information Sciences. Refer to Exhibit D.1.1.ii in Appendix D for a diagram of the University of Oregon's information organization.

D.1.1.4 Benefits and Costs

Most immediately, the benefits of consolidating information on the Ann Arbor campus would include data consistency and connectivity and the reduction of data redundancy and inaccurate or obsolete information between departments. Additionally, maintaining a complete model of the campus would have potential to contribute to informed performance analysis and scenario planning. Increasing data accuracy and usability of the existing GIS platform could reduce the necessity for outside consultants for routine planning exercises, such as stormwater analysis or renovation coordination. Also, increasing the information included in the GIS platform could expand the audiences served and reduce staff time spent in generating individualized tools.

Costs would include initial investment in data collection and infrastructure in the form of both equipment and work hours. Some investment might be necessary to identify stakeholder and user groups that would benefit from access to campus information in a GIS format, and then to develop access infrastructure that will maintain information security based on each user group. At the time of issuance of this report, estimation of the scope of work and its financial cost are beyond the scope of the report, and further evaluation is required.

D.1.1.5 Barriers and Uncertainties

Uncertainties include the actual number of work hours that would be required to gather and format existing data sources into one complete model, as well as if this work could be completed by existing staff members or would require hiring specialists. Conversations with representatives from Plant Operations and the Space Information office indicate that key members are open to the coordination and sharing of information, but are concerned about the time and staff required. It is likely that new staff or a combination of staff and work-study positions for graduate students would be required for this initiative.

D.1.2 Format existing GIS information into accurate 3D model of campus topography, building footprints, and groundscape with key, regularly updated associated attributes

D.1.2.1 Recommendation and Background

The Buildings Team recommends enhancing the existing campus Geographic Information System to include three-dimensional information on buildings and topography, and to attach an expanded universe of attributes to campus features represented in the model.

Generating a GIS model with this level of resolution increases the potential for scenario planning and analysis. Accurate three dimensional visualization of building envelopes could be used for efficient construction coordination and choreographing. Campus-wide sustainability innovations, such as the institution of green roofs on campus buildings or the installation of on-site renewable energy production, could be virtually tested and reviewed for their cost-benefit performance and environmental impact. Room-by-room digital models of campus buildings would permit comprehensive documentation of space utilization information, maintenance and repair history or needs, and could house institutional knowledge like the locations of key system access points that might be lost through staff turnover.

D.1.2.2 University of Michigan Current Staff Practices and Culture

Currently, the GIS platform maintained by Plant Operations performs primarily as a representation tool. Staff members in individual Utility shops, AEC campus planning, and the Environmental Protection and Permitting Program can obtain accurate geographic information for key components of utility systems. Current practices do not include, however, the ability to add information regarding the performance of these systems' components or update information related to monitoring or maintenance. This information is collected under a separate system that is not tied to spatial information.

The Space Information office has indicated that it has relatively accurate digital three dimensional models of several of the buildings on central campus. This models indicate overall building footprint, overall height, floor-to-floor height, and first-floor elevation. Very few of them reflect individual floor plans or buildings' systems' layouts.

D.1.2.3 Peer Institutions and References

When the University of North Carolina, Charlotte, first explored the possibility of instituting a campus geographic information system, they intended to simply locate all buildings, equipment, and grounds. Through working with a GIS consultant, UNCC vastly expanded the capability of their system to include: "identifying employee locations at both the building and floor levels; visualizing work requests on a map according to total per building, dollar value, and work order system; accessing information about design services projects including costs via maps; [and] determining emergency phone locations and status of assets".[44] Additionally, the Facilities Information System can link to individual building automation systems, harvesting operational information from various locations on campus and storing it for performance review in one comprehensive database.

Corporate industries with working interests in harsh environments use three-dimensional GIS input to coordinate construction efforts and train workers before they are even on site. BP Exploration Alaska "uses GIS technology to accurately simulate the environmental and logistical constraints of remote projects", allowing crews "to visualize and 'walk through' a work environment before arriving on-site."[45] This generates situational awareness of a project and its constraints prior even starting the construction process, and helps reduce construction conflicts and environmental impacts.

D.1.2.4 Benefits and Costs

Similar to benefits from section D.1.1, expanding the existing GIS platform to contain three dimensional information and increase data resolution will give University administration, staff, and operations a more comprehensive view of the sustainable and ecological health of the Ann Arbor campus. Including floor plan information on a building-by-building basis can assist in the documentation and storage of institutional knowledge that does not currently have a record standard, such as the location of emergency shut off valves or the zoning of an air handling system. A sufficiently detailed model with flexible analysis controls could eliminate the need for some outside consultants for both planning and operations.

Cost investments would also be similar to those stated in section D.1.1. Significant time and work hours would be required to collect, verify, and input accurate physical information into the GIS model. Additionally, insuring accurate and timely information updates and access would require the development of methods for recording maintenance and system changes. This necessitates initial equipment investment and training for University staff.

D.1.2.5 Barriers and Uncertainties

Barriers and uncertainties include timeline associated with such an extensive information upgrade. As previously stated, the Space Information office maintains three-dimensional models of some of the campus buildings, but the Buildings Team is not certain of the actual extent. Additional uncertainties include institutional reception to reporting and documentation changes. A review of current the practices of building engineers and the staff of the Utility Shops could inform tools required for most accessible information infrastructure.

D.2 Developing GIS Capacities as Research Opportunities (C, E, M, CA)

D.2.1 *Establish a pilot project as an academic and operational collaboration to develop a comprehensive GIS model of one portion of the Ann Arbor campus*

D.2.1.1 Recommendation and Background

As a means to establish the best practices for instituting recommendations outlined in Section D.1.2, the Buildings Team recommends that one portion of the Ann Arbor campus be identified as a Pilot Project for the development of a comprehensive and interactive GIS model. This Pilot Project would unite students, faculty, and University staff to document and input existing campus conditions and develop appropriate and innovative analysis tools.

Running a pilot project for a small portion of the campus would permit the investigation and demonstration of analysis capacities without the investment of time and resources required for modeling the entire campus. This process would identify key information sources and analyses that would produce valuable results across the complete campus and potentially satellite campuses.

D.2.1.2 University of Michigan Current Staff Practices and Culture

Several academic departments within the University of Michigan are aggressively pursuing new and innovative methods of augmenting their research practices with geographic information systems. Both the School of Natural Resources and Urban and Regional Planning department within Taubman College require Geographic Information System courses as foundation skills. The Institute for Social Research uses GIS extensively for organizing demographic data. The Center for Statistical Consultation and Research offers a Graduate Certificate with a focus on GIS, as well as Applied Remote Sensing and Spatial Statistics. The Spatial and Numeric Data Services (SAND) lab acts as the central repository for GIS resources, information, and support.

Many of the research streams that invest in GIS as a resource are engaged with questions of human and ecosystem health, climate, materials footprint, and community awareness; however, at this point in time, very few of these research efforts are coordinated with the University's attempts to institute these values on their campus. Due to security concerns, operation and maintenance of campus geographic information is partitioned from academic and research resources, and is not generally accessible to students and faculty.

D.2.1.3 Peer Institutions and References

Adrian Smith + Gordon Gill Architecture (AS + GG), an established design firm based in Chicago and Dubai with an emphasis on high-performance and sustainable architecture, developed the Chicago Central Area De-Carbonization Plan.[46] Though this case study does not reference operations at a peer institution, it provides a robust example of the potential for collaboration between design disciplines and operational interests.

Working with the city of Chicago, AS + GG developed a comprehensive database and 3D model of every building in the Central Chicago area. This model included information on the energy use, size, age, use, and estimated carbon footprint of each building, as well as data on the existing infrastructure of the downtown area. By combining information on buildings, infrastructure, water, transportation, land use, waste, and community engagement, AS + GG developed an action plan for the City of Chicago to meet the carbon reduction goals stated in the Chicago Climate Action Plan. The DeCarbonization plan "interweaves energy engineering, architecture, and urban design".[47] Working with one comprehensive model allowed the City of Chicago to understand the inter-relationships between elements of the community and the built environment and to develop synergistic solutions for carbon reduction. Going forward, the City of Chicago will use the model to track performance improvements in the central downtown area. The DeCarbonization model is a strong example of the possibilities for visualization and virtual modeling to contribute to real-world climate change mitigation.

D.2.1.4 Benefits and Costs

Including student and faculty researchers in the process would provide multiple benefits, potentially alleviating the staffing pressure from facilities and operations, creating research and educational opportunities in emerging fields, and encouraging interdisciplinary collaboration between ecologists, landscape and building architects, planners, and engineers. Geographic Information Systems are a growing territory of interest across several academic disciplines. A real-world interdisciplinary geo-spatialization project would be an attractor for new faculty and student talent.

Costs would include start up research funds to sponsor a faculty-led team to undertake the pilot project. These costs could potentially be mitigated by state and nation wide research grants or corporate partnerships available to GIS related projects. Additional costs would include staff time to engage in the pilot project. Higher-level staff within AEC and Facilities and Operations would be required to provide experience and guidance for campus procedures.

D.2.1.5 Barriers and Uncertainties

Uncertainties include the comprehensiveness and availability of campus data. The best documented campus area would most likely be the best candidate for a pilot project, but there could be significant benefits to focusing efforts on an area of campus that is currently less developed. Additional barriers could include limitations to the development of data collection methodologies. One of the most important components to test will be user-friendly methods for accurate data collection. Investing in this technology on a small scale may be less cost effective than upgrading all campus equipment.

D.2.2 *Explore possibilities for high-fidelity long-range (25-50 years) GIS-based modeling of environmental impacts of campus development decisions*

D.2.2.1 Recommendation and Background

Many of the components of sustainable architecture, landscape design, and planning are intended to provide long-term positive impacts on environmental and human health. However, apprehending the full effect (positive or negative) of development decisions over a long time range can be extremely difficult. Cutting edge research labs in North America have demonstrated the effective linking of GIS information models with high resolution digital visualization programs to test the environmental results of various development and ecological protection scenarios. These models are designed so users can manipulate key conditions of the built and natural environment and generate a clear understanding of the potential impact of these conditions. The Buildings Team recommends that the University of Michigan invests in research in long-range GIS-based environmental modeling efforts, both to provide a practical tool for reaching the University's sustainability goals and to build research capacities at the University of Michigan. Visualizations are often more compelling and accessible communication devices than statistical models or charts. Products of such a model could be used to increase community awareness of environmental efforts at the University and at large.

D.2.2.2 University of Michigan Current Staff Practices and Culture

A number of departments at the University support student and faculty research that would be integral to this project, including the School of Natural Resources and the Environment, Taubman College of Architecture and Urban Planning, and the College of Engineering.

Current Campus Master Planning efforts employ a flexible framework plan which is continually updated to include best practices for sustainable development as they are proven on campus. At the initiation of any major building or grounds project, several key players engage in several discussions about the potential concerns and opportunities for the sustainable performance and environmental impact of the project.

D.2.2.3 Peer Institutions and References

The Institute for a Sustainable Environment (ISE) at the University of Oregon has partnered with the Pacific Northwest Ecosystems Research Consortium (PNWERC) to examine the ecology of the Willamette River in northwest Oregon. The Project "Trajectories of Change in the Historical

Floodplain of the Willamette River" examined the conditions of the river and its watershed over the course of 100 years, and then utilized their findings to project what the conditions of the river would be in 40 years depending on development patterns and planning regulations. Using geographic information tied to 3D animation software called Maya, the ISE could rapidly depict what the Willamette River basin would look like if land development continued at its current rate, if the development rate increased as it had historically, and if conservation measures were adopted in development regulations that worked to protect and restore the ecosystem health of the river basin. Using this model, researchers and stakeholders could test what factors would have the greatest environmental impact and could make informed decisions on how best to influence planning measures to protect the natural resources of the river.[48]

D.2.2.4 Benefits and Costs

Benefits would include positioning the University of Michigan as a leader in projective ecological planning and impact modeling. Additionally, by focusing efforts around the Ann Arbor campus and the delicate watershed of the Huron River, the University would be sponsoring the development of a tool that could inform planning decisions and quantify long-term benefits of sustainable planning decisions.

Costs would include start up research funds to sponsor a faculty-led team to undertake the project, though as with section D.2.1, these costs could potentially be mitigated by state and nation wide research grants or corporate partnerships available to GIS related projects. Collecting, verifying, and inputting the appropriate data would also represent an initial investment, however departments at the University may already contain some of the necessary information.

D.2.2.5 Barriers and Uncertainties

Uncertainties include faculty and staff members most suited for such a project as well as most significant information for impact evaluation. Additionally, the cost of equipment, time, and work hours required to develop a functional model are also uncertain, and may represent prohibitive start-up investment if research is not already underway.

IV. INTEGRATION & CONCLUSION

The recommendations developed during the Phase II Integrated Assessment process by the Buildings Team have aimed to target specific institutional processes and practices with the goal of overall elevation of sustainable design integration into small projects on the Ann Arbor campus. In general, each recommendation identifies an existing impediment to implementation and identifies means to address the larger ambitions of each goal through application within existing U-M departments, staff compliments and policies. The preceding report aims to frame each of the areas of our investigation in the context *of a stretch goal*, recognizing that timeframes associated with pilot projects, assessment and eventual uptake of the strategies would likely occur across a range of durations, as ongoing performance assessments inform U-M Policies.

With respect to the degree to which recommendations contained within the Building Team's report address the broad goals established by the Integration Team: *Climate, Human Health, Ecosystem Health, Materials Footprint, Community Awareness*, we have made efforts to incorporate to the greatest degree possible, the maximum bandwidth of these criteria within each individual recommendation. As the impetus for our efforts was to focus on recommendations that would transform the institutional culture of the transformation of sustainable building delivery at U-M, this naturally follows. By keeping recommendations broad in nature and focused upon institutional and departmental process change, the specific impacts of the recommendations would likely be shaped more by the outcomes achieved by each affected agency (AEC, Planet Blue, Plant Operations) through their execution of related mandates over time, rather than through quantifiable means legible immediately after implementation. Similarly, the potential impact of these recommendations would be entirely depended on the scope of work undertaken by the related agency. A larger portfolio of sustainable projects undertaken by either AEC or Planet Blue would result in greater measureable impacts within this framework. The Buildings Team has also endeavored wherever possible in this report to prioritize the inclusion of Community Awareness and the development of academic research opportunities to enhance the learning experience within the U-M Community as a result of related recommendation implementation.

The Buildings Team is hopeful that its contributions to Campus Sustainability discussions at U-M will be of value, and may help to catalyze increased implementation of sustainable design practices at U-M through the reframing of financial metrics for evaluation, improvement of staff capacities, and advancement of advanced technologies towards a sustainable campus environment.

Synergies with other Teams for Integration

It is anticipated that recommendations regarding resource reuse and recycling (B.3) should be reviewed alongside parallel recommendations identified by the Food Team and Purchasing Team, in order to identify the degree to which overlaps and synergies between related practices may be capitalized upon. The discussion of the didactic potential and marketing role of sustainable construction projects captured in (B.4) may have synergies with recommendations framed by the Culture Team related to campus awareness regarding sustainable practices.

APPENDIX A

Additional Case Studies and Figures Supporting Section A: "Capital Project Approval Guidelines for Small Construction Projects

Case Study 1: Net Present Value evaluation of ECM's

Planet Blue staff and the Energy Conservation Committee (ECC) provided the Buildings Team with four sample ECMs during a Fall 2010 project proposal approval meeting. Consistent with SID guidelines, all four projects detailed the initial investment required for the project (including design, labor, and materials) as well as the annual expected energy savings based on current year utility rates. Projects that met the eight-year simple payback requirement would be approved by the committee. All projects incorporated a 10% margin of error rate into their calculations.

To highlight the differences between simple payback modeling and NPV, the Buildings Team recalculated all four sample ECMs using the NPV criteria. In particular, the pro forma ECM calculations gave consideration to changes in energy cost, an assumed cost of capital, and an eight-year project useful life.

The cost of capital utilized in the pro forma ECM analysis is 8%. With consideration given to the University's current 10 year annualized return of 9% and Harvard University's 9% IRR requirement for sustainability projects, we employed a slightly more conservative estimate for the cost of capital for case illustration points. An 8% cost of capital captures the opportunity cost of foregone projects, investment potential, and inflation. Should NPV analysis be adopted as a policy for decision-making, more thoughtful consideration should be given to the relevant discount rate for each University unit.

The pro forma analysis assumes an increase in energy costs over the eight-year useful life of all project proposals. The current simple payback model utilizes the current utility rate, but volatility in energy rates is a significant factor affecting the real payback of a project We acquired historical and expected future University utility rates for electricity, steam, and natural gas and inquired into the University's rate setting procedure. Utility rate setting procedures are a collaborative process between Financial Operations, Facilities and Operations, and the Provost's Office. The cross functionality of the team engaged in the rate setting process is one of the key success factors of the process and it allows for rates to be set with long term stability perspectives.[ix] The Buildings Team was provided with historical rates from 2007 through 2009, as well as expected utility rates through 2013. The raw data is presented in EXHIBIT A.1.4.i. The Buildings Team calculated the yearly percentage change in utility rates for purchased and Central Power Plant rates to observe trends and averages in utility prices.

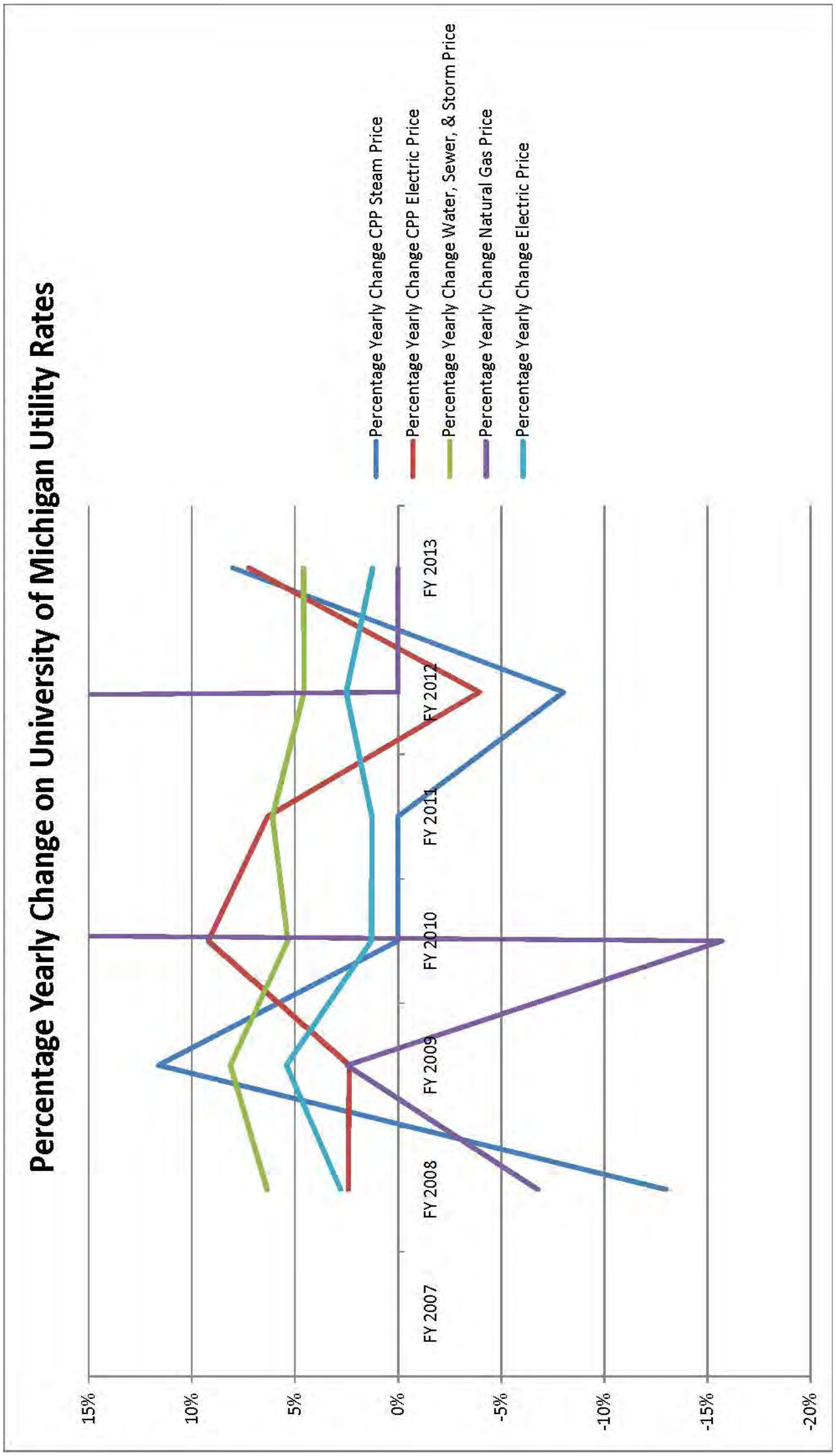

FIGURE A.1.4.i :
Graphical Representation of Annual Percentage Change in U-M Energy Contracts (Graph produced by A. Ambroselli from data provided by U-M Utilities)

The graph above depicts the percentage yearly change of the five principle energy contracts at the University. It illustrates the immense variability in the year over year historic and anticipated costs of energy. While some year's energy costs decline, most years follow the expected trend of rising energy cost. Volatility and rising energy costs fundamentally challenge the simple payback model's assumption of constant yearly cost savings. Thus, the pro forma analysis of certain Planet Blue ECMs utilizes a default assumption of 5% annual increase in energy cost, but in conjunction with a sensitivity analysis for best and worst case scenarios (2% and 8% annual increases respectively).

Finally, the Buildings Team maintained an assumed eight-year useful life for all projects in order to benchmark against the default case of an eight-year maximum simple payback. Should NPV criteria be evaluated, project proposals should utilize a time horizon of the entire life of the project, which in many cases is assumed to far exceed the eight-year minimum threshold. For a discussion of the utilization of the FCA database to benchmark useful life of fixed assets, refer to in SECTION B.2.0 of this report.

Through completing a pro forma analysis on the ECMs under NPV, the Buildings Team found that on average the investment decision would not change between simple payback and NPV analysis. However, as highlighted below, the assumptions of the cost of capital, annual energy cost, and expected project useful life have significant implications on the 'real value' of a project, and assumed benefit or impact returned to the client unit.

FIGURE A.1.4.ii :
Pro Forma Energy Conservation Measure Analysis under Net Present Value

ECM 1:

Scenario Summary			
	Slowly Rising Energy Cost	*Moderately Rising Energy Cost*	*Rapidly Rising Energy Cost*
Changing Cells:			
Assumed Change in Energy Cost	2%	5%	8%
Result Cells:			
Net Present Value	$ 242,232	$265,542	$$288,852

ECM 2:

Scenario Summary			
	Low Rising Energy Cost	*Moderate Rising Energy Cost*	*High Rising Energy Cost*
Changing Cells:			
Assumed Change in Energy Cost	2%	5%	8%
Result Cells:			
Net Present Value	$6,030	$10,740	$15,450

ECM 3:

Scenario Summary			
	Slowly Rising Energy Cost	*Moderately Rising Energy Cost*	*Rapidly Rising Energy Cost*
Changing Cells:			
Assumed Change in Energy Cost	2%	5%	8%
Result Cells:			
Net Present Value	$1,323	$4,518	$7,714

The first ECM generated a simple payback of .5 years. Under the NPV modeling approach, the annual cost savings per year generate positive 'real value' of approximately $265,500 over the eight-year assumed payback period, under the default assumptions of an 8% cost of capital and

5% annualized increase in energy cost. Notice that the investment decision would not change using one model over the other.

The second and third sample ECMs were identical projects proposing the installation of occupancy sensors in their respective buildings. ECM 2 generated a simple payback period of 5.9 years while the third paid back in 5.4 years. The Buildings Team noticed the consistency between the simple payback of both projects. The initial investments of both projects were similar, but the expected annual energy cost savings differed between the two buildings. When compounded by the cost of capital each year, the NPV of two very similar projects (both in project type and cost) are vastly different. ECM 2 had an NPV of approximately $10,740 while ECM 3 had an NPV of $4500. ECM 3 paid back much slower than ECM 2, and accordingly, the NPV of this particular project is significantly lower over the eight-year time horizon than the second project. While both returned positive value, the speed at which the breakeven point is reached differs, as is the 'real value' returned to the client academic unit.

In these situations, it is imperative to understand the implications of the assumption inputs relevant to the model at hand. While all of these projects do pay back within the eight-year time horizon, careful consideration should be given to the variances between the two proposals and their expected 'worth' to the University. In all three cases, the Net Present Value of the projects is positive. That is, at some point during their expected useful life, they will generate positive *real* cash savings for the unit the ECM is applied to. The important consideration is the speed and the overall magnitude of that payback for capital budgeting decisions.

Further, while none of these projects failed to pay back within the eight-year time horizon, many scenarios will exist where the simple payback and the NPV modeling approach differ. That is, a project may seem to pay back in simple terms, but when considering the cost of capital, changes in energy cost, and the expected or actual useful life (versus required payback period), the NPV may actually turn out to be negative. Conversely, the more common case with sustainability initiatives is the assumed 'base case' where projects fail to meet the simple payback threshold, but do return positive value when considering the real effects of the future cash flows. In these cases, the investment decision would differ between simple payback and the NPV model, and careful consideration must be given to the assumption inputs and the appropriateness of one metric over the other. With those calculations, it is then possible to rank each one of these projects against each other when applicable. During the approval meeting, the ECC approved ECM project proposals on a 'first-in' basis as is currently done. The Buildings Team found this appropriate given the project specificity and current client needs of all proposals. However, given the budgetary constraints at fiscal year end, we imagined scenarios where renovations and ECMs may have to be ranked against each other in order to remain within AEC or Planet Blue's current operating budget. The sensitivity analysis and real cash value of the projects determined by NPV calculations allow such factors to be considered in decision-making.

Case Study 2: Evaluation of Cost savings of Intangible Benefits on a LEED certified Building

In order to best illustrate the economic benefits of utilizing expected value calculations for decision-making, the Buildings Team performed an economic analysis of certain sustainability projects. The following is a case example of the economic benefit required to meet the discounted criteria discussed in the context of NPV. To highlight how expected value calculations could prove useful for decision makers in the AEC or Planet Blue, the Buildings Team developed hypothetical project scenarios of $2, $5, and $8 Million. For further scenario analysis, each building could potentially achieve LEED accreditation. The Buildings Team imagines that even relatively small projects as low as $2 Million could potentially qualify for some LEED credits. Exhibit A.2.3.i below outlines the cost premium for each LEED rating - Platinum, Gold, Silver, and Certified under two distinct academic studies. The Buildings Team uses the cost premium average across both studies of 3.87%, which is higher than both the LEED Silver and Base Certification premiums cited in both studies.[49]

Capital Project Initial Investment (A_1)	LEED Certification	LEED Project Initial Investment (A_2)	Internal Rate of Return (r)	Change in Energy Cost (u)	Cash Flow Factor (x)	Required Initial Cash Flow for Non-LEED (B_1*x)	Required Initial Cash Flow for LEED (A_2*x)
$ 2,000,000.00	3.87%	$ 2,077,475	8%	5%	0.148679	$ 297,358	$ 308,877
$ 5,000,000.00	3.87%	$ 5,193,688	8%	5%	0.148679	$ 743,395	$ 772,192
$ 8,000,000.00	3.87%	$ 8,309,900	8%	5%	0.148679	$ 1,189,432	$ 1,235,508

EXHIBIT A.2.3.i :
Cost premiums associated with achieving LEED accreditation on capital projects.

$\$0 = A - \Sigma_{1:n}[\, Ax(u^{(n-1)}) *(1/r^n)]$
Where

x = Variable. Cash flow or savings factor

n = Expected useful life of the project. Varies from 1 to eight-years by assumption in previous section
u = Utility rate. Varies by an annual increase of 5% each year
r = Cost of capital. Assumed 8% to calculate IRR (NPV = $0)

A = Initial investment
*A*x* = Initial cash flow required

In simple terms, this model forecasts the required initial (and subsequent) energy cost savings required in order to breakeven on both LEED and Non-LEED projects over an eight-year expected useful life in real dollar terms. The model assumes an annual rise in energy cost of 5% over the eight-year period, and an 8% required cost of capital.

The Internal Rate of Return (IRR) on a project is the *cost of capital* or discount factor such that the Net Present Value is $0. That is, IRR finds the breakeven point in real terms to evaluate a project. The Buildings Team uses an IRR of 8% and an annual increase in energy cost of 5% as discussed in Appendix A, Case Study 1. Using the given parameters, we solve for the initial cash flow factor required for both LEED and Non-LEED projects to return a Net Present Value of $0 (Real terms breakeven point).

Project Year	0	1	2	3	4	5	6	7	8
Initial Investment	$5,193,688								
Required Cash Flow		$772,192	$810,802	$851,342	$893,909	$938,605	$985,535	$1,034,811	$1,086,552
Discounted Cash Flow	($5,193,688)	$714,993	$695,132	$675,823	$657,050	$638,798	$621,054	$603,803	$587,030
Net Present Value	($5,193,688)	($4,478,695)	($3,783,563)	($3,107,740)	($2,450,690)	($1,811,892)	($1,190,838)	($587,035)	($5)
Intangible Cash Flow		$317,778	$317,778	$317,778	$317,778	$317,778	$317,778	$317,778	$317,778
Discounted Intangible Cash Flow		$294,239	$272,443	$252,262	$233,576	$216,274	$200,254	$185,420	$171,685
Net Present Value	$0	$294,239	$566,682	$818,944	$1,052,520	$1,268,795	$1,469,048	$1,654,469	$1,826,154
Triple Bottom Line NPV	($5,193,688)	($4,184,456)	($3,216,881)	($2,288,796)	($1,398,170)	($543,097)	$278,211	$1,067,434	$1,826,149

EXHIBIT A.2.3.ii:
Internal Rate of Return and Required Initial Cash Flow for LEED Projects

Going forward, the Buildings Team will provide its analysis using the base case of a hypothetical $5,000,000 LEED Project. The University of Michigan maintains a minimum LEED Silver requirement for capital projects exceeding $10,000,000, so this case provides an interesting point of comparison to current policy. For this hypothetical LEED Certified renovation, an initial cost savings of $772,192 would be required. Each year this initial cash flow would increase by 5%, the assumed annual increase in energy cost. Each future cash flow is then discounted by 8% to reflect the decline in real value of those cash savings in the future.

This case highlights the difficulties policy makers encounter as they attempt to implement sustainability projects within their organizations. Is this required initial cash flow actually feasible? To what extent will the heating, cooling, power, and water cash savings of this proposed green project actually meet that substantial required return? For larger capital projects versus simple conservation measures, this is the obvious dilemma. The required return is not economically realistic within the parameters given. The Rocky Mountain Institute Sustainability Report cited payback as one of the most significant barriers to undertaking green capital projects. While projects are merited based on their consistency with an organization's value proposition and overall purpose, the payback threshold is unfortunately prohibitive in many instances – organizations must often forego extremely valuable projects or opportunities because the payback does not meet the required threshold.

Does this imply that an organization can do nothing to make a rational, economic argument for the other impacts or benefits that a project will be deemed to have? The Buildings Team believes that when projects are deemed to have strong strategic purposes, financial modelers should aim to include the expected values of those intangible impacts to best highlight the overall impact of a project beyond its simple bottom line payback. As discussed above, the Buildings Team recognizes three principle qualitative benefits of sustainable construction – beyond the simple scope of payback in energy efficiencies or utility consumption. Sustainable building practices increase student and faculty health, increase overall productivity and efficiency, and attract and retain higher caliber talent to the University. An abundance of case studies, news articles, and anecdotes offer support for these claims. Green building, with the wider acceptance of LEED certification, is a growing industry because of the recognition that such practices lead to "lower overhead costs, greater employee productivity, less absenteeism, and stronger employee attraction and retention" within organizations from Fortune 500 Companies to large research Universities.[xvii] Lockwood's *Harvard Business Review* discussion of the advantages of green construction cited several case statistics relevant to this discussion. One study noted that sustainable building practices improved worker productivity by approximately 15%, with 58% of employees self-reporting an individual improvement in productivity since the renovation. Sick time in this case study decreased by 5%.[xvii]

While case statistics provide no burden of proof for rationalization of these metrics for this particular institution, policy makers can imagine how such factors should weigh into any large-scale capital renovation. Do decision makers believe that sustainable building practices will increase morale and thereby increase productivity? Do they believe that quality building materials and increased morale may reduce sick days or absenteeism? Will sustainable building practices increase the ability for the University to attract and retain the *Leaders and Best* from across the world? Moreover, are sustainable constructions more likely to receive larger gifts in development campaigns?

If the answer to any of these questions for any given project is yes, then intangible benefits must be included in the Net Present Value evaluative process at their expected value. The following table highlights a hypothetical intangible valuation for the mid-level LEED project discussed above.

	Intangible Factor	Potential Value	Probability	Weight	Expected Value
Student and Faculty Health	Reduced Absenteeism	$ 35,556	50%	1	$ 17,778
	Community Public Health	$ 500,000	5%	0.5	$ 12,500
Morale and Productivity	Staff Productivity	$ 200,000	50%	1	$ 100,000
	Community Satisfaction	$ 500,000	5%	0.5	$ 12,500
Talent Attraction and Retention	Recruitment and Retention	$ 500,000	10%	1	$ 50,000
	Development Campaign	$ 5,000,000	2.5%	1	$ 125,000
Intangible Benefit					$ 317,778

EXHIBIT A.2.3.iii:
The Expected Value of Intangible Factors

The table above is a hypothetical calculation for how expected value methodologies could be applied to rationalize certain capital expenditures for sustainability projects. The variables *Reduced Absenteeism*, *Staff Productivity*, and *Development* are indirect-use values while the variables *Community Public Health, Satisfaction, and Talent Recruitment and Retention* are non-use values. The total intangible benefit calculated is the annual intangible benefit that may then be added into the Net Present Value calculation to determine the overall ‘triple-bottom-line’ impact of the proposal, beyond the strict economic payback. While this is merely a hypothetical scenario, rationalization of the values and weights in the table is an important consideration before inclusion of these factors because they are subjective.

The intangible value assigned to *Reduced Absenteeism* was calculated as a function of cumulative salaries paid, divided by an assumed 225 working days in a calendar year. The Buildings Team imagined a renovation project in a University facility with 100 full time faculty members (including tenured professors, lecturers, graduate student instructors, and facilities personnel). The hypothesized average salary is $80,000 across all 100 individuals. The $35,000 total benefit is then the annual intangible benefit of a foregone additional sick or personal day because of the health benefits of the green construction. The Buildings Team hypothesized that this could occur with a probability of 50%. As a true, quantifiable or direct use value (one with true economic substance), the weight applied to it is 1.

The intangible value assigned to *Community Public Health* is an assumed $500,000, but with only an assumed probability of occurrence of 5%. As an indirect-use benefit, the weight on this intangible (non-use value) variable is .5.

Staff Productivity was calculated using the same cumulative salaries paid assumption as the *Reduced Absenteeism* variable ($80,000 * 100 individuals). The Buildings Team assumed an annual increase in productivity of 2.5%, with a probability of 50%. Productivity, as a quantifiable, direct-use value receives a weight of 1.

The variables *Community Satisfaction, Recruitment and Retention,* and *Development Campaign* are all wholly hypothetical values for the purpose of illustration. A potential value is proposed, each with an expected probability of occurrence. Once again, indirect-use values (those that could be quantified) are assigned a weight of 1, while non-use value intangibles (qualitative impacts) receive a weight of .5.

The cumulative discounted effect of the intangible variable’s impact in this case example is nearly $2 Million over the eight-year expected life of this $5 Million LEED Project. Inclusion of the intangible variables – those which we can reasonably assume will have some overall material impact on the University community – raises the Net Present Value of this project from the assumed $0 base case used to calculate the required cash flows to nearly $2 Million in net benefit realized. Through performing this analysis, the Buildings Team does not claim to rationalize the true sustainable costs and benefits of any given project. However, the calculation does provide rationalized, quantified expected benefits to some of the intangible impacts a green construction project may have. As mentioned, University staff already considers these attributes in qualitative terms, but being able to attach a reasonable expected value to each variable elucidates the perceived true cost and benefit to the University system.

APPENDIX B
Additional Figures Supporting Section B: "Building Renovations Under $10M"

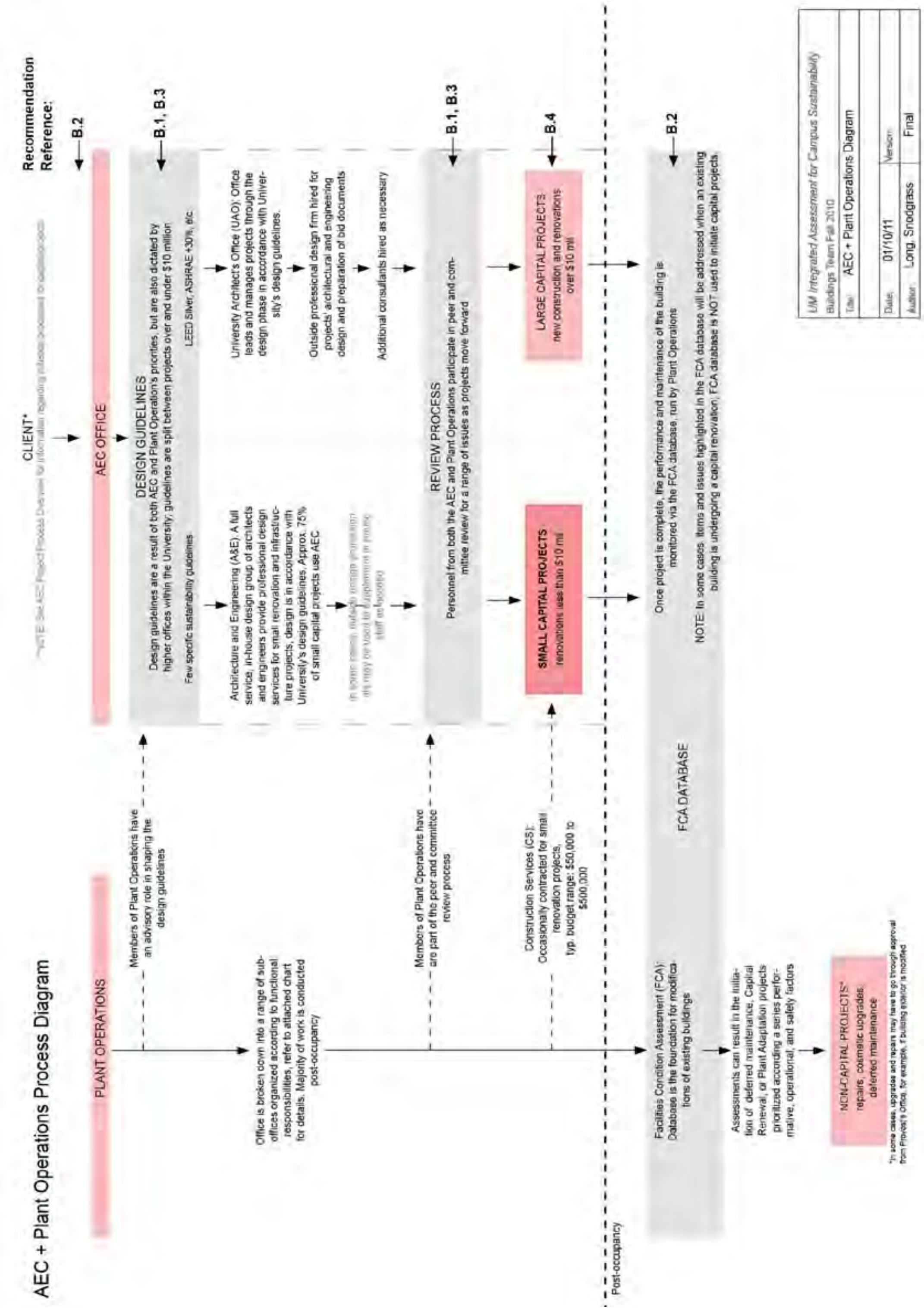

EXHIBIT B.1.1.i: Process diagram for Initiation and Execution of Small Capital Projects

EXHIBIT B.4.1.i: Number of buildings receiving LEED Certification and registering for LEED enrollment[50]

APPENDIX C
Additional Figures Supporting Section C: "Planet Blue Programs and Practices"

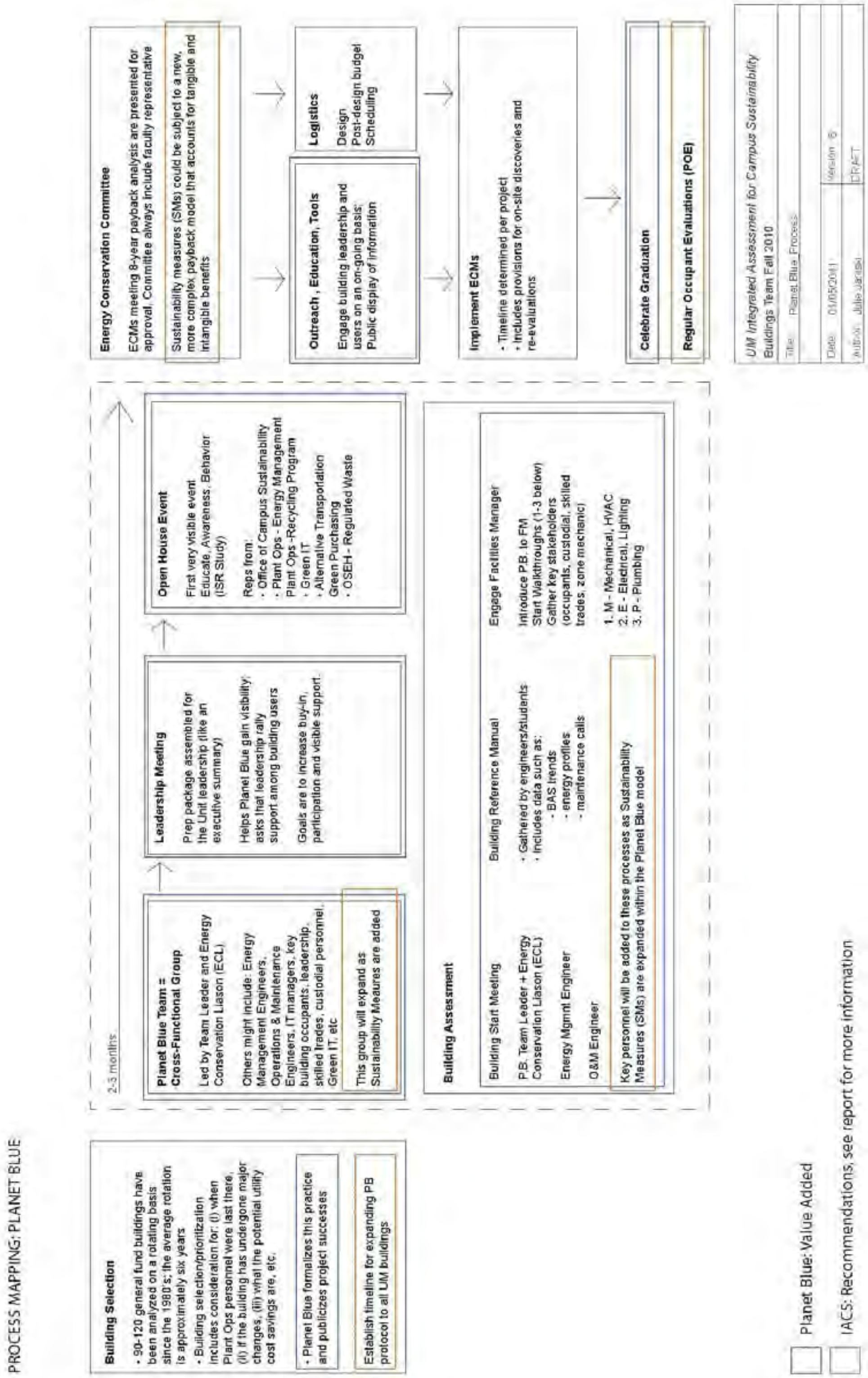

EXHIBIT C.2.2.i: Planet Blue Process Map

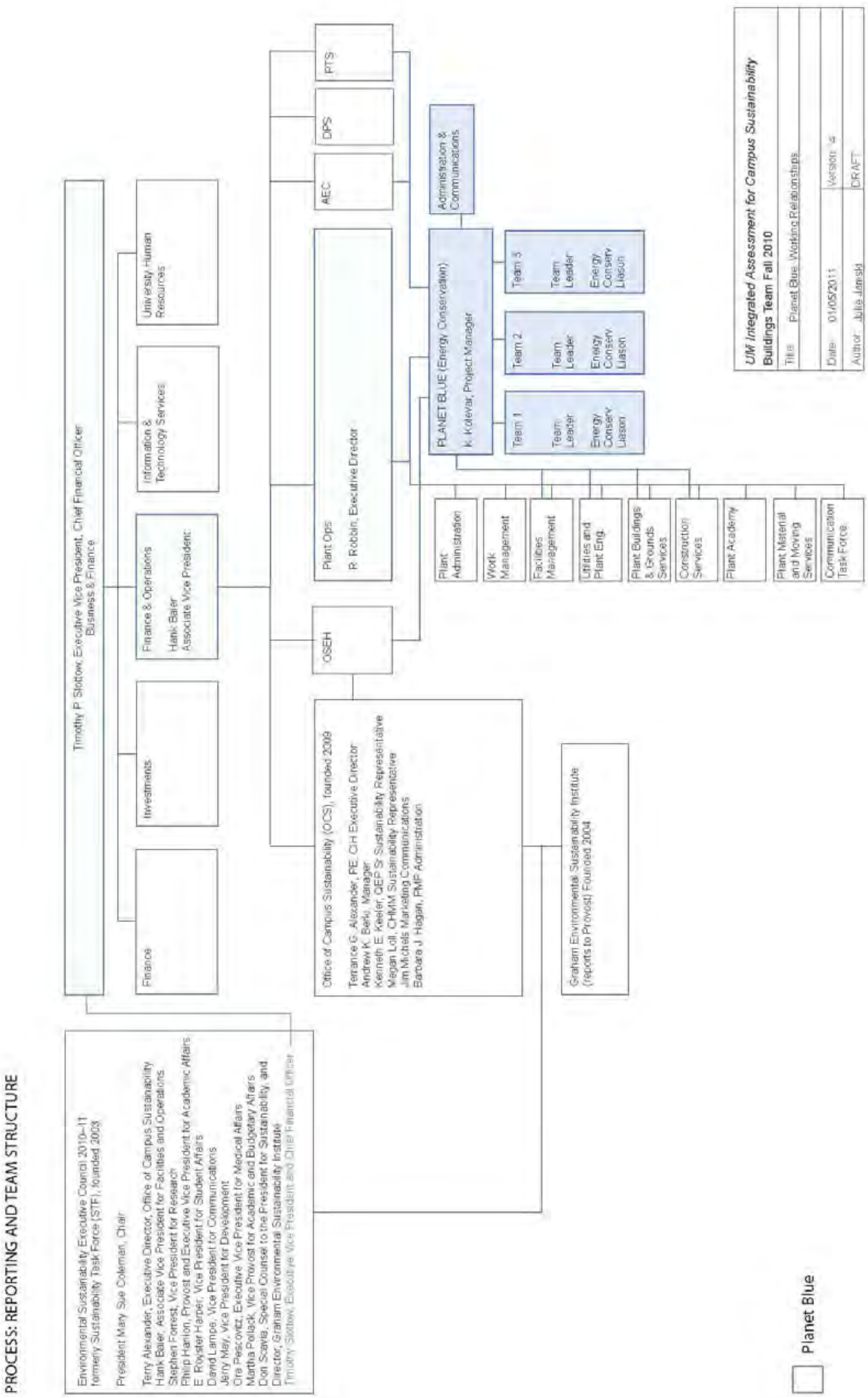

EXHIBIT C.2.2.i: Planet Blue Organization and Team Composition

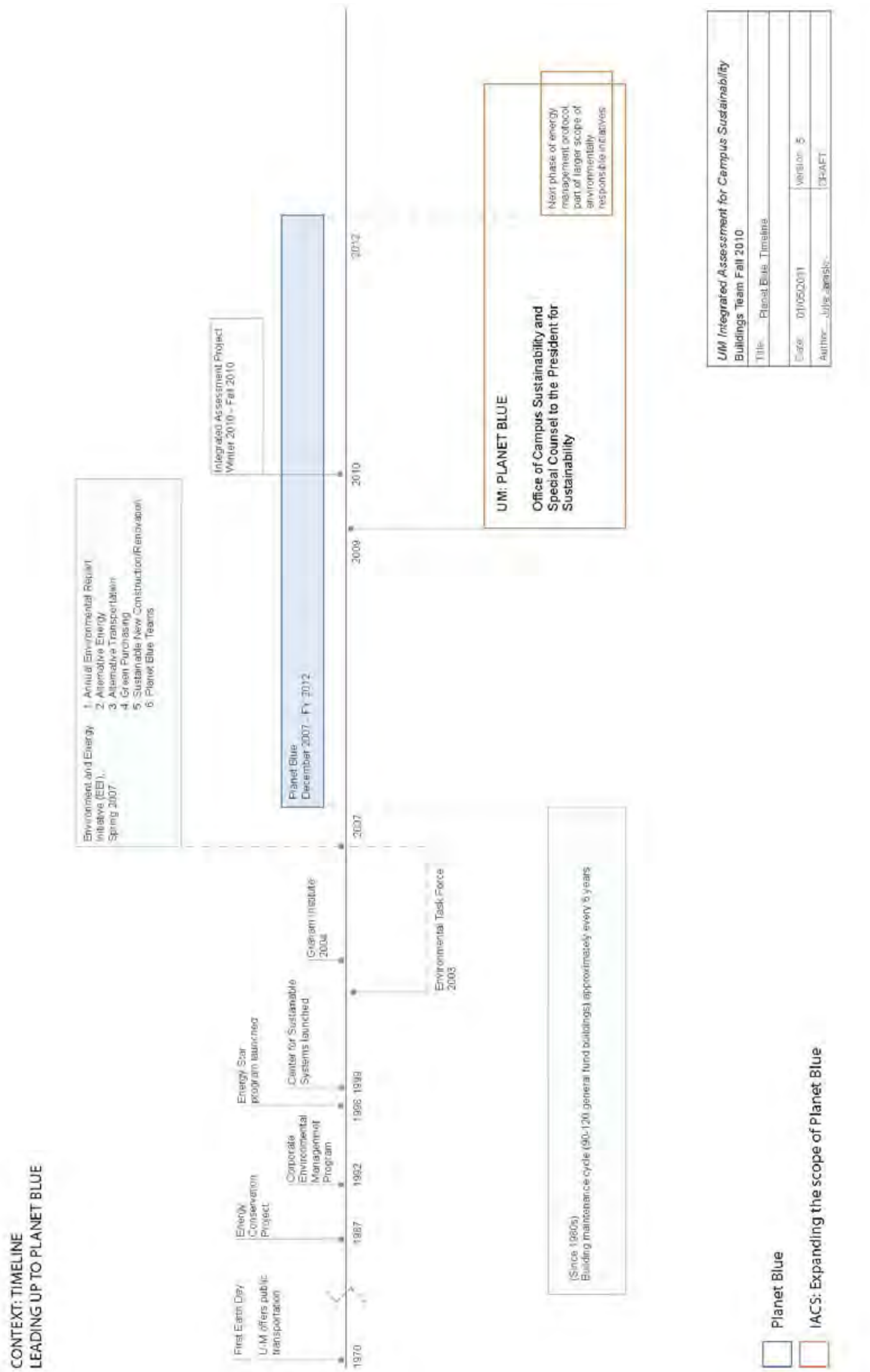

EXHIBIT C.2.4.i: Timeline of U-M Energy Conservation Program Preceding Planet Blue

APPENDIX D
Additional Figures Supporting Section D: “GIS Systems Integration and Analysis in Planning and Monitoring at U-M”

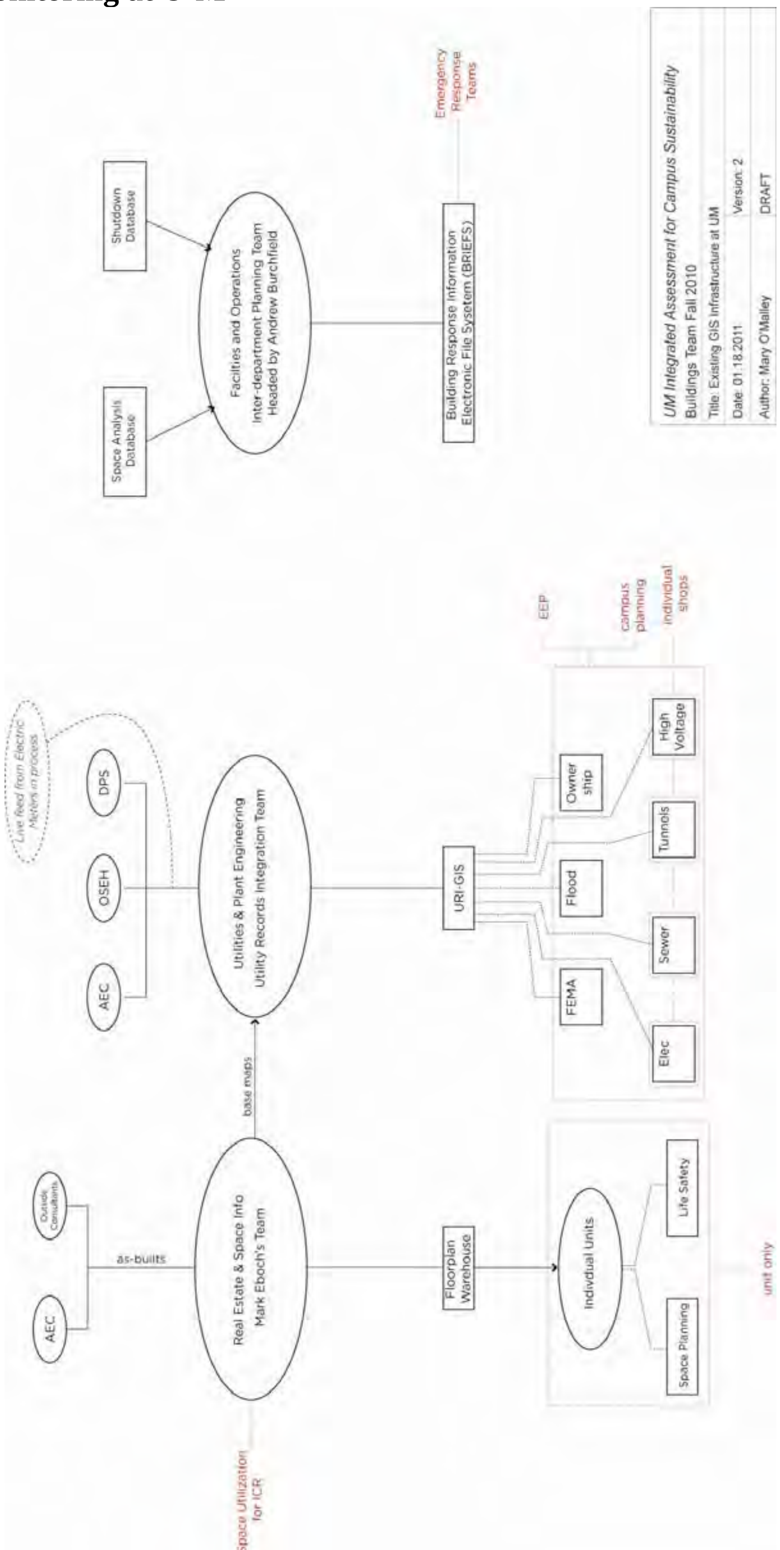

EXHIBIT D.1.1.i: Current U-M information organization

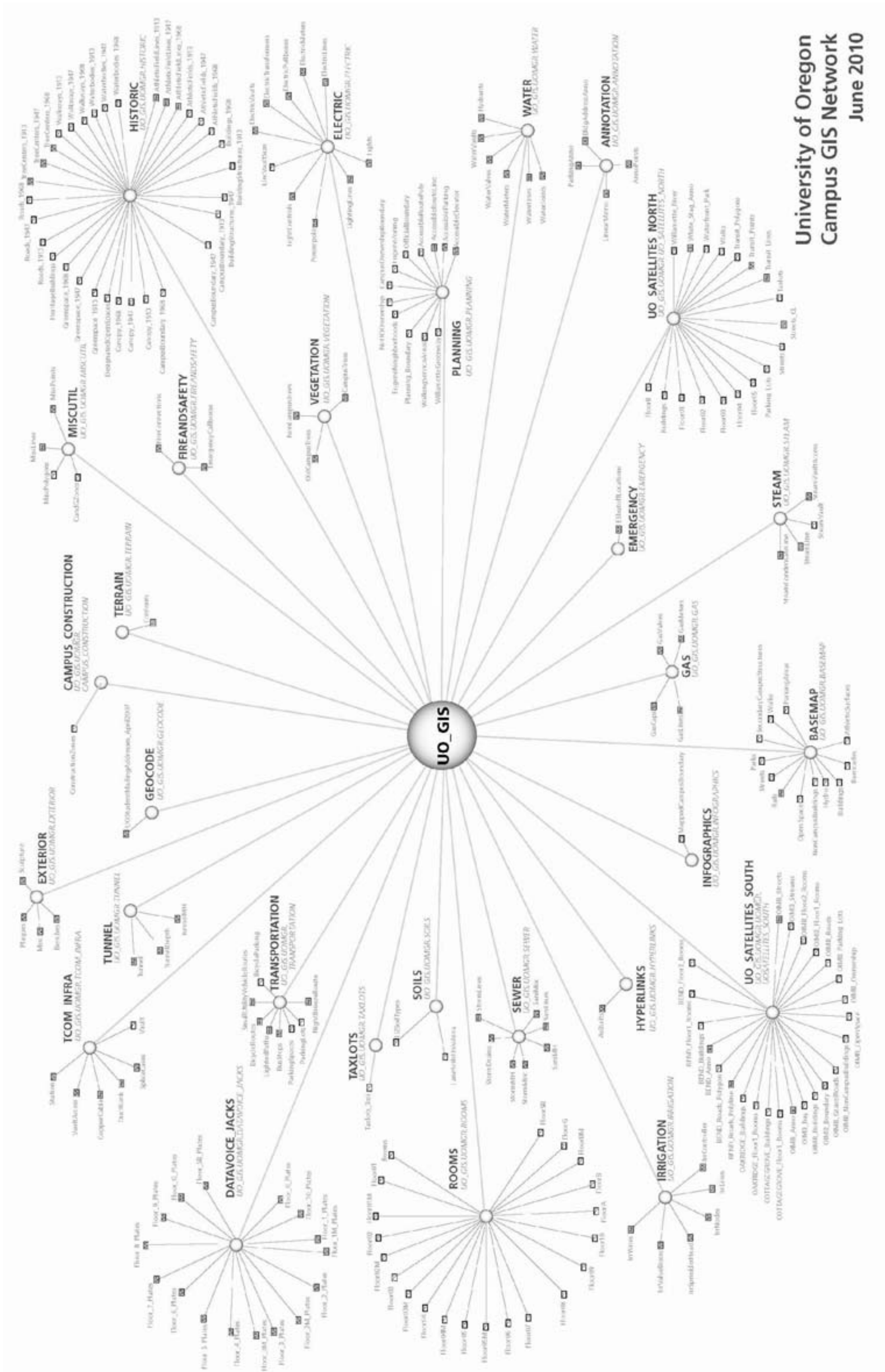

EXHIBIT D.1.1.ii: University of Oregon Infographics Lab Data Model[43]

			Economic Aspects			Environmental Aspects			Social Aspects		
		Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footpri	Human Health	Community Awareness/ Reputational	Learning/Researc h Opportunities
Capital Project Approval Guidelines	Employ Net Present Value criteria for approval of capital projects	1	1	2	5	*	*	*	N/A	NA	N/A
	Incorporate Expected Value of intangible factors into payback modeling for capital projects	2	1	3	4	N/A	N/A	N/A	*	*	*
Renovations Under $10 Million	Develop in-house capacity to perform energy modeling for small renovation projects	1	2	5	4	2	2	2	2	5	5
	Expand in-house commissioning practices to include design-phase commissioning for small renovation projects	5	2	5	3	4	4	4	4	N/A	N/A
	Expand thermal scanning program to include small renovation projects	7	3	3	3	4	4	4	4	N/A	N/A
	Provide annual training sessions for AEC staff on the latest sustainable building practices specific to small renovation projects	3	4	N/A	4	5	5	5	5	5	4
	Utilize FCA database as a benchmark for renovations against expected useful life of equipment	2	N/A	4	5	3	3	3	3	N/A	N/A
	Develop construction practices code of conduct specific to small renovation projects, including a materials reuse/recycling program	4	4	5	5	5	4	5	3	5	3
	Actively market UofM's reputation and recruitment agendas associated with sustainable design through building renovations	6	N/A	1	3	N/A	N/A	N/A	N/A	5	N/A
	Use the built environment as a core hands-on teaching tool to expand current curricula and advance student initiatives of sustainable practices	8	N/A	*	N/A	N/A	N/A	N/A	N/A	N/A	4

			Economic Aspects			Environmental Aspects			Social Aspects		
		Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footpri	Human Health	Community Awareness/ Reputational	Learning/Researc h Opportunities
Planet Blue Programs and Practices	Develop a highly integrated, nuanced cost and benefit analysis for complex packages of building upgrades that will account for synergies between sustainability measures	3	1	2	5	*	*	*	*	*	*
	Define a timeline for implementing the Planet Blue program at all U-M buildings to ensure that sustainability measures are consistently applied	4	2	4	5	5	5	4	4	5	2
	Form working groups of key U-M staff and faculty to identify additional scope opportunities, with associated metrics within Planet Blue	2	2	3	5	5	5	4	4	5	2
	Prescribe formal sustainability measures and metrics related to water and recycling during FY2012	1	2	3	4	4	4	4	4	5	2
	Execute regular post-occupancy evaluations to track seasonal building performance and occupant comfort	5	1	3	2	2	2	2	2	5	1
	Complete a comprehensive review of the Planet Blue process to date	6	1	3	N/A	1	1	1	1	1	1
	Designate a revolving fund specifically for pilot projects related to innovative sustainability projects on campus	8	1	1	N/A	2	2	2	2	N/A	N/A
	Use the Planet Blue process model to implement innovative sustainability projects identified by key working groups	7	*	2	*	4	4	4	4	5	2
	Link existing University information resources (SMS, GIS) to create comprehensive model of the physical and environmental conditions of campus	1	3	3	4	2	2	2	2	4	5

			Economic Aspects			Environmental Aspects			Social Aspects		
		Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footpri	Human Health	Community Awareness/ Reputational	Learning/Research Opportunities
GIS Integration and Analysis	Format existing GIS information into accurate 3D model, update attributes regularly	2	5	4	4	4	4	4	4	4	5
	Establish a pilot project to develop a comprehensive GIS model of one portion of Ann Arbor campus	3	3	1	3	3	3	3	3	4	4
	Explore long range GIS-based modeling of environmental impacts of campus development	4	5	4	5	5	5	5	5	5	5

		Economic Aspects			Environmental Aspects			Social Aspects		
	Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
Employ *Net Present Value* criteria for approval of capital projects	1	1 - Capital costs associated with utilizing NPV as a decision making criteria are negligible	2 - Incremental operating costs from using NPV would be marginal - potential increases in labor from consideration given to the assumptions of each project	5 - The payback or financial impact of this recommendation is significant	* - The value or rank placed on C, E, M varies with the individual project. These factors will be affected to the degree that the valuation includes appropriate benchmarking and evaluation of intangible factors. The metric is subjective based on user perception of what benefits are associated with approving any given project.	* - The value or rank placed on C, E, M varies with the individual project. These factors will be affected to the degree that the valuation includes appropriate benchmarking and evaluation of intangible factors. The metric is subjective based on user perception of what benefits are associated with approving any given project.	* - The value or rank placed on C, E, M varies with the individual project. These factors will be affected to the degree that the valuation includes appropriate benchmarking and evaluation of intangible factors. The metric is subjective based on user perception of what benefits are associated with approving any given project.	N/A - The NPV of a project does not directly affect intangibles	N/A - The NPV of a project does not directly affect intangibles	N/A - The NPV of a project does not directly affect intangibles
Incorporate *Expected Value* of intangible factors into payback modeling for capital projects	2	1 - Capital costs associated with utilizing expected value as a decision making criteria are negligible	3 - Incremental operating cost from using expected value could be material - increases in labor due to further modeling, assumption rationalization	4 - The payback or financial impact of this recommendation is significant	N/A - The expected value of a intangible benefits does not directly affect environmental performance	N/A - The expected value of a intangible benefits does not directly affect environmental performance	N/A - The expected value of a intangible benefits does not directly affect environmental performance	* - The value or rank placed on H, CA, L varies with the individual project. These factors will be affected when users perceive intangible externalities to exist in a particular project, and thus, the metric is subjective in all cases.	* - The value or rank placed on H, CA, L varies with the individual project. These factors will be affected when users perceive intangible externalities to exist in a particular project, and thus, the metric is subjective in all cases.	* - The value or rank placed on H, CA, L varies with the individual project. These factors will be affected when users perceive intangible externalities to exist in a particular project, and thus, the metric is subjective in all cases.

		Economic Aspects			Environmental Aspects			Social Aspects		
	Prioritization of Recommendation	**Capital Costs**	**Operating Costs**	**Payback**	**Climate**	**Ecosystem Health**	**Materials Footprint**	**Human Health**	**Community Awareness/ Reputational Benefit**	**Learning/Research Opportunities**
Develop in-house capacity to perform energy modeling for small renovation projects	**1**	2 - Expanding capacity would generate incremental overhead costs, energy modeling software would be required	5 - Employing additional staff would incur significant additional labor costs	4 - Immediate cost savings from foregone outside contractors; time savings from institutional knowledge	2 - Employing in-house staff versus contractors will have marginal impacts on C, E, M in early years, but best practices will offer more opportunities for sustainable construction in the future	2 - Employing in-house staff versus contractors will have marginal impacts on C, E, M in early years, but best practices will offer more opportunities for sustainable construction in the future	2 - Employing in-house staff versus contractors will have marginal impacts on C, E, M in early years, but best practices will offer more opportunities for sustainable construction in the future	2 - Employing in-house staff versus contractors will have marginal impacts on H in early years, but best practices will offer more opportunities for sustainable construction in the future	5 - Employing in-house staff will significantly boost the AEC's recognition as a leading designer, generating both awareness and opportunity at the University	5 - Employing in-house staff will significantly boost the AEC's recognition as a leading designer, generating both awareness and opportunity at the University
Expand in-house commissioning practices to include design-phase commissioning for small renovation projects	**5**	2 - Expanding capacity would generate incremental overhead costs, energy modeling software would be required	5 - Design phase commissioning could be a significant incremental operating as a result of additional labor, complex system models, sensitivity analysis	3 - Extensive modeling more accurately predicts system behavior, but payback is prohibitive	4 - Design phase commissioning develops projects to meet targets within C, E, M. Provides customization based on individual project	4 - Design phase commissioning develops projects to meet targets within C, E, M. Provides customization based on individual project	4 - Design phase commissioning develops projects to meet targets within C, E, M. Provides customization based on individual project	4 - Design phase commissioning could model factors that contribute to H such as IAQ, daylighting	N/A	N/A
Expand thermal scanning program to include small renovation projects	**7**	3 - Additional thermal scanning would require additional equipment, software	3 - Additional labor required for thermal scanning on small projects	3 - Thermal scanning most accurately predicts system behavior to quantify annual energy savings	4 - Thermal scanning most accurately predicts system behavior and performance - Critical to C, E, M, H	4 - Thermal scanning most accurately predicts system behavior and performance - Critical to C, E, M, H	4 - Thermal scanning most accurately predicts system behavior and performance - Critical to C, E, M, H	4 - Thermal scanning most accurately predicts system behavior and performance - Critical to C, E, M, H	N/A	N/A

	Prioritization of Recommendation	Economic Aspects: Capital Costs	Economic Aspects: Operating Costs	Economic Aspects: Payback	Environmental Aspects: Climate	Environmental Aspects: Ecosystem Health	Environmental Aspects: Materials Footprint	Social Aspects: Human Health	Social Aspects: Community Awareness/ Reputational Benefit	Social Aspects: Learning/Research Opportunities
Provide annual training sessions for AEC staff on the latest sustainable building practices specific to small renovation projects	**3**	4 - Annual training is a significant capital cost	N/A	4 - Annual training builds institutional knowledge, education may be amortized over the useful life of the employee	5 - Annual training in sustainability criteria directly affects project selection and success in C, E, M, H	5 - Annual training in sustainability criteria directly affects project selection and success in C, E, M, H	5 - Annual training in sustainability criteria directly affects project selection and success in C, E, M, H	5 - Annual training in sustainability criteria directly affects project selection and success in C, E, M, H	5 - Training opportunities will attract and retain high caliber, sustainability-minded engineers. Publicity for the University	4 - Training opportunities are a key learning opportunities for engineers at a research institution
Utilize FCA database as a benchmark for renovations against expected useful life of equipment	**2**	N/A - FCA Database already exists, but is not utilized to its potential	4 - Would require significant additional labor hours to maitain and track projects	5 - Very high impact of using technological infrastructure to benchmark projects	3 - FCA database may aid in project selection, foresight, but will ultimately have mid-level effects on environmental performance	3 - FCA database may aid in project selection, foresight, but will ultimately have mid-level effects on environmental performance	3 - FCA database may aid in project selection, foresight, but will ultimately have mid-level effects on environmental performance	3 - FCA database may aid in project selection, foresight, but will ultimately have mid-level effects on environmental performance	N/A	N/A
Develop construction practices code of conduct specific to small renovation projects, including a materials reuse/recycling program	**4**	4 - Materials reuse/recycling program could be very capital intense if implemented in house. Code of conduct capital costs are negligible	5 - Materials reuse is quite labor intense compared to demolition/disposal.	5 - Markets exist for recycled material, saved materials inventory all generate real cost savings - Very high payback	5 - Materials recycling mitigates millions of tons of GHG, particulate matter	4 - Materials recycling precludes dumping, contamination of local land fills	5 - Materials recycling saves direct materials, promotes sustainability of production inputs across all units	3 - General sustainable construction practices may reduce construction noise, improve IAQ	5 - U-M may receive significant publicity, recognition for leading in construction recycling, best practices	3 - Disposal vs recycling materials could provide research opportunities
Actively market UofM's reputation and recruitment agendas associated with sustainable design through building renovations	**6**	N/A	1 - Few incremental operating costs for marketing materials	3 - Material impact on very small annual expense	N/A	N/A	N/A	N/A	5 - Marketing material/signage generates campus enthusiasm and pride for sustainability initiatives	N/A

		Economic Aspects			Environmental Aspects			Social Aspects		
	Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
Use the built environment as a core hands-on teaching tool to expand current curricula and advance student initiatives of sustainable practices	**8**	N/A	* - Project specific	N/A	N/A	N/A	N/A	N/A	N/A	4 - Research potential, expansion of curriculum possible with expansion of sustainaiblity based projects

		Economic Aspects			Environmental Aspects			Social Aspects		
	Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
Develop a highly integrated, nuanced cost and benefit analysis for complex packages of building upgrades that will account for synergies between sustainability measures	**3**	1 - Capital costs associated with using NPV, expected value, or other broad metrics are negligible	2 - Incremental operating costs would be marginal - Some additional labor to give considseration to all broad impacts required	5 - Payback is currently most significant limiation to the Planet Blue scope, process. Expansion of idea of payback would generate real value for all units	* - The value or rank placed on C, E, M varies with the individual project. These factors will be affected to the degree that the valuation includes appropriate benchmarking and evaluation of intangible factors. The metric is subjective based on user perception of what benefits are associated with approving any given project.	* - The value or rank placed on C, E, M varies with the individual project. These factors will be affected to the degree that the valuation includes appropriate benchmarking and evaluation of intangible factors. The metric is subjective based on user perception of what benefits are associated with approving any given project.	* - The value or rank placed on C, E, M varies with the individual project. These factors will be affected to the degree that the valuation includes appropriate benchmarking and evaluation of intangible factors. The metric is subjective based on user perception of what benefits are associated with approving any given project.	* - The value or rank placed on H, CA, L varies with the individual project. These factors will be affected when users perceive intangible externalities to exist in a particular project, and thus, the metric is subjective in all cases.	* - The value or rank placed on H, CA, L varies with the individual project. These factors will be affected when users perceive intangible externalities to exist in a particular project, and thus, the metric is subjective in all cases.	* - The value or rank placed on H, CA, L varies with the individual project. These factors will be affected when users perceive intangible externalities to exist in a particular project, and thus, the metric is subjective in all cases.
Define a timeline for implementing the Planet Blue program at all U-M buildings to ensure that sustainability measures are consistently applied	**4**	2 - Few additional capital costs, some additional overhead	4 - Would require additional labor, capacity to meet needs of all U-M buildings and campuses	5 - Planet Blue model is cost savings to the University. Expansion of scope to all buildings saves expenses in direct proportion to project expenses	5 - Expansion of scope to all U-M buildings and campuses reduces total University contribution of GHG, mitigating negative climate effects	5 - Expansion of scope to all U-M buildings and campuses reduces total University contribution of pollutants, mitigating negative ecosystem effects	4 - Expansion of scope to all U-M buildings and campuses reduces total University contribution of material inputs such as unrecycled materials	4 - Expansion of scope to all U-M buildings and campuses improves wellness and community health in applicable facilities	5 - Planet Blue's key competency is CA - expanding scope will have direct effects on the sustainable culitre at the U-M	2 - Expansion of Planet Blue could provide certain research opportunities to students and faculty

		Economic Aspects			Environmental Aspects			Social Aspects		
	Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
Form working groups of key U-M staff and faculty to identify additional scope opportunities, with associated metrics within Planet Blue	**2**	2 - Few additional capital costs, some additional overhead	3 - Would require additional labor, capacity to plan for expansion of scope, implement	5 - Planet Blue model is cost savings to the University. Expansion of scope to all buildings saves expenses in direct proportion to project expenses	5 - Expansion of scope to all U-M buildings and campuses reduces total University contribution of GHG, mitigating negative climate effects	5 - Expansion of scope to all U-M buildings and campuses reduces total University contribution of pollutants, mitigating negative ecosystem effects	4 - Expansion of scope to all U-M buildings and campuses reduces total University contribution of material inputs such as unrecycled materials	4 - Expansion of scope to all U-M buildings and campuses improves wellness and community health in applicable facilities	5 - Planet Blue's key competency is CA - expanding scope will have direct effects on the sustainable culutre at the U-M	2 - Expansion of Planet Blue could provide certain research opportunities to students and faculty
Prescribe formal sustainability measures and metrics related to water and recycling during FY2012	**1**	2 - Few additional capital costs, some additional overhead	3 - Would require additional labor, capacity to plan for expansion of scope, implement	4 - Expansion of scope into water saves units utilities expenses, recycling costs are negligible. Expansion of scope saves expenses in direct proportion to project expenses	4 - Expansion of scope to water, recycling mitigates GHG emissions, water usage. Planet Blue then employs systems based sustainability goals	4 - Expansion of scope to water, recycling mitigates GHG emissions, water usage. Planet Blue then employs systems based sustainability goals	4 - Expansion of scope to water, recycling mitigates GHG emissions, water usage. Planet Blue then employs systems based sustainability goals	4 - Expansion of scope to water, recycling mitigates GHG emissions, water usage. Planet Blue then employs systems based sustainability goals	5 - Planet Blue's key competency is CA - expanding scope will have direct effects on the sustainable culutre at the U-M	2 - Expansion of Planet Blue could provide certain research opportunities to students and faculty
Execute regular post-occupancy evaluations to track seasonal building performance and occupant comfort	**5**	1 - Capital costs negligible	3 - Some additional labor, overhead to administer POEs	2 - Little direct financial payback	2 - Post-occupancy evaluations wil not have direct material effects on environmental performance	2 - Post-occupancy evaluations wil not have direct material effects on environmental performance	2 - Post-occupancy evaluations wil not have direct material effects on environmental performance	2 - Post-occupancy evaluations wil not have direct material effects on human health	5 - Post-occupancy surveys meet the needs of all stakeholders and generates awareness, excitement from building use	1 - Potential ISR initiative

	Prioritization of Recommendation	Economic Aspects: Capital Costs	Economic Aspects: Operating Costs	Economic Aspects: Payback	Environmental Aspects: Climate	Environmental Aspects: Ecosystem Health	Environmental Aspects: Materials Footprint	Social Aspects: Human Health	Social Aspects: Community Awareness/ Reputational Benefit	Social Aspects: Learning/Research Opportunities
Complete a comprehensive review of the Planet Blue process to date	6	1 - Capital costs negligible	3 - Additional labor, overhead to perform review	N/A	1 - Review, while essential for benchmarking, will not contribute to environmental, social performance	1 - Review, while essential for benchmarking, will not contribute to environmental, social performance	1 - Review, while essential for benchmarking, will not contribute to environmental, social performance	1 - Review, while essential for benchmarking, will not contribute to environmental, social performance	1 - Review, while essential for benchmarking, will not contribute to environmental, social performance	1 - Review, while essential for benchmarking, will not contribute to environmental, social performance
Designate a revolving fund specifically for pilot projects related to innovative sustainability projects on campus	8	1 - Some initial start up costs, capital costs negligible	1 - No additional operating costs through changing fund structure	N/A	2 - Revolving fund ensures longevity, ease of administration for innovative environmental projects	2 - Revolving fund ensures longevity, ease of administration for innovative environmental projects	2 - Revolving fund ensures longevity, ease of administration for innovative environmental projects	2 - Revolving fund ensures longevity, ease of administration for innovative environmental projects	N/A	N/A
Use the Planet Blue process model to implement innovative sustainability innovative sustainability projects identified by key working groups	7	* - Project specific	2 - Relatively few incremental labor, overhead costs	* - Project specific	4 - Expansion of scope, innovation generates opportunity for C, E, M, H	4 - Expansion of scope, innovation generates opportunity for C, E, M, H	4 - Expansion of scope, innovation generates opportunity for C, E, M, H	4 - Expansion of scope, innovation generates opportunity for C, E, M, H	5 - Planet Blue's key competency is CA - expanding scope will have direct effects on the sustainable culutre at the U-M	2 - Expansion of Planet Blue could provide certain research opportunities to students and faculty

	Prioritization of Recommendation	Economic Aspects: Capital Costs	Economic Aspects: Operating Costs	Economic Aspects: Payback	Environmental Aspects: Climate	Environmental Aspects: Ecosystem Health	Environmental Aspects: Materials Footprint	Social Aspects: Human Health	Social Aspects: Community Awareness/ Reputational Benefit	Social Aspects: Learning/Research Opportunities
Link existing University information resources (SMS, GIS) to create comprehensive model of the physical and environmental conditions of campus	**1**	3 - Wide range integration of campus systems would require capital investment in technological infrastructure, overhaul of current platforms, significant labor. Some capacity already exists	3 - Additional capacity, labor required annually to maintain	4 - Amortized over useful life of system, project generates real payback over its useful life. Reduces future consulting fees, staff time on certain projects	2 - Basic integrated GIS platform provides framework for environmental, social sustainability, but only expansion would generate true impacts	2 - Basic integrated GIS platform provides framework for environmental, social sustainability, but only expansion would generate true impacts	2 - Basic integrated GIS platform provides framework for environmental, social sustainability, but only expansion would generate true impacts	2 - Basic integrated GIS platform provides framework for environmental, social sustainability, but only expansion would generate true impacts	4 - Possibility for U-M to lead in technological based engineering, forecasting	5 - Significant untapped potential for research, modeling
Format existing GIS information into accurate 3D model, update attributes regularly	**2**	5 - Significant upgrade of current system to incorporate 3D. Require software, capacity, and extensive training	4 - Additional capacity, labor required annually to maintain	4 - Amortized over useful life of system, project generates real payback over its useful life. Reduces future consulting fees, staff time on certain projects, precision of information	4 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	4 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	4 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	4 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	4 - Possibility for U-M to lead in technological based engineering, forecasting	5 - Significant untapped potential for research, modeling
Establish a pilot project to develop a comprehensive GIS model of one portion of Ann Arbor campus	**3**	3 - Initial capital investment for pilot project. Infrastructure, labor	1 - Applicable only for pilot year, additional labor - much could be research/grant based	3 - Lower payback due to project specificity, but pilot determines financial feasibility of further study. High impact recommendation.	3 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	3 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	3 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	3 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	4 - Possibility for U-M to lead in technological based engineering, forecasting	4 - Significant untapped potential for research, modeling. Project specific prompts lower rating

		Economic Aspects			Environmental Aspects			Social Aspects		
	Prioritization of Recommendation	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
Explore long range GIS-based modeling of environmental impacts of campus development decisions	**4**	5 - Significant initial capital investment, training	4 - Additional capacity, labor required annually to maintain	5 - Amortized over extended useful life of system, project generates real payback over its useful life. Reduces future consulting fees, staff time on certain projects, precision of information	5 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	5 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	5 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	5 - GIS modeling can incorporate systems based performances and expectations. High value for predictibility	5 - Possibility for U-M to lead in technological based engineering, forecasting	5 - Significant untapped potential for research, modeling

IACS - Buildings Team
Meetings with Facilities and Operations Staff Members

Requested	Date	Day	Times	Location	Topic	Attendants
GIS meeting	10/18/2010	Mon	900a-1100a	AEC Model Conference Room	Existing GIS systems	M. Swanson, F&O; M. Eboch, AEC; T. Catchot, AEC; J. Green, SAND; K. Keeler, OCS; R. Garrett, F&O; G. Thun, IACS-B; M. O'Malley, IACS-B; A. Ambroselli, IACS-B
Planet Blue Introduction	10/21/2010	Thur	900a-1030a	Plant Acad Conf Rm	Planet Blue - Gen Pt1	K. Kolevar, PB; K. Keeler, OCS; G. Thun, IACS-B; M. O'Malley, IACS-B; A. Ambroselli, IACS-B; J. Janiski-IACS-B
Buildings Under $10Mil	10/21/2010	Thur	1130a-100p	OSEH Fishbowl	Building Renovations + FCA database	D. Karle, AEC; M. Contrera, AEC; M. Bowen, AEC; K. Keeler, OCS; G. Thun, IACS-B; M. O'Malley, IACS-B; A. Ambroselli, IACS-B; T. Long, IACS-B; C. Snodgrass, IACS-B
Planet Blue Introduction	10/28/2010	Thur	300p-430p	Plant Acad Conf Rm	Planet Blue - Gen Pt2	K. Kolevar, PB; K. Keeler, OCS; M. O'Malley, IACS-B; A. Ambroselli, IACS-B; J. Janiski - IACS-B
ECC Mtg	11/3/2010	Wed	900a-1000a	Plant Acad Conf Rm	ECC Meeting	K. Kolevar, PB; ECC representatives; A. Ambroselli, IACS-B; J. Janiski, IACS-B; N. Seeba, IACS-B
GIS Meeting	11/4/2010	Thur	1000a-1100a	OSEH Fishbowl	EP3 GIS usage	J. Kosco, EP3; P. Szornyi, EP3; K. Keeler, OCS; M. O'Malley, IACS-B
MEP walkthru	11/9/2010	Tue	100p-330p	North Ingalls Building, Rm 1346	Walkthru	D. Rife, PB; N. Seeba, IACS-B
Bldg Start-Up Mtg	11/10/2010	Wed	100p-230p	Plant Acad Conf Rm	Dana Bldg Startup Meeting	K. Morgan, PB; J. Janiski, IACS-B
Leadership Mtg	11/11/2010	Thur	100p-130p	Plant Ops, tbd	NIB leadership meeting	D. Rife, PB; N. Seeba, IACS-B
Gen Project Mtg	12/2/2010	Thur	1000-1100a	Dana Bldg, Rm 1006	Dana Bldg Intro Meeting	K. Morgan, PB; J. Janiski, IACS-B
Bldgs Team Follow up	12/15/2010	Wed	1000-1130a	OSEH Fishbowl	Feedback to Prelim Recs	K. Kolevar, PB; D. Karle, AEC; R. Garrett, F&O; M. Contrera, F&O; M. Bowen, F&O; D. Uchman, AEC; M. Swanson, F&O; E. Albert, PB; K. Keeler, OCS; G. Thun, IACS-B; M. O'Malley, IACS-B; A. Ambroselli, IACS-B; J. Janiski, IACS-B; T. Long, IACS-B; C. Snodgrass, IACS-B

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Appendix E. II. : Phase 2 Energy Team Report

University of Michigan

Campus Sustainability Integrated Assessment: Phase 2

Energy Team

Dr. Gregory Keoleian, Faculty Lead
Robb De Kleine, CSS Research Specialist

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January 14, 2011

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This assessment was conducted in collaboration with the Center of Sustainable Systems, University of Michigan.

Contents

NOMENCLATURE

B20	A liquid fuel mixture composed of 80% diesel and 20% biodiesel
Btu	British Thermal Unit
CHP	Combined Heat and Power
CHW	Chilled Water (used for building cooling)
CPP	Central Power Plant
DHW	Domestic Hot Water
E85	A liquid fuel mixture composed of 85% ethanol and 15% gasoline
ETC	Evacuated Tube Collectors
GHG	Greenhouse Gas
GHP	Geothermal Heat Pump
GSHP	Ground Source Heat Pump
HHW	Heating Hot Water
NCCP	North Campus Chilled Water Plant
PV	Photovoltaic
REC	Renewable Energy Certificates
Syngas	A synthetic gas composed of hydrogen and carbon monoxide that can be combusted in a similar manner as natural gas.
WTW	Well to Wheel

1 EXECUTIVE SUMMARY

In phase 2 of the Campus Integrated Assessment Project, the Energy team was directed to explore the potential use of renewable energy technologies on campus and make recommendations on the adoption of these technologies based on their environmental benefits, feasibility, and cost effectiveness. The following technologies were considered: biomass, geothermal, solar (photovoltaics and solar thermal), wind (turbines and renewable energy credits), and hybrids vehicles (passenger vehicles and buses).

Based on the analysis conducted in this project, the feedback from operational staff, and the various scientific and legislative frameworks dealing with climate change, the Energy Team recommends that the University **adopt a stretch goal of reducing GHG emissions levels by 25% compared to the University's 2005 levels within the next decade**. We recommend that the following strategies be considered for reaching this goal (in order of ranking):

- **Energy Conservation:** The University should strive to reduce absolute energy demand by 10%. Given the future growth in the campus in terms of additional buildings and facilities, existing operations will have to reduce GHG emissions by even more than 10%. The work of the Planet Blue Operations Team serves as a model for achieving these reductions, but their resources and efforts should be increased to reach this goal.
- **Biomass:** After a 10% reduction in overall energy demand, a 15% reduction in GHGs from renewable energy sources is required to achieve our stretch goal. Of the technologies investigated that have the potential to achieve a significant reduction, biomass power was the most cost effective option. A full scale biomass conversion of the CPP would be very difficult given the logistics of transporting and processing biomass on the Central Campus although opportunities exist for replacing one or more boilers with a biomass compatible option. It would be more feasible to construct a facility on the North Campus which could provide heat and power to the North Campus and potentially the Medical Campus and the North Campus Research Complex. The analysis showed that a plant sized to meet 100% of the North Campus heating demand could reduce GHGs by about 15%. Additional operational efficiencies can be achieved by centralizing the heating systems on the North Campus.
- **Geothermal:** Given the reasonable payback period compared to other renewable options, geothermal systems should be implemented as a strategy for heating water to be used either for heating and cooling on the North Campus and/or pre-heating water for steam generation for the CPP or possible North Campus power plant. Given that this is a very scalable technology, the University should conduct a pilot project to gain expertise for future installations.
- **Hybrid Buses:** Whenever funding can be located to offset most or all of the cost premiums, the University should purchase hybrid buses. This can result in immediate cost savings, but the overall GHG reduction is relatively small.
- **Solar Thermal:** Solar thermal systems are more cost effective than PV systems and are the preferred strategy for harvesting solar energy on the campus roof space.
- **Photovoltaics:** Use PV on targeted sites on roofs and parking lots as a visible demonstration of the University's commitment to sustainability.
- **RECs**: In addition to efforts on the Ann Arbor campuses, renewable energy credits should be used as needed to meet GHG reduction goals.

2 INTRODUCTION

2.1 Project Background

In phase 1 of the University of Michigan's Campus Integrated Assessment, the Energy Team explored various renewable technologies and their impact on greenhouse gas (GHG) emissions for U-M's Ann Arbor campuses. Technologies used currently both on the U-M campus as well as at other universities, organizations, or companies across the country were considered. Based on the findings of the Phase 1 report, the energy team was given the following objectives in phase 2 of the project.

- Develop a detailed action plan and associated targets for expanding U-M's renewable energy sources (e.g., geothermal, solar thermal, photovoltaics, wind, biomass) for heating, cooling, and electricity needs.
- Develop a detailed action plan and associated targets for expanding use of alternative fuels in U-M's vehicle fleet.

2.2 Phase II Analysis

The energy team explored different technologies and strategies in the following categories to realize the Phase 2 objectives:

- Biomass
- Geothermal
- Solar (PV and Solar Thermal)
- Wind (Wind Turbines and Renewable Energy Credits)
- Hybrid Vehicles

The team estimated the capacity, efficiency, capital costs, and annual cost savings from implementing technologies using information from similar projects, industry averages, and existing University data. This was used to calculate payback periods to assess the cost effectiveness of each technology. Paybacks periods were calculated using both a 0% discount rate (i.e., simple payback) and a 5% discount rate. In addition, carbon costs of $0, $20, and $50 per metric ton of CO2 equivalent were used to understand the impact of a carbon pricing regime on operational costs and payback periods.

The team made every effort to capture and quantify the energy potential as well as all the financial costs and savings as accurately as possible with the resources and time available for the project. Still, there is considerable uncertainty remaining in the values presented here. In some cases, ranges or scenarios are used to capture some of this uncertainty. The values presented here give an indication of the relative energy potential and cost effectiveness of each strategy, but separate engineering analysis is necessary to more accurately account for all costs and benefits.

2.3 Overview of Current University's Energy Infrastructure

The University of Michigan provides many different services to students, staff, and residents of Ann Arbor and beyond including education, health care, sports and recreation, housing, and transportation. Significant energy consumption is required to carry out these activities. The majority of energy is needed for use in campus buildings. Buildings consume approximately 99% of the total energy used each year by the University of Michigan. In an average campus building, 47% of energy goes toward space heating, 12% goes toward space cooling, and 2% goes toward heating domestic hot water.

The University operates a large energy infrastructure, and at the heart of this infrastructure is the Central Power Plant (CPP). The facility is a combined heat and power (CHP) plant, meaning that it produces heat and electricity simultaneously. CHP plants are very efficient since waste heat from electricity generation is captured and utilized. Our CHP plant uses natural gas-fired conventional boilers to produce high-pressure steam from water. The steam then passes through a steam turbine to create electricity, and is then fed through a network of tunnels to buildings all around the Central and Medical Campuses. In a separate mechanism, natural gas-fired combustion turbines are used to produce electricity. The waste heat from the gas turbines, which would normally be lost in conventional power plants, is captured and used in waste heat boilers, which produce steam to supplement the steam from the conventional boilers. The steam produced by the CPP is used for heating and cooling buildings (through absorption chillers) as well as supplying hot water for use in the buildings through a domestic hot water loop (DHW) that circulates through the Central Campus. The CPP supplies almost half of the University's total annual electricity demand. The remainder is purchased through the regional utility, DTE Energy.

The U-M North Campus is not serviced by the CPP. Instead building heating is provided using separate boilers for each building or for a small group of buildings. The North Campus chiller loop does provide chilled water to a network that includes some of the buildings on the North Campus for cooling purposes.

To provide transportation, the University operates its own bus fleet for students and staff around the Ann Arbor campuses. In addition, the University owns and operates a fleet of passenger vehicles that are leased to different academic and operational departments. U-M also maintains a rental fleet for short term travel by students, faculty, and staff. The campus buses use a mixture of 20% biodiesel (B20) and an E85 ethanol blend is used to fuel many of the campus passenger vehicles.

Currently, most of the energy used by the University is generated from the combustion of fossil fuels either on the campus itself or offsite at DTE power plants. These fossil fuels release carbon dioxide when burned and as such, add to the concentration of CO2 in the atmosphere and contribute to climate change. Figure 1 shows the breakdown of the carbon emissions associated with the University.

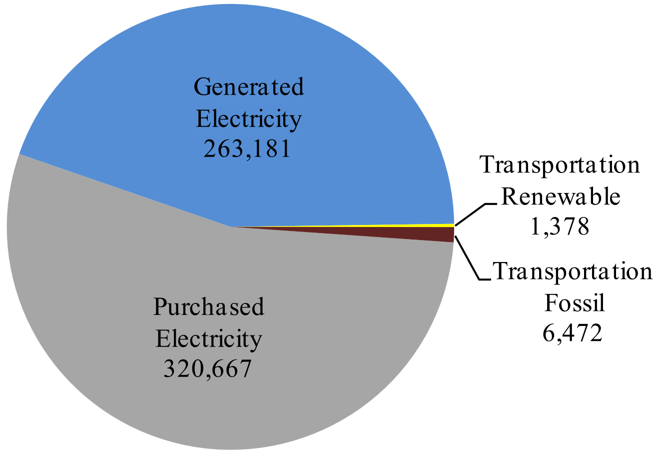

Figure 1: U-M Reported Greenhouse Emissions by Source, 2009 (metric tons CO_2-equivalence)

3 ACTION PLAN

3.1 Biomass Introduction

The Energy Team Phase I report identified an opportunity for the University to use biomass as a fuel source for heating and electricity on campus. Because it is assumed that the combustion of biomass releases carbon that was recently sequestered by vegetation, biomass is considered to be a zero-emissions fuel.[1] Thus, the use of biomass as a fuel source can greatly reduce the University's greenhouse gas emissions. Biomass can provide cost savings compared to current energy sources. Biomass can be used at the Central Power Plant on Central Campus, and on North Campus. Each area has a unique set of circumstances, and is discussed below.

3.1.1 Central Power Plant

Biomass could be used as a fuel at CPP, but because the facility is currently configured for natural gas, the biomass would have to be converted to ―syngas" before it could be fed into the existing boilers and turbines. This conversion requires heating (not burning) biomass to release carbon monoxide and hydrogen. The resulting gas can be burned like natural gas. The gasification process requires a significant new investment in equipment, but can potentially be used to remove pollutants and impurities in the raw biomass feedstock before the syngas is combusted, and it can handle a variety of biomass feedstock types.[2]

3.1.1.1 Costs of Biomass

Table 1 below summarizes the capital cost estimates for a biomass gasification system (using fluidized bed technology at atmospheric pressure), associated infrastructure, and the biomass feedstock. The assumption is that biomass will be used to replace 100% of the natural gas consumed at the CPP (which in 2009-2010 was 34.1 million CCF per year). Peak natural gas consumption was 6,520 CCF per hour. Using the assumptions listed in the appendix, this rate was converted to an equivalent number of dry tons of biomass per day. This calculation yields a maximum system capacity of 1,300 dry tons per day; however, average demand amounts to approximately 790 dry tons per day. Capital costs are adjusted for the calculated maximum system capacity[2]. The 4.2-acre biomass storage area is assumed to be located on University property so no land acquisition costs are included.

Table 1: Capital Costs for Biomass Gasification System

Gasification Equipment	$44,400,000
Installation	$22,200,000
Biomass Prep-yard	$10,100,000
Biomass Storage Area (4.2 acres)	$296,000
Total Capital Cost	*$77,000,000*

Biomass costs are difficult to estimate with precision, so two different price scenarios are used: a best-case scenario ($25 per dry ton delivered) and a worst-case scenario ($50 per dry ton delivered). The best-case scenario price used in this analysis is in the range of what plants in Michigan currently pay for biomass feedstock, while the worst-case scenario price reflects a best estimate of a price that would almost assuredly allow the University to procure sufficient biomass fuel. Table 2 lists the relevant current annual operating costs and the anticipated annual operating costs for biomass gasification.

Table 2: Annual Costs for Biomass Gasification System ($/year)

Category	$25/ton Biomass	$50/ton Biomass
Current Costs		
Natural Gas Costs	$25,000,000	$25,000,000
Costs of Using Biomass		
Biomass Fuel Costs	$7,180,000	$14,400,000
Biomass Prep-yard Labor	$711,000	$711,000
Gasification O&M	$1,750,000	$1,750,000
Total Biomass Costs	*$9,640,000*	*$16,800,000*

3.1.1.2 Benefits of Biomass

The benefits from using biomass fall into three categories—economic, environmental, and social. The economic benefit is annual cost savings from biomass (which will vary depending on fuel prices). The environmental benefit is the reduction in greenhouse gas emissions and the reduction in use of nonrenewable fuels. The social benefit is the increase in local employment due to use of biomass in place of natural gas. Estimated annual cost savings are shown in Table 3 below, using the best- and worst-case biomass prices as well as three different levels of carbon prices.

Table 3: Annual Cost Savings with Biomass ($/year)

Carbon Price	**$25/ton Biomass**	**$50/ton Biomass**
No Carbon Price	$15,300,000	$8,150,000
$20/metric ton	$19,000,000	$11,800,000
$50/metric ton	$24,500,000	$17,300,000

Table 4 below shows the payback period for the biomass gasification system with no discount rate (i.e., simple payback), and a 5% discount rate.

Table 4: Payback Period for Biomass Gasification System (Years)

Carbon Price	$25/ton Biomass	$50/ton Biomass
	0%Discount Rate	
No Carbon Price	4	7
$20/metric ton	4	5
$50/metric ton	3	4
	5% Discount Rate	
No Carbon Price	5	9
$20/metric ton	4	6
$50/metric ton	3	4

Table 5 below shows how much natural gas consumption would be displaced annually by using biomass at the CPP, as well as the associated GHG emissions reductions and the cost per metric ton of CO_2 avoided under best- and worst-case biomass prices. GHG emissions from trucking the biomass to the plant are included in the calculations. Assuming the biomass fuel is urban wood waste diverted from landfill, there is also a benefit in terms of landfill space saved.

Table 5: Environmental Benefits of Biomass

Category	Quantity
Annual Natural Gas Saved	34,100,000 CCF
Annual Greenhouse Gas Emissions Reduced	181,000 metric tons CO_2
Percentage of Total Campus Emissions	30.7%
Cost per Metric Ton of CO_2 Avoided ($25/ton Biomass)	-$84.50
Cost per Metric Ton of CO_2 Avoided ($50/ton Biomass)	-$44.90
Landfill Space Saved	287,000 tons

3.1.1.3 Technical Guidance

Biomass poses challenges for use in conventional combustion turbines. With current gasification technology, the syngas produced directly from biomass feedstocks has too many impurities and has a Btu content which is too low to allow it to be used in conventional combustion turbines. After significant processing, syngas could theoretically be blended with natural gas as a fuel in a combustion turbine. Moreover, this technology for producing and using syngas will likely improve over time and could allow increased proportions of syngas in combustion turbines in the future.

However, biomass makes sense for use with steam cycle boilers. Biomass is much simpler and less costly to integrate the use of syngas as a fuel for a boiler producing steam for a typical steam cycle.[3] Coincidentally, the CPP will soon be replacing one of its boilers. This is an opportunity to integrate a biomass gasification system with the new boiler, which is likely to be cheaper than retrofitting the existing boilers in the CPP to handle syngas fuel. It appears unrealistic to expect that the combustion turbines at the CPP could use unblended syngas as a fuel, but a more detailed engineering assessment would be needed to determine the feasibility of such an option.

Because of the uncertainties and possibly large costs associated with biomass gasification at the CPP, it may be prudent to invest first in a small-scale gasification system that would produce enough syngas to offset a modest portion of natural gas use. This would reduce the initial investment required and allow operations staff to evaluate any effects on plant equipment from substituting syngas for natural gas. Integrating biomass gasification with the new CPP boiler seems to be a more logical choice. As the gasification system is proven, additional investments could be made in a larger gasification system. Assuming there are no problems identified with this gradual approach (e.g., unacceptably low efficiency of a small-scale system), a small system could be installed during an initial pilot phase lasting one year, after which a decision would be made about the feasibility and cost-effectiveness of scaling up to a larger system that would offset most or all of the natural gas used at the CPP. In addition, it is advisable to ensure that the gasification system can handle a variety of biomass feedstock types, since it is possible that no single feedstock will be in sufficient supply at acceptable prices during the entire year.

3.1.1.4 Barriers to Implementation

Gasification of biomass is not a well-developed commercial technology. It is being demonstrated in a number of facilities worldwide, but there is no large-scale commercial plant currently operating. Since the technology is not well-understood, there could potentially be difficulties in securing environmental permits. Also, operations staff are not familiar with the technology, making it more challenging to initially implement and operate the system reliably, and unforeseen difficulties could add to the costs of such a project.

Another major barrier is storing and transporting very large volumes of biomass fuel. In order to replace 100% of current natural gas use with biomass fuel, a storage area of about 4.2 acres would be necessary. An area of that size would have to be located on University property in the vicinity of North Campus, or outside of Ann Arbor, and there may be a real cost for purchasing land or an opportunity cost for using University property in such a way. There would be significant truck traffic to deliver biomass to the storage area, and more importantly, to deliver the biomass from the storage area to the CPP itself. Rough calculations suggest that about 39 large truckloads of biomass per day would have to be delivered to the CPP on average throughout the year, and 66 truckloads per day during times of peak demand. Having to route such a large volume of truck traffic through the middle of Ann Arbor is a major concern. There may be difficulty in find a site for the biomass prep-yard given the lack of space around the CPP.

There are also barriers associated with securing sufficient biomass feedstock at a reasonable and predictable price over the long term. These issues are discussed separately in the appendix. The availability and logistics of biomass are a major concern because there are no comparable issues with the highly-reliable natural gas infrastructure that currently supplies the CPP.

3.1.1.5 Uncertainties

Given that biomass gasification is not a widely-deployed commercial technology, there is significant uncertainty associated with any cost estimates of such a system. Beyond the uncertainty regarding equipment, installation, and labor costs, there is a high degree of uncertainty related to the availability of sufficient biomass feedstock at a predictable price. Again, these issues are discussed separately below. The prices of both natural gas and biomass feedstocks will vary over time, often unpredictably, so it is difficult to forecast exactly what fuel cost savings the CPP would realize if it used biomass. However, if the University can secure a long-term biomass supply contract, the use of biomass may provide greater fuel cost stability than natural gas.

3.1.2 North Campus

A central CHP plant providing heat and electricity would likely be a more efficient and cost-effective way to meet North Campus' energy needs. In addition, the efficiency from being able to utilize both the electricity and heat from a CHP system, centralizing the heating equipment on the North Campus could allow for equipment downsizing since the individual buildings will have heating loads that peak at different times and thus the overall network peak heating demand will be less than the sum of the individual building's peak demands. In addition, decreasing the amount of equipment can reduce maintenance costs. Operations staff have already identified such a plant as a long-term goal.

Using biomass at this plant would, in most scenarios, provide cost savings and large GHG emissions reductions. In addition, since there is no existing plant, biomass could be direct-fired instead of gasified. Direct-fired biomass CHP plants are a common technology with lower capital costs and less uncertainty than biomass gasification systems, and would therefore be a more logical choice for North Campus. Such a system would consist of a boiler in which the biomass fuel is combusted to produce high-pressure steam. The steam would run through a steam turbine to produce electricity and would then be converted to hot water and sent through a network of pipes to heat North Campus buildings. Operations staff have already indicated interest in connecting North Campus buildings in a hot water pipe network, and a CHP plant could take advantage of this, although it is not known when such a network might be installed.

3.1.2.1 <u>Costs of Biomass</u>

Based on data for energy usage in North Campus buildings, it was determined that the total annual heating load is about 728,000 MMBtu, and the annual electrical demand is about 91.9 million kWh. It was determined that a CHP plant should maximize cogeneration in order to be most cost-effective, which means that the plant must be designed to meet all heating demand on North Campus, but only a portion of electricity demand. This would require a plant with a maximum capacity of about 800 dry tons per day; the average demand, though, would be only about 300 dry tons per day. The boiler technology is assumed to be a circulating fluidized bed (CFB) at atmospheric pressure, and electricity is generated by a back-pressure steam turbine. If the plant is designed to allow flexibility in electricity generation from the steam turbine, then during times of low heating demand the steam turbine can produce enough electricity to meet 100% of North Campus electricity demand. Overall, the CHP system studied in this analysis would supply 100% of heating demand and about 60% of electricity demand for north campus.

Table 6 below shows capital costs for the CHP plant,[2] which are adjusted for the calculated maximum system capacity. The 2.6-acre biomass storage area is assumed to be located on University property so there are no land acquisition costs included. It is assumed that a hot water pipe network already exists connecting all major buildings on North Campus, and that the CHP plant is situated so that 2,000 feet of hot water piping is needed to connect the plant to the existing network. Also, 2,000 feet of electric wiring ducts are needed to connect the plant to the existing substation just south of the Francois Xavier-Bagnoud building.

Table 6: Capital Costs of CHP Plant ($)

CFB Boiler	29,000,000
Back-Pressure Steam Turbine	3,060,000
Biomass Prep-yard	6,390,000
Biomass Storage Area (2.6 acres)	69,000
Hot Water Pipe and Electric Duct Installation	1,320,000
Total Capital Cost	*39,800,000*

Table 7 shows current and anticipated annual operating costs with a biomass CHP plant. As with the CPP system, two different price scenarios are used: a best-case scenario ($25 per dry ton delivered) and a worst-case scenario ($50 per dry ton delivered).

Table 7: Annual Costs ($/year)

Category	$25/ton Biomass	$50/ton Biomass
Current Costs		
Natural Gas Costs	6,440,000	6,440,000
Electricity Costs	6,850,000	6,850,000
Boiler O&M Costs	1,000,000	1,000,000
Total Current Costs	*14,300,000*	*14,300,000*
Costs of Using Biomass		
Biomass Fuel Costs	1,950,000	3,890,000
Biomass Prep-yard Labor	288,000	288,000
CHP Plant O&M	1,330,000	1,330,000
Purchased Electricity	2,710,000	2,710,000
Total Biomass Costs	*6,270,000*	*8,220,000*

3.1.2.2 Benefits of Biomass

The benefits from using biomass fall into three categories: economic, environmental, and social. The economic benefit is annual cost savings from biomass (which will vary depending on fuel prices). The environmental benefit is the reduction in greenhouse gas emissions and the reduction in use of a nonrenewable fuel, i.e., natural gas and the coal used to generate the majority of DTE electricity. The social benefit is the possible increase in local employment from sourcing, delivering, and potentially farming biomass. Estimated annual cost savings are shown in Table 8 below, using the best- and worst-case biomass prices as well as three different carbon price scenarios.

Table 8: Annual Cost Savings with Biomass ($/year)

Carbon Price	$25/ton Biomass	$50/ton Biomass
No Carbon Price	8,010,000	6,070,000
$20/metric ton	10,300,000	8,360,000
$50/metric ton	13,700,000	11,8000,000

Table 9 below shows the payback period for the biomass CHP plant with no discount rate (i.e., simple payback), and a 5% discount rate.

Table 9: Payback Period for CHP System (Years)

Carbon Price	$25/ton Biomass	$50/ton Biomass
	No Discount Rate	
No Carbon Price	5	6
$20/metric ton	4	5
$50/metric ton	3	4
	5% Discount Rate	
No Carbon Price	6	7
$20/metric ton	4	5
$50/metric ton	3	4

Table 10 below shows how much natural gas consumption would be displaced annually by using biomass in a CHP plant on North Campus, as well as the associated GHG emissions reductions and the cost per metric ton of CO_2 avoided under best- and worst-case biomass prices. GHG emissions from trucking the biomass to the plant are included in the calculations. Assuming urban wood waste is the biomass feedstock and it is diverted from landfills, there is also a benefit in terms of saving landfill space.

Table 10: Environmental Benefits of Biomass CHP Plant

Category	Quantity
Annual Natural Gas Saved	8,790,000 CCF
Annual Greenhouse Gas Emissions Reduced	87,100 metric tons CO_2
Percentage of Total Campus Emissions	14.7%
Cost per Metric Ton of CO_2 Avoided ($25/ton Biomass)	-$92.10
Cost per Metric Ton of CO_2 Avoided ($50/ton Biomass)	-$69.70
Landfill Space Saved Per Year	112,000 tons

3.1.2.3 Technical Guidance

If a biomass CHP plant were built to supply North Campus, it is not likely that a gradual phase-in would be cost-effective. This means that there would be a high initial investment required in the plant itself and the associated infrastructure for distributing heat and electricity to North Campus buildings. As with the system at the CPP, it is advisable to employ a combustion system that can be configured to handle a variety of biomass feedstocks. While gasification systems usually have the capability to do this, basic direct-fired systems often do not. The use of a more flexible direct-fired boiler will increase costs, but will greatly reduce the risk associated with relying on a single feedstock type, which may experience price and supply volatility. A CFB boiler was chosen over a simpler and cheaper stoker boiler because it has the potential for greater fuel flexibility, and also because it enables higher fuel conversion efficiency, lower NO_x and SO_x emissions, and faster combustion control response time.[2]

3.1.2.4 Barriers to Implementation

One of the main barriers to a CHP plant for North Campus is the fact that the prerequisite network of hot water pipes connecting all North Campus buildings has not yet been installed. It is not known when this network will be installed, and, until it is certain that such a network will be in place, it will be impractical to construct a CHP plant. Given the difficulties that operations staff anticipate with building such a network, this could delay a CHP plant significantly.

Even though direct-fired biomass is a relatively well-understood technology within Michigan—because there are currently six commercial-scale biomass plants in the state—there may be environmental permitting difficulties. All the current plants use stoker boilers[4], so a CFB boiler may take longer to permit, despite its likely environmental benefits in terms of reduced NO_x and SO_x emissions. Further, the Ann Arbor community is known as highly environmentally-conscious, which means there will likely be opposition to the construction of a new power plant within the city with a new smokestack. One possible solution is to locate the CHP plant at the North Campus Research Center, where there are existing stacks, although this may cause other problems. There may even be opposition to the use of biomass as a fuel, since it is perceived as less environmentally-friendly than other renewables such as wind or solar.

As with the biomass gasification system for the CPP, there would be a need for a biomass storage area, in this case an area of 2.6 acres. Because there is space available in the vicinity of North Campus, it seems possible to locate the storage area close to the CHP plant itself; in addition, there would be relatively little difficulty in siting the biomass prep-yard for the plant. Also, there is less concern about truck traffic given the probable location of a CHP plant near North Campus, but it may still be logistically difficult to coordinate 15 large truckloads per day on average, with a peak rate of 40 large truckloads per day.

3.1.2.5 Uncertainties

The technological uncertainties associated with direct-fired biomass CHP systems are low compared with biomass gasification, so the capital costs quoted above are more certain than the gasification system costs quoted for the CPP. But the other uncertainties described above in the CPP section apply in this case as well including concerns about biomass availability and logistics, and about fluctuations in biomass and natural gas costs

As mentioned above, it is not certain that a CFB boiler is the optimal choice for a CHP plant on North Campus. The benefits of a CFB boiler may not justify the extra costs compared to a stoker boiler, and a more detailed engineering analysis is necessary to determine the optimal boiler type, the optimal steam turbine type, and an optimal configuration for the entire CHP system.

3.1.3 Biomass Availability

If the University plans to invest in the infrastructure to use biomass as a fuel, it is critical to determine that there is sufficient biomass feedstock available within a reasonable distance. The National Renewable Energy Laboratory (NREL) has created a GIS-based online tool[5] for estimating biomass resources across the U.S., and it allows users to calculate biomass energy availability within a specified radius of a given point. Using the tool to estimate four types of biomass within 50 miles of Ann Arbor yields the following results:

Table 11: Estimate of Biomass Available Within 50 Miles of Ann Arbor

	Dry Tons Available Per Year	Btu/dry lb.	MMBtu Available Per Year
Crop Residues	2,730,000	6,500	35,500,000
Primary Mill Residues	55,600	8,500	945,000
Urban Wood Waste	902,000	8,500	15,300,000
Forest Residues	75,000	8,500	1,280,000
Total			*53,100,000*

For the most part, primary mill residues are primarily produced in northern Michigan and already taken by other users (largely used for energy production at the mills themselves or at the existing wood-fired biomass plants), and forest residues in general are too costly to collect and transport to urban markets.[4] Despite the large volume that is theoretically available, crop residues such as corn stover and wheat straw are also likely to be costly, perhaps as high as $70-100 per dry ton. This is due to high costs for collection, drying, transportation and the need to replace the nutrient value of the residues with other fertilizers to ensure continued agricultural productivity.[6] Based on this analysis, such prices for crop residues would probably not provide significant cost savings to the University compared to natural gas and purchased electricity, so crop residues are not likely to be a cost-effective fuel.

Urban wood waste, then, is the primary feedstock in southern Michigan which is theoretically available in sufficient quantities and at a low enough price to be feasible as a fuel for the University. However, the NREL estimates in the table above are based on high-level data that do not take into account factors on the ground and should be considered a theoretical maximum; the amount that is actually accessible will be lower, and the amount that is affordable will be lower still, depending on the price that the University is willing to pay for the biomass feedstock.

Two different studies were recently undertaken to provide better ―on-the-ground" estimates of urban wood waste in southeast Michigan, where most of it is concentrated. The first, from 2007, estimated that about 1,666,000 tons of urban wood waste were generated annually in a 14-county area of southeast Michigan.[7] This analysis estimates that the CPP would require 287,000 tons annually and a North Campus CHP plant would require 112,000 tons annually (for a total of 399,000 tons), so there would appear to be sufficient biomass available. However, it is not known how much of that wood waste went to existing uses. The second study, from 2009, estimated that 3,710,000 tons of wood waste were annually going to landfill (i.e., not to existing uses) within a 16-county area of southeast Michigan.[8] The difference between the two estimates demonstrates the uncertainty about total wood waste availability, but the estimates also show that there is likely a large volume of wood waste going into landfills which could possibly be diverted for use as fuel.

3.1.4 The Biomass Market in Michigan

The biomass market in southern Michigan is not considered mature, nor is it well-understood or predictable. In northern Michigan, where there is a large amount of timber production and where five existing wood-fired power plants are located, the market is much better-established. Those five plants are dependent on the forest products industry for their feedstock, and are currently experiencing decreased supply due to overall lower demand for wood products during the recession.[4]

The market in southern Michigan, mostly focused on urban wood waste as described above, experiences fluctuations due to economic conditions. Urban wood waste is produced as a result of economic activity (construction waste, shipping pallets, edgings and trimmings, etc.), and is therefore subject to the same supply decreases during recessions. But it is worth noting that a large portion of urban wood waste comes from urban tree removal and land clearing, which is less subject to these macroeconomic forces.

No matter the volatility of supply, there are competing uses for urban wood waste in Michigan. Specifically, wood waste can fetch a higher price as landscape mulch, woodchips, and firewood than it can as fuel for energy generation; 87.7% of production from wood waste yards in southeastern Michigan goes to these uses, while only 6.5% of production is industrial fuel for power plants.[8] However, as mentioned above, the fact that a large portion of wood waste currently goes to landfill (the lowest-value use of all) suggests that there is potentially more biomass available for energy generation at the University.

It should be noted that the Genesee Power Station in Flint (the only wood-fired plant in southern Michigan), which has an annual demand of 300,000 tons that is comparable to what the University would require, has challenges in meeting its fuel needs with urban wood waste and is constantly looking to diversify its supply. It has an exclusive supply contract with Mid-Michigan Recycling, a company which gathers wood waste from all over southern Michigan; in some cases, it sources biomass from as far as 100 miles, in places such as Holland and Big Rapids on the western side of the state, in addition to its primary operations in southeastern Michigan.[4] One important point, though, is that the Genesee Power Station is constrained in the fuel price it can pay by its power purchase agreement with Consumers Energy, while the University likely has the flexibility to pay somewhat higher prices, as long as they still provide cost savings compared to current energy sources. Ultimately, until the University actually attempts to secure biomass supplies, it is difficult to determine if sufficient quantities at reasonable prices will be accessible, even though the studies quoted above show that there is theoretically enough biomass available.

The challenge, then, is to secure a long-term supply contract that can ensure sufficient biomass quantities at affordable and predictable prices for the University. Sourcing from multiple suppliers would be onerous for operations staff, so it would be beneficial to find a single supplier that could aggregate sufficient biomass quantities and effectively take on the risk associated with supplying the biomass, as Mid-Michigan Recycling does for the Genesee Power Station. Mid-Michigan Recycling itself may be one option to consider. Another could be renewaFUEL, LLC, a company that produces high-Btu wood briquettes (uniform 1-inch cubes from sawdust) which have been successfully co-fired in a coal boiler operated by the city of Wyandotte. The company is currently investigating the possibility of opening a new production facility in southeastern Michigan or northwestern Ohio, depending on the availability of biomass feedstock and the potential for new customers in the area, so it may be an option for the University.[9]

3.1.5 Sustainability of Biomass

Although they can reduce greenhouse gas emissions, there are other direct and indirect concerns associated with biomass feedstocks, which vary greatly with the type of biomass. Since in this analysis urban wood waste is the main feedstock option, the sustainability of the feedstock itself is only indirectly dependent on forest management and only in the long term; this then reduces the University's responsibility to ensure sustainable management of the forests from which the biomass ultimately comes. If wood waste can be reused (e.g., shipping pallets), then it generally is until it can no longer perform its function adequately. When wood waste can be converted to higher-value uses (e.g., landscape mulch), it often is, although this is not always true. It would not be economically sustainable to appropriate wood waste as a fuel source that could be put to higher-value uses, but it is certainly sustainable to divert wood waste from going to a landfill as long as the costs of collection and transportation are not too great.

In a landfill, the wood waste would degrade over time and release GHG emissions; putting this biomass to use for energy generation also releases GHG emissions but simultaneously saves landfill space for more dangerous wastes and provides economic value by producing heat and electricity that would otherwise come from fossil fuel sources and saving landfill disposal costs. Compared to coal-generated electricity, biomass produces fewer NO_x and SO_x emissions as well. Thus, as long as there is a steady flow of urban wood waste that cannot be put to higher-value uses, this form of biomass is a fuel that can provide significant economic and environmental benefits.

There is one possible negative environmental impact from the use of biomass as a fuel, if it displaces natural gas (as would be the case at the CPP, and for the heating demand on North Campus). Natural gas is a cleaner fuel in terms of the non-GHG air emissions it produces, so combusting biomass can increase SO_x, NO_x and other air emissions.[10] However, this possible increase in air emissions should not under any scenario outweigh the benefits of biomass in terms of cost savings and GHG emissions reductions.

3.2 Geothermal

At the heart of any geothermal heating and cooling system lies a geothermal heat pump (GHP). This machine utilizes the constant temperature of the earth as a heat source or sink. For large commercial projects, boreholes are typically drilled vertically and plumbed with U-shaped piping. An antifreeze solution is pumped through the network and exchanges heat with surrounding earth. During the summer, the heat pump transfers the building's heat into the fluid circulating through this geoexchange field. The circulating fluid dumps heat into the cool earth, and returns for the next cycle. The process is reversed during the winter. Variations on this technology include utilizing lake, river or aquifer water. The use of this near-constant-temperature medium for exchange enables GHPs to achieve very high heating and cooling efficiencies. Moreover, the heat pump simultaneously produces chilled water while heating, and produces hot water while in chilling mode. If this can be used, the overall efficiency can be even higher. Many large institutions, including universities, have experienced great success using these systems at various scales (see Phase I Campus Sustainability Report).

This project explored installing geothermal systems in areas of the North, Central, and South Campuses as described below.

3.2.1 Technical Guidance

Different considerations are required based on the proposed site of a geothermal installation because the different campuses have different infrastructure and geothermal resources (i.e., land and water). These considerations are explored below.

3.2.1.1 North Campus

As of 2010, the North Campus Chilled Water Plant (NCCP) currently houses three 1300-ton chillers with a total rated capacity of 3,900 tons.[11] The NCCP Expansion Project (Phase 2), to begin in 2011, will significantly increase the capacity of the plant in order to meet the cooling demands of additional North Campus buildings (EECS, GG Brown, Music, Space Research, and NAME). Additional expansions of the plant are planned for as early as 2020.

Several pre-existing heating districts exist on North Campus as well. Each heating district shares a common boiler plant or balances its heating load between multiple boiler plants (see list in appendix). Each of the buildings in these districts is also served or will be served (as a result of the Phase 2 expansion) by the NCCP CHW loop. These pre-conditions minimize the incremental capital expenditure on connecting infrastructure that could be used by a geothermal system.

In order to utilize the hot water produced by a GHP located in the NCCP, HHW piping must be laid from NCCP to the district boiler plant of interest. The hot water produced by the GHP could then be used to pre-heat boiler makeup water, provide boiler blowdown water, or be fed directly into the HHW loops which heat the buildings.

Figure 2 shows three possible locations for geoexchange fields on North Campus along with the potential number of boreholes it could have and the associated heating/cooling capacity. Geoexchange fields should be located as close as possible to the heat pump itself, in order to minimize pumping energy. The stormwater retention ponds are located further away, but have the advantage of being saturated, which improves heat transfer between the soil and circulating fluid.

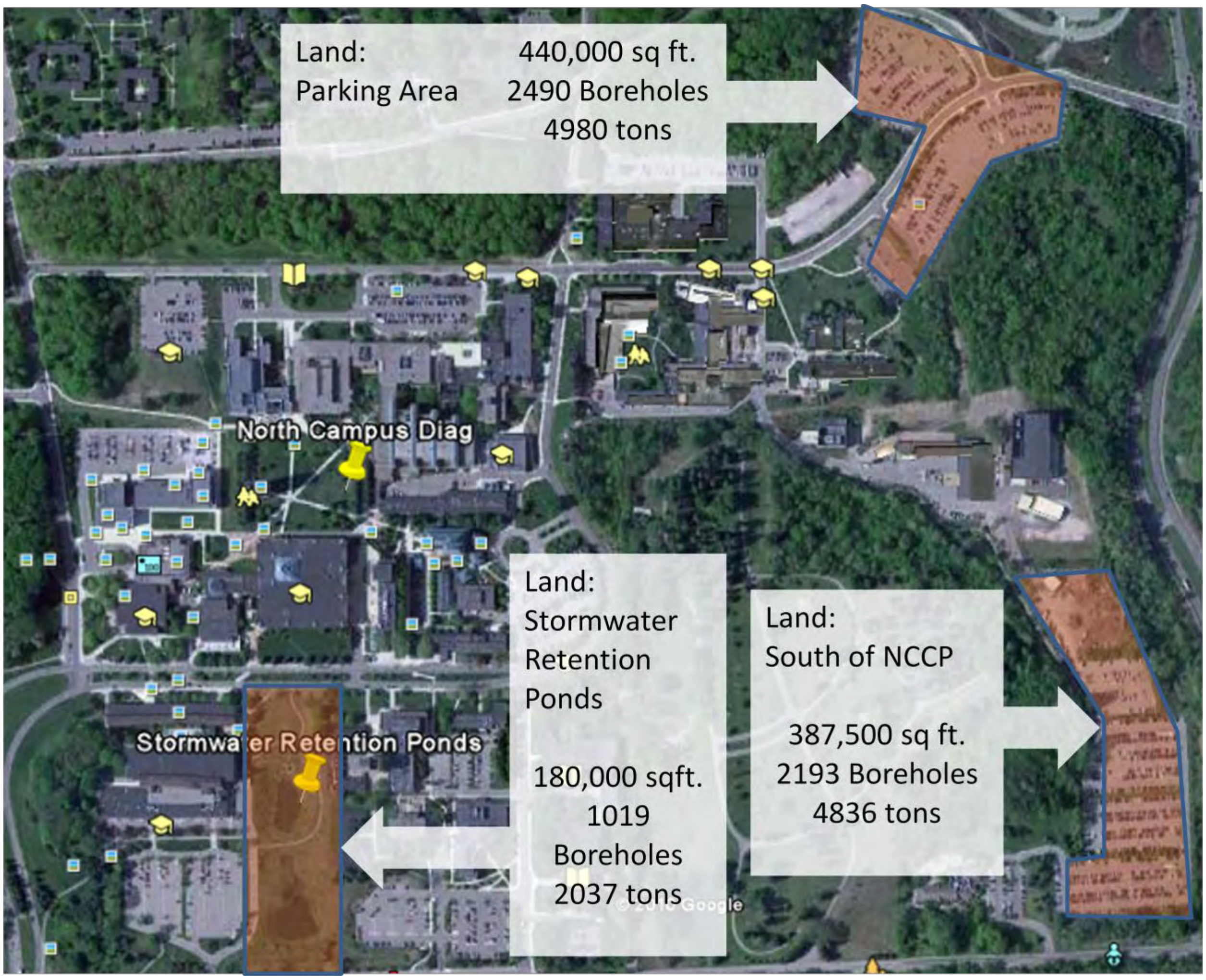

Figure 2: Three Potential North Campus Geothermal Resources

The estimations of capacity in the figure above, as well as in the figure below illustrating geothermal resources of Central Campus, use several simplifying design assumptions based on industry rules-of-thumb. These assumptions are summarized below in **Error! Reference source not found.**. Note that the center-to-center borehole offset of 20 feet used in this model is a very conservative value, near the upper limit of commonly-used offsets (typically 10-20 feet). It should be clear that geothermal ―capacity" is virtually unlimited, and is restricted only by the area of land available for use, the borehole density, and the depth to which the boreholes are drilled.

3.2.1.2 Central Campus

Several smaller district CHW loops exist on Central Campus. The Dental School chiller plant houses 2,400 tons of installed capacity, as well as cooling towers on the roof which provide free cooling, and operate year-round. The Palmer Drive chiller plant houses 4,500 tons of installed capacity. U-M Plant Operations recently conducted an investigation of the prospect of tying these two systems together, and eventually eliminating two smaller chillers in nearby buildings. This plan is shown in Figure 3.

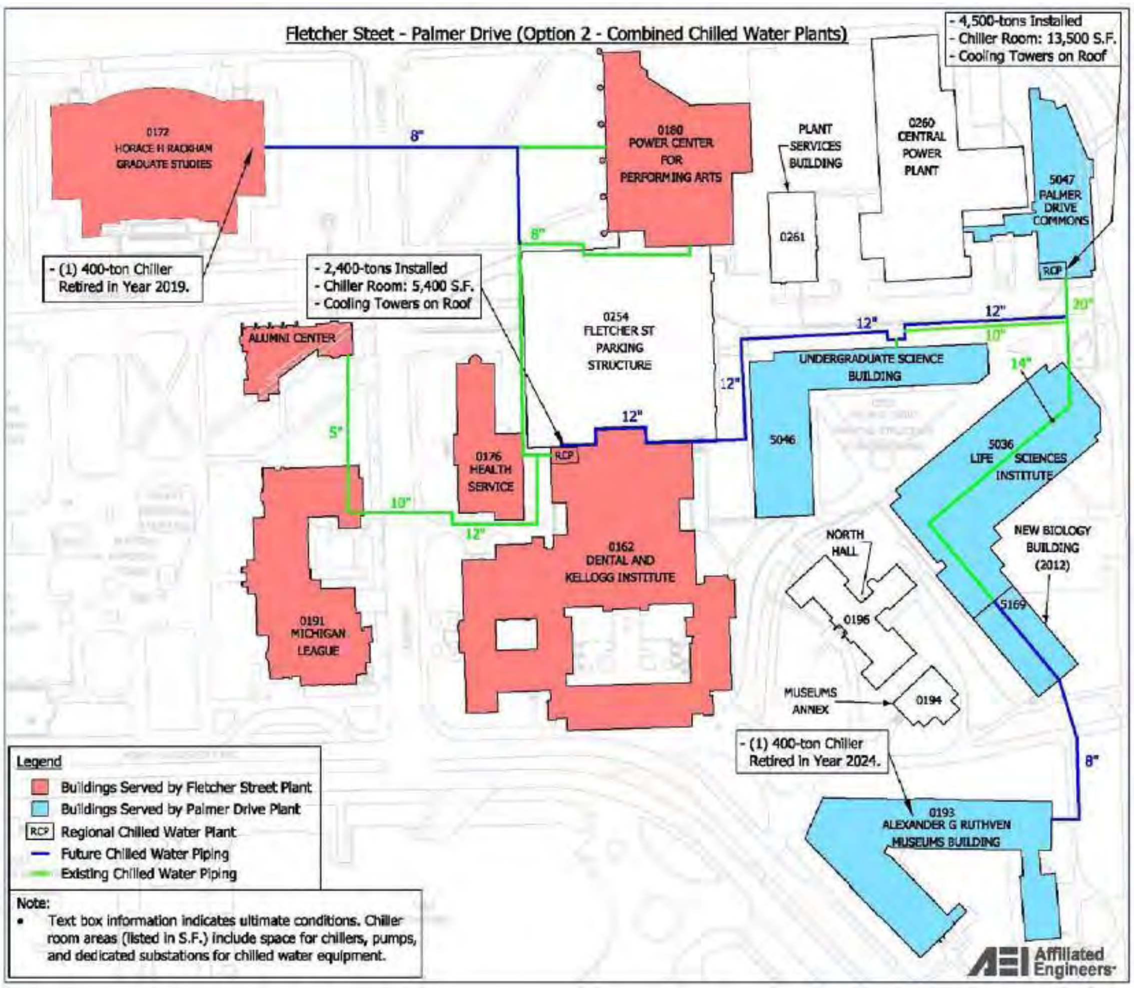

Figure 3: Proposed Extensions to Central Campus Chilled Water Networks

Palmer Field, located adjacent to both the Central Power Plant and the proposed expanded CHW district, could serve as the location for the geoxchange field on the Central Campus. The Power Plant has year-round demand for process heating, which could be supplied by a heat pump located in its vicinity. Like North Campus, the geothermal capacity of Central Campus is limited only by land area, borehole density, and borehole depth. Again using the same assumption of a 20 foot borehole offset, the area in center of the track and under the tennis and basketball courts could contain up to 1490 boreholes generate 2970 tons of heating/cooling capacity. After the borefield is installed, these areas could continue to be utilized as recreational spaces.

3.2.1.3 Stadium

Due to its location in a flood plain, the Michigan Stadium must constantly pump water from its basement in order to stay dry. A geothermal heat pump coupled to this groundwater source could be utilized to provide efficient heating and cooling to the stadium penthouses, supply domestic hot water, and possibly be tied into the nearby Hoover boiler plant, which serves several nearby buildings. If the rate of water pumping is sufficient, this represents an excellent energy and cost-savings opportunity. A general rule of thumb is 1.5-3.0 gallons of water per minute per ton of cooling capacity for an open loop heat pump. We were unable to obtain data on the temperature and volume of water being pumped from the stadium and thus analysis was not possible for this project, but a future study of this resource is recommended.

3.2.2 Costs and Benefits

Some of the considerations needed to develop an accurate cost model are outlined in Table 12. The items in bold text were included in the analysis, but the remaining items could not be quantified during this project.

Table 12: Factors for Estimating Geothermal System Costs

Factors in Calculating Capital Costs	
Incurred • **Ground source heat pump (GSHP)** • **Geoexchange field** • **Drilling** • **HDPE pipe** • **Pipe headers** • Thermal exchange fluid pumps • Boiler and chiller plant interconnects	Avoided • Boiler replacement • Chiller replacement
Factors in Calculating Net Operating Costs	
Incurred • **Electricity** • **GSHP** • **Thermal exchange fluid pumps** • GSHP maintenance (minimal)	Avoided • **Electricity (assume NCCP chillers)** • **Natural gas (CPP or heating boilers)** • Chiller maintenance (minimal) • Boiler maintenance (moderate)

Numerous simplifying assumptions have been made in order to build a cost model for a proposed geothermal systems. Here, the base case uses 85% efficient natural gas boilers for heating, and chilled water produced by NCCP for cooling. The appendix give the values for the key parameter assumptions used in the model.

In addition to the electricity used to operate the ground source heat pump, there is an electricity cost associated with the fluid pumps that circulate thermal fluid in the geoexchange field. Required flow is very much dependent on geoexchange field configuration and size, as well as heating and cooling requirements. A reasonable ballpark estimate of the pumping energy requirement is 15% of the energy requirement to operate the GSHP. Therefore, a reasonable COP for the entire system (including pumping energy penalty) for heating and cooling is simply 0.85 times the COP given in **Error! Reference source not found.** above.

Taking into consideration the costs incurred and avoided as shown in bold in Table 12, the capital cost of a ground source heat pump system, including GSHP, and geoexchange field is $1,500 per ton installed capacity. Energy utilization and savings compared to the base case is calculated based on operating the GSHP system at an average of 90% rated load year-round, half of the time in cooling mode and half of the time in heating mode. Notably, avoided capital costs as identified for alternative scenarios are omitted.

In this simple model, the energy savings and cost savings per ton of capacity are constant. In order to capture the additional capital costs to implement a district geothermal heating system (e.g., fluid pump purchase costs and interconnection costs), three different payback times were calculated. The first payback time simply ignores these additional costs, under the assumption that they will be perfectly offset by the avoided costs of maintenance and equipment replacement. The second and third payback time posits that the entire system capital cost will amount to twice and three times the calculated capital cost.

The strength of this method is that it avoids the need to calculate interconnection costs, fluid pump capital costs, avoided capital replacement costs, and avoided maintenance. The weakness of this method is that the cost of system interconnection is not expected to scale linearly with system size. This may lead to an inappropriately low estimation of project cost for small systems (e.g., 200 tons) and an excessively high estimation of total project cost for larger systems (e.g., 1600 tons).

Using the efficiency and cost parameters described above, the simple payback time for a geothermal district heating and cooling system is approximately 8-24 years, under a very wide range of cost and payback scenarios (see appendix). For a geothermal system combined with cooling towers (which would increase the system efficiency), this period is reduced to 6-18 years. The simple payback time is considerably reduced under in a carbon tax scenario: 3-10 years, according to the $50/MT CO2 model. Considering that borehole fields have expected lifetimes of over 50 years, and U-M typically replaces chiller equipment after 25 years of service, this is a favorable payback. Avoided CO2 emissions amount to approximately 5.14-6.27 $MTCO_2$ per year per installed ton system capacity, or a reduction of 0.002% of total CO2e emissions per ton.

3.2.3 Uncertainties

In the absence of the capital costs shown in (non-bold) plain text in Table 12, it is difficult to accurately predict payback times for a generic regional geothermal district heating and cooling system. A cost model would have to be constructed specific to each system size, location, connected load parameters, and equipment replaced. Greater model accuracy could be achieved with geothermal test wells to determine soil conductivity. This would pin down the energy-optimal and cost-effective geoexchange field design and dimensions.

3.3 Solar

3.3.1 Solar Introduction

Harvesting energy from solar radiation is another way to increase renewable energy on the Ann Arbor campuses. The two approaches we examine for utilizing solar energy are using photovoltaic (PVs) and solar thermal heating systems. PV systems use an array of solar panels and an inverter to convert solar energy into electricity. Solar thermal heating systems, on the other hand, pump water or antifreeze through collectors to absorb heat from the sun. The fluid then runs through a heat exchanger to generate hot water, which can be used for space heating or used in the building.

Because both solar thermal and PV systems typically utilize roof space, there is a tradeoff between the two. In evaluating capacity across campus, we have identified a list of buildings that seem to be the best candidates for solar installations based on the size of the roof area, the structural capacity of the roof to support equipment loads, and the lack of apparent shading. In the calculations in this report, we dealt with the tradeoff between PV and solar thermal by dividing the priority list of roof space. We attempted to place solar thermal projects closer to the Central Power Plant, where the hot water can be more easily integrated into domestic supply. Housing buildings, which actually use significant amounts of hot water, were also prioritized for solar thermal. The remainder of the buildings was allocated to PV. Because of the lack of available data on roof areas, we were unable to include in our calculations three other buildings that we identified as good candidates for solar installations: West Quad dormitory, Alice Lloyd and the Michigan League. These buildings should, however, be considered in future studies.

Table 13: PV and Solar Thermal Priority Buildings

PV Priority Buildings	Solar Thermal Priority Buildings
• North Campus Recreation Building • Angell Hall • Mason Hall • School of Education • University Hospital • Taubman Medical Center	• Central Campus Recreation Building • Dental Institute • Power Center for Performing Arts • Undergraduate Science Building • Modern Languages Building

In addition to roof mounted arrays, solar PV was also evaluated in the context of solar carports to cover existing campus parking lots.

3.3.2 Photovoltaics (PVs)

When considering PV, there are many technologies for panels, differing in price and efficiency. Most photovoltaic panels are made of silicon and come in either monocrystalline, polycrystalline (cast or ribbon), or thin film forms. A promising new technology uses cadmium telluride (CdTe) instead of silicon, and has been shown to decrease cost dramatically. Efficiencies range from 8% with thin film to 19% with monocrystalline silicon. U-M currently has a 33 kW PV system on the roof of the School of Natural Resources & Environment, which was installed in 2005, that utilizes both thin film and polycrystalline panels[12].

The efficiencies and costs of the specific technologies evaluated are represented in the table below:

Table 14: Efficiency and Cost for PV by Type

	Panel Efficiency[13]	Price per Watt[14]
Thin film	8%	$ 1.37
Monocrystalline	19%	$ 2.27
Polycrystalline, cast	14%	$ 1.80
Polycrystalline, ribbon	13%	$ 1.80
CdTe	10%[15]	$ 0.93[16]

3.3.2.1 Forecasts of Costs and Benefits

Total PV capacity on campus was evaluated using four different scenarios: 10%, 15%, and 20% of general funds roof space, and the PV priority list of buildings. In the case of the priority buildings, an assumption that 75% of roof space may be covered in panels was used to allow for safety perimeters and access pathways, we find potential PV capacity to range from 2.3 million kWh/year to 17 million kWh/year. Comparing this to total electricity use on campus for FY09 of 570 million kWh[17], this represents 3% of consumption.

Table 15: PV Performance by Scenario and PV Type

	10% Scenario	15%	20%	Priority
	kWh/year	kWh/year	kWh/year	kWh/year
Thin film	3,600,000	5,400,000	7,200,000	2,300,000
Monocrystalline	8,500,000	12,700,000	17,000,000	5,500,000
Polycrystalline, cast	6,300,000	9,400,000	12,500,000	4,100,000
Polycrystalline, ribbon	5,800,000	8,700,000	11,600,000	3,800,000
CdTe	4,500,000	6,700,000	8,900,000	2,900,000

Table 16 shows the total capital costs will range from $8 million to $58 million, depending on technology and capacity scenario used. Additionally, as shown in Table 17, the cost per kWh generated ranges from $0.13-0.24. These figures assume that the installed cost of the system is equal to twice the module cost[18] and that each system has a lifetime of 20 years, which is a conservative estimate.

Table 16: PV Capital Costs (in millions)

	10%	15%	20%	Priority
Thin film	$17	$26	$35	$11
Monocrystalline	$29	$43	$58	$19
Polycrystalline, cast	$23	$34	$46	$15
Polycrystalline, ribbon	$23	$34	$46	$15
CdTe	$12	$18	$24	$8

Table 17: Cost per kWh Generated

	10%	15%	20%	Priority
Thin film	$0.24	$0.24	$0.24	$0.24
Monocrystalline	$0.17	$0.17	$0.17	$0.17
Polycrystalline, cast	$0.18	$0.18	$0.18	$0.18
Polycrystalline, ribbon	$0.20	$0.20	$0.20	$0.20
CdTe	$0.13	$0.13	$0.13	$0.13

If we use these results to determine avoided purchase of electricity under the various scenarios, we can estimate avoided carbon emissions. These reductions range from 1,700 metric tons to 12,400 metric tons based on the scenario and technology employed. This represents between 0.29% and 2.1% of total emissions from the University of Michigan, respectively. The simple payback period ranges from 29 years to 81 years, depending on the technology used and the price of carbon.

In addition to roof-mounted PV, we also considered pole-mounted PV to be placed in existing campus parking lots. For the purposes of these calculations, we assumed panel coverage of 50% of parking lot area, breaking that down into Central Campus only or all campuses (Central, North, Medical, and South). Available areas are shown in Table 18 below.

Table 18: Parking Lot Areas by Campus (in square feet)

Central	35,857
North	4,770,709
Medical	695,999
South	2,604,751
Total	*8,107,317*

Using these area estimates, total annual generation was calculated for the Central Campus and All Campus scenarios, considering each of the five technologies evaluated for rooftop PV. Capacity ranged from 195,000 kWh/year to 105 million kWh/year; this higher value represents 18.4% of U-M electricity usage. System costs ranged from $520,000 to $285 million, and cost per kWh generated ranged from $0.11 to $0.20/kWh as shown below. Using the generation estimates, parking lot PV would reduce annual carbon emissions by up to 76,300 MT CO2 – or 12.9% of total campus emissions. Simple payback ranges from 49 years with no carbon price and installations only on Central Campus to 14 years with a $50/MT price on carbon and installations on parking lots across all campuses.

Table 19: Parking Lots Annual Generation (kWh/year)

	Central	**All Campus**
Thin film	190,000	44,000,000
Monocrystalline	460,000	105,000,000
Polycrystalline, cast	340,000	77,000,000
Polycrystalline, ribbon	320,000	72,000,000
CdTe	240,000	55,000,000

Table 20: Parking Lot PV System Cost ($)

	Central	**All Campus**
Thin film	760,000	172,000,000
Monocrystalline	1,260,000	285,000,000
Polycrystalline, cast	1,000,000	226,000,000
Polycrystalline, ribbon	1,000,000	226,000,000
CdTe	520,000	117,000,000

Table 21: Parking Lot PV Cost per kWh ($/kWh)

	Central	All Campus
Thin film	$0.20	$0.20
Monocrystalline	$0.14	$0.14
Polycrystalline, cast	$0.15	$0.15
Polycrystalline, ribbon	$0.16	$0.16
CdTe	$0.11	$0.11

It should be noted the rooftop PV calculations included an overall system efficiency factor, in addition to the solar cell efficiency, of 80% to account for line losses, snow losses, inverter losses, etc. The parking lot PV didn't include this 80% efficiency because they would typically use micro-inverters which are more efficient than central inverters, and snow loading would be less of a problem on tilted carports than on flat roofs.

3.3.2.2 Technical Guidance

The roofs included in our priority list are predominantly flat and would need additional structure to support tilted panels. As a general rule, roofs constructed prior to 1980 should be able to support PV solar arrays, which weigh 3-5 pounds per square foot (psf), because they were built to support stone ballasts at 5-8 psf[19]. Most of these buildings, then, seem to be suitable, although a structural engineer would be needed to verify. Wind loads may also create problems and will need to be further investigated for each site, depending on the desired tilt of the panels and the height of placement above the roof. Thin film panels should create no wind load, and crystalline panels can minimize load when fixed a maximum of 6 inches above the roof[20] and at an angle close to 20º from horizontal. The worst angles for created uplift are between 10-15º and at 90º.[21]

Additionally, PV arrays are area-intensive. To minimize fixed costs, the largest roof areas should be used first, before considering smaller, less cost-efficient projects. When calculating available roof space, note that a 4-10 foot perimeter of open space is required on all roofs as a safety precaution (hence our assumption of 75% of roof space used for panels), and lab buildings are generally infeasible due to the HVAC and fume hood equipment on top. When using thin film panels (approximately 12" wide), the distance between roof ribs is also important in determining how much roof area can be utilized. It should also be noted that PV systems cannot be installed on certain roofing materials, such as slate or tile.

Finally, campus roofs have an average lifetime of 25 years, and PV installation should be combined with regular roof replacement when possible to cut down on costs. This roof lifetime is compatible with the 20-30 year lifetime of most PV panels. PV panels should be recycled at the end service whenever possible to reclaim hazardous material like cadmium thus avoiding negative impacts on ecosystems and human health.

For parking lot PV, capacity calculations were based on 50% of existing parking lot areas (not including parking structures) and cost estimates include system costs and installation but not the construction of poles. Existing light and utility poles may be used in some cases. Wind and structural loads should be considered as in the rooftop installations.

3.3.2.3 Institutional Barriers

The greatest institutional and regulatory barriers in implementing PV systems are the requirements for roof space. In situations like the agreement-in-progress with DTE to lease roof space, legal contracts for easements must be negotiated. These easements may be a hindrance to U-M future growth (if long term contracts) or maintenance (without proper allowances for emergency repairs to access the leased roof). Other institutional barriers include fire safety codes that may limit feasibility of PV implementation, as well as roof access for installation and maintenance. Not all University roofs currently have easy access and panels inherently make roof maintenance more difficult. Even in areas where the roof is accessible, inclement weather can make maintenance and repair of these systems problematic.

Access and roof maintenance are eliminated as concerns with parking lot PV. However, the main concern with installing PV arrays on campus parking lots is the aesthetic, given that these arrays would be more visible than rooftop-mounted ones. This could be a boon to publicity or a barrier, depending on public opinion.

3.3.2.4 Uncertainties

It is difficult to calculate the potential of solar PV given the lack of data on campus roofs. To date, only a few informal studies have been undertaken, resulting in largely nonexistent or incomplete data on roof area, slope, material, and orientation. This analysis relied primarily on the Roof Replacement Model for General Funds buildings, but many ideal buildings, such as the hospital buildings, housing, and the Michigan League, are not tracked as part of this model. We therefore also relied heavily on Google Earth to estimate roof areas and orientation, so before U-M can implement these recommendations, data will need to be verified in a formal study.

Other uncertainties include the availability of financial incentives. Because PV is a costly form of renewable energy, most funding will likely need to come from donors and/or state or federal grants.

3.3.3 Solar Thermal Systems

Solar thermal systems use roof mounted equipment to heat a circulating fluid, which in turn can be used to heat water. There are varying levels of systems available, affecting efficiency and price. The technologies that we have examined for this proposal (due to climate suitability and commercial availability) are flat plate collectors and evacuated tube collectors (ETC).[22] U-M already has a parabolic trough collector installed, but its location is not ideal and it therefore has not performed up to its potential. Furthermore, the special collectors are difficult to have serviced since there is only one company that deals with them.[23] Because of these difficulties, we have focused on evaluating campus potential of evacuated tube and flat plate collector systems, which are more established technologies and do not require special maintenance.

Standard solar thermal systems for residential and commercial buildings include at least solar collector panels, a heat exchanger, and a hot water thermal holding tank. U-M, however, has a DHW loop that circulates through central campus heat primarily by the CPP so a thermal holding tank is normally not required. Using solar thermal equipment to preheat water to CPP steam generation was also considered.

3.3.3.1 Costs and Benefits

As done for the solar PV resource potential calculations, we have conducted calculations for solar thermal resource potential based on four different roof area scenarios: 10%, 15%, 20% of general fund roof space, and the priority solar thermal buildings identified in Table 13.

We also recommend further investigating the possibilities of putting solar thermal collectors on campus housing, especially those with dining halls. These buildings have an almost constant need for hot water. In fact, they generally have their own booster heaters to further heat and pressurize the water that comes in from the CCP DHW loop. As a result, having a solar thermal heat source immediately prior to the water entering the building's loop can save energy from the booster heaters. Incidentally, these are powered through steam, which is also produced by CPP from natural gas.

To do an initial high level estimate of the potential solar resource, we assume the use of evacuated tubes on campus roof space used for heating water in the DHW loop. Using the 10%, 15%, and 20% general fund roof space assumption and average Michigan temperatures and solar radiation level, U-M can achieve the following output shown in Table 22.

Table 22: U-M Campus Potential with Evacuated Tube Systems

Scenarios	Annual kBtu Output	Annual Gallons HW Heated
10% RRM	62,200,000	224,600,000
15% RRM	93,200,000	337,000,000
20% RRM	124,000,000	449,000,000

This annual hot water production corresponds from about 2.6 to 5.3 times the total U-M hot water consumption throughout a year (85.3 million gallons in FY10).

Hot water at U-M's central campus is generated with natural gas combustion at the power plant, so cost savings come from natural gas savings. These cost savings are shown in Table 23. Each system has the same simple payback of 16.5 years since they are all linearly scaled (the more roof area, the more production and natural gas savings by linear factors).

Table 23: Solar Thermal Payback Under Various Scenarios

Scenario	Capital Cost	Annual Savings
10% RRM	$7,400,000	$451,000
15% RRM	$11,100,000	$676,000
20% RRM	$14,800,000	$901,000

To calculate the potential of the priority solar thermal buildings, both evacuated tube and flat plate technologies were employed. Both of these technologies have different efficiency profiles. In the case of the University, the flat plate collector were found to be more efficient for initially heating water (i.e., heating from 60°F to 120°F) than boosting the temperature of already heated water (i.e., heating from 90°F to 120°F). Evacuated tube technology was more efficient in the later case and thus it was selected for boosting the heat in the DHW while flat plate technology was selected for pre-heating for the CPP. This preheated water can be used in the DHW loop or for pre-heating water to be used in steam generation. See the appendix for more discussion of the technology efficiency. Table 23 shows the results of the analysis for solar thermal priority buildings using these assumptions.

Table 24: Solar Thermal Priority Building Scenario Results

	Flat Plate	Evacuated Tube	Total
Buildings			
Area (sq.ft)	52,400	130,000	180,000
Capital cost ($)	$ 630,000	$ 2,300,000	$ 3,000,000
O&M costs ($)	$ 42,000	$ 81,000	$ 120,000
Annual Cost Savings ($)	$ 95,000	$ 140,000	$ 240,000
Annual kBtu output	13,000,000	20,000,000	$33,000,000
Annual CO2 emissions cut (metric tons)	700	1100	1,800

Adding the potential for a carbon tax can also make the system look more cost effective. The Solar Thermal Priority List scenario saves 1800 metric tons of CO_2 annually, which is 0.3%

of U-M's carbon emissions. Under different carbon tax regimes, the value of the system changes again. The payback periods using the different carbon prices and discount scenarios are shown in Table 25.

Table 25: Solar Thermal Priority Payback (years)

Carbon Tax Regime	Simple Payback	5% Discount
$0/metric ton CO2	14	24
$20/metric ton CO2	13	22
$50/metric ton CO2	12	18

3.3.3.2 <u>Technical Guidance</u>

South-facing roof areas with a tilt close to latitude (42°) would be ideal to install solar thermal systems. However, there are very few roofs at U-M that meet this criterion. A preliminary study was done by the Architecture, Engineering, and Construction department finding five south-facing roofs with tilt angle ~20°. These are all athletic buildings with steel and aluminum rooftops, totaling over 73,800 square feet in available area. We have also used Google Earth to look for other flat, unshaded rooftops that could potentially be hold tilted installations. This totals at least 365,000 available square feet, and includes both buildings with high consumption of domestic hot water such as dorms and dining halls as well as building with open roof areas that are connected to the central campus steam system. Of these roof areas, the ones built prior to 1980 have an additional weight capacity of 5-8 lbs/sq ft because they were built for ballasted roofs.[24] Other roof areas would need further investigation to establish additional weight capacity. Solar thermal collectors weight about 4-5 lbs/square foot, so this is within the available range.[25] Heat exchangers and thermal storage tanks (if required) need not be located on the roof. Plus, the pumps for pumping the anti-freeze and the water could be potentially powered by a solar PV panel on the roof.

3.3.3.3 <u>Barriers to Implementation</u>

The most significant barrier is the high capital costs required to install the system. Some training will be required to maintain solar thermal systems, but maintenance is only needed every 5-8 years, and only involves a replacement of the antifreeze solution. Additionally, an annual maintenance inspection of the system is recommended. Load analysis may be needed in newer buildings to confirm roof weight capacity.

3.3.3.4 <u>Uncertainties</u>

An uncertainty in these calculations will be in the payback period, which is dependent on the fluctuation of natural gas prices. We used only the current gas price, but changes in the price can affect the NPV payback period for the system. Another major uncertainty is lack of available roof area data. The roof replacement model significantly excludes data on campus housing buildings and hospital buildings. Pricing estimates for these systems are also very uncertain, since preliminary research has shown a huge range of values from $30/sq ft including installation costs to well over $100/sq ft. This variation is primarily because of the scale of investment and the installation costs which will not go up in the same proportion with the number of installed collectors. Finally, O&M costs for repairing and/or replacing electrical systems and piping structures due to failure of pumps etc. could not be estimated.

3.4 Wind

Two approaches were looked examined in regards to using wind power. The first is to develop and operate wind farms directly. The second is to purchase wind power from DTE Energy through renewable energy certificates (RECs)

3.4.1 Wind Turbines

Wind energy is a proven, cost effective, renewable source of clean energy. The state of Michigan has several wind energy resources that can be harvested to power the University. No locations on campus are suitable for wind energy. These wind turbines would be located off campus in the state of Michigan. The analysis will consider investing in two 1.5 MW turbines that will be built and operated by an independent party, but additional turbines could be constructed.

3.4.1.1 Costs and Benefits

The estimated cost of this project ranges from $5.4 to $6 million[26]. Typical maintenance fees are 2 percent per year of the installed costs that range from $108,000 to $120,000 annually[27]. The range in the cost is attributed to site specific and transmission issues that may be encountered depending on the locations of the turbines.

Based upon a 29.8% capacity factor, the two turbines will generate approximately 7,830,000 kWh of energy annually[28]. This will save approximately 5,700 metric tons of carbon dioxide annually. By producing its own energy, the University will save $.08/kWh produced through purchasing less energy from DTE. Thus, taking into account the annual maintenance costs the University can save from $507,000 to $519,000 annually. Also, the cost savings from producing renewable energy coupled with a $20/metric ton carbon tax ranges from $621,000 to $633,000 annually. If a $50/metric ton carbon tax was in place the University would save from $793,000 to $804,000 annually. The payback periods using the different carbon prices and discount scenarios are shown in Table 26.

Table 26: Wind Turbine Payback Periods (years)

Carbon Tax Regime	Simple Payback	5% Discount
$0/metric ton CO2	16-19	10-11
$20/metric ton CO2	12-13	9-10
$50/metric ton CO2	9-10	7-8

Other benefits include reducing the University's sensitivity to fluctuations in energy prices, and enhanced green marketing to increase application rates and public visibility.

3.4.1.2 Technical Guidance

The University would contract out development and operational services for the wind turbines. Therefore, no technical guidance is needed, since these services would be outsourced.

3.4.1.3 Barriers to Implementation

Availability of transmission space is a potential barrier since transmission is in high demand throughout the state, however the amount of energy produced by two turbines is small and it is assumed there would be transmission space available to accommodate the power produced. Also, availability of land with a good wind resource is a potential barrier.

3.4.1.4 Uncertainties

The costs to develop wind energy could rise, depending on the demand for developers and the capital costs associated with wind energy.

3.4.2 Renewable Energy Credits

A renewable energy credit (REC) represents proof that a non-tangible energy commodity, was generated from a renewable energy source[29]. This commodity can be bartered, sold, or traded on the open market. RECs allow the buyer flexibility to support renewable energy sources that may not otherwise be widely available.

RECs are an easy and quick method that the University currently uses to reduce its carbon footprint. The University can continue to have a positive impact on GHG emission by increasing the amount of RECs purchase. The University currently purchases 9 million kWh, approximately 2% of total purchased energy, of RECs from DTE. This analysis will consider increasing the University's total purchased energy to 5%. A 3% increase from the current purchases.

3.4.2.1 Costs and Benefits

The 9 million kWh of RECS currently purchased from DTE, cost the University $180,000 annually. This cost represents a $0.02 premium/KWH above the normal purchased energy. Increasing REC purchases to 5% would require 13.5 million kWh of REC and represent a $270,000 annual cost increase. This represents an NPV of $1.66 million over 10 years.

Investing in 13.5 million kWh in RECs would save 9,800 metric tons of carbon dioxide annually. Utilizing a 5% discount rate, if a carbon tax of $20 per ton was implemented the annual investment would have a payback period of less than 2 years. If a carbon tax of $50 per ton was implemented, the annual investment would have a payback period of less than 1 year. The payback period would remain the same with a 0% discount rate.

The additional benefits of RECs include enhanced green marketing to increase application rates and public visibility, improving the air quality for the state of Michigan, helping the state of Michigan satisfy its Renewable Portfolio Standard, and creating a stronger connection with the University's utility provider

3.4.2.2 Technical Guidance

No technical guidance is required since the energy is generated and delivered by DTE.

3.4.2.3 Barriers to Implementation

It is easy to amend the contract with DTE to purchase additional RECs. No technical barriers to implementation currently exist.

3.4.2.4 Uncertainties

DTE could potentially raise the prices of the RECs once the contract retires. However, this analysis can be reevaluated to determine if the increase in costs outweigh the benefits associated with RECs.

3.5 Hybrids

Hybrid vehicles offer improved fuel economy compared to conventional vehicles and as a result can reduce GHG emissions and save on fuel costs. The analysis considered the impact of purchasing hybrid busses and hybrid vehicles for use in the campus vehicle fleet.

In FY 2009, the U-M Department of Transportation Services (DTS) owned over 1,000 vehicles. Of these vehicles, 447 could be replaced with hybrid vehicles based on use-type. The vehicles that could not be replaced by hybrids were minivans, cargo vans, utility vans, and large work trucks ranging from large pick-up trucks to dumptrucks. This study modeled replacing all sedans with Fusion Hybrids, all SUVs with Escape Hybrids, all Tahoes and Suburbans with Tahoe Hybrids, all pick-up trucks with an engine size between 4.0L and 6.0L with the Silverado Hybrids, and all buses with Gillig Hybrids. More details on the vehicle fleet and the replacements modeled are shown in the appendix.

3.5.1 Costs and Benefits

To calculate the potential annual energy and emissions savings, the model used several factors: fuel economy (MPG data)[30], an assumption of the ratio between highway and city driving for each use-type, an assumption of vehicle miles travelled per year, and the energy content of the different fuels (LHV data)[31]. These data and assumptions are outlined in the appendix.

In addition, to calculate better understand the fossil fuel savings from hybrids vehicles, the analysis considered the life-cycle fossil fuel requirements and GHG emissions for the fuels used. This is commonly refered to as ―Well-to-Wheel" (WTW) analysis. Much of the U-M passenger vehicle fleet is flex-fuel capable and uses E85 fuel, which is composed of 85% ethanol from renewable sources such as corn. At first glance, it would seem that a hybrid using conventional petroleum would need to consume less than 15% of the fuel used by a flex fuel vehicle using E85 to have less fossil fuel consumption. However, significant amounts of fossil fuels are needed to growth, harvest, and process corn into ethanol, which dramatically reduces the sustainability of ethanol. WTW analysis takes this into consideration.

To find the magnitude of energy and GHG savings from hybrids, the analysis considered replacing the entire fleet of passenger vehicles and buses in 2010. If a vehicle did not have a 2010 model for the same use-type and fuel-type, a similar type vehicle was modeled in its place. For example, DTS has many Ford Taurus E85 vehicles, but Ford does not make a 2010 Taurus E85, so a 2010 Ford Fusion E85 was used. The total energy and emissions of the hybrid was then subtracted from the total energy and emissions of the non-hybrid to calculate energy and emission savings. See Table 26 and Table 27 below for results.

Table 27: Annual Energy and Emission Savings from Hybrids

Energy Savings (Gal Gasoline eq/yr)	**Fusion**	**Escape**	**Tahoe**	**Silverado**	**Total Cars**	**Gillig**	**Total Fleet**
Count (#)	225	14	8	140	**387**	60	**447**
At the Pump	36500	2700	755	16200	**56100**	85600	**142000**
Emissions Savings							
EPA (Tons CO2e/yr)	415	60	0.4	426	**902**	N/A	**902**
WTW (MT CO2e/yr)	241	31	3	183	**458**	856	**1310**

Table 28: Annual Energy and Emissions Savings per Vehicle

Energy Savings/Vehicle (Gal Gasoline eq/yr)	Fusion Hybrid	Escape Hybrid	Tahoe Hybrid	Silverado Hybrid	Gillig Hybrid
At the Pump	162	193	94.4	115	1430
Emissions Savings/Vehicle					
WTW (MT CO2e/yr)	1.1	2.2	0.4	1.3	14.3

The potential energy and emissions savings from hybrid integration in relation to U-M totals were calculated using total fossil fuel requirements for transportation fuels consumed in FY 2009 and total U-M GHG emissions in FY 2009. Total potential annual emissions saved by hybrids (1,310 MT CO2e) is equivalent to 0.22% of U-M total emissions.

3.5.1.1 Financial Feasibility of Hybrid Integration

The total cost over the lifetime of the vehicles was calculated by adding the purchase price to the net present value of the fuel costs over the lifetime of the vehicle and then subtracting the net present value of the resale value of the vehicle. A discount rate of 5% was used. The total costs vary depending on the purchase price, predictions of fuel prices, and the availability of funding.

This study modeled two different purchase price scenarios: an assumption of the DTS price [32], and the same assumption of the DTS price with US Department of Energy (DOE) funding. The DOE funding for hybrids is $2,000 per hybrid passenger vehicle (sedans, SUV, and light-duty trucks), and anywhere from 10% of MSRP to 100% of the cost upcharge for hybrid buses[33]. Although, DOE funding in not available to U-M directly, the regional Clean Cities Coordinator can allocate DOE funding to U-M. The Southeastern Michigan Clean Cities Coordinator is the Clean Energy Coalition, who is currently allocating funding to DTS for 100% of the upcharge for four hybrid buses[34].

This study also modeled two fuel price scenarios using US Energy Information Agency (EIA) low oil price scenario predictions and high oil price scenario predictions. The EIA predictions of fuel prices decrease on average 1-2% annual in fuel prices over the life of the vehicle in the low fuel price scenario and increase 10% annual in the high fuel price scenario.

To assess the financial feasibility of hybrid replacement the costs of the hybrid were subtracted from the costs of the non-hybrid. If a positive value is the result, the hybrid option is cheaper and if a negative value is the result, the hybrid is more expensive. See **Error! Reference source not found.** and Table 31below for results.

Table 29: Total Lifetime[i] Costs of Passenger Car Hybrid Integration by Model

Hybrid Model	Count	DTS Price No Funding EIA Low	DTS Price No Funding EIA High	DTS Price w/ Funding EIA Low	DTS Price w/ Funding EIA High
Fusion	225	$584,000	$400,000	$275,000	$91,200
Escape	14	$30,100	$17,000	$10,900	($2,260)
Tahoe	8	$77,100	$65,900	$65,100	$53,800
Silverado	140	$711,000	$522,000	$501,000	$312,000
Total	387	$1,400,000	$1,000,000	$851,00	$454,000

[i] These costs represent the lifetime of the vehicles dependent on use-type. See appendix for vehicle lifetimes.

Table 30: Total Lifetime Error! Bookmark not defined. **Costs of Hybrid Bus Integration**

Hybrid Model	Count	(90% MSRP)	(90% MSRP)	(MSRP-Upcharge)	(MSRP-Upcharge)3
Gillig	60	$5,700,000	$4,070,000	($2,520,000)	($4,150,000)

The results show by replacing campus buses with hybrid buses that if the University could save up to $4.2 million over the lifetime of the buses if funding can be found to cover the cost premium of hybrid busses compared to conventional buses. Purchasing hybrid passenger vehicles could cost as much as $1.4 million over their lifetime compared to conventional vehicles in the low fuel cost scenario. Under this scenario, the cost per metric ton of CO2 equivalent abated is $510 per metric ton. Thus, without funding the DTS purchase price and low fuel price scenario makes hybrids the least attractive financially and the DTS price with funding for 100% of the upcharge for the hybrid buses and high fuel price scenario is the most attractive financially.

3.5.2 Technical Guidance

The best way to integrate hybrids is to consider the hybrid option when replacing a vehicle. Table 31 and Table 32 show the cost of replacement of vehicles at the end of their service life with on a per vehicle basis.

Table 31: Lifetime Costs of Hybrid Passenger Cars per Vehicle Compared to Non-Hybrid Option

Hybrid Model	DTS Price No Funding EIA Low	DTS Price No Funding EIA High	DTS Price w/ Funding EIA Low	DTS Price w/ Funding EIA High
Fusion	$2,590	$1,780	$1,220	$406
Escape	$2,150	$1,210	$780	($161)
Tahoe	$9,640	$8,230	$8,130	$6,730
Silverado	$5,080	$3,730	$3,580	$2,230

Table 32: Lifetime Costs of Hybrid Buses per Vehicle Compared to Non-Hybrid Option

Hybrid Model	(90% MSRP)	(90% MSRP)2	(MSRP-Upcharge)	(MSRP-Upcharge)3
Gillig	$95,000	$67,800	($42,100)	($69,200)

This results of the analysis showed that given the price of fuel DTS pays, the EIA fuel price predictions, the purchase price DTS pays for new vehicles, the Fusion Hybrid and the Escape Hybrid are much more cost effective than the Silverado and the Tahoe hybrid. However, the Gillig hybrid is the most cost effective considering funding is available for the entire upcharge. Hybrid buses offer the most energy and emissions savings of the hybrid vehicles, but are only financially feasible if funding is available for 65-80% of the incremental costs depending on fuel prices.

3.5.3 Barriers to Implementation

3.5.3.1 <u>Economic Barriers</u>

Fuel Prices

The price DTS pays for E85 fuel is 17% cheaper than conventional gasoline as of October 2010. Since there are no available hybrid vehicles on the market that can run on E85, this study modeled Hybrids using conventional petroleum compared to E85 non-hybrids. The difference in fuel prices made the hybrids less attractive financially. Essentially, the difference in fuel price made it more difficult for the hybrid to make up its difference in purchase price in fuel savings.

DTS pays less per gallon than the average consumer pays at the pump. This bulk discount saves U-M money on fuel, but makes hybrids less attractive. The value of a hybrid vehicle is in fuel savings, so the cheaper the price of fuel the less valuable a hybrid vehicle.

DTS Purchase Price Discount

Based on previous purchases, DTS gets a 20% discount on non-hybrids and a 12% discount on hybrids, thus making it harder for hybrids to pay for themselves in fuel savings.

VMT

The average passenger vehicle owned and maintained by DTS are not driven extensively. Most are in the range of 20,000 to 30,000 miles at resale. Hybrid vehicles are more attractive financially the more they are driven. For the case of U-M, vehicles are not driven enough each year for hybrids to pay their premium back in fuel savings.

3.5.3.2 Regulatory Barriers

The Corn and Ethanol Subsidy

The corn and ethanol subsidy make E85 cheaper than E10. As discussed above, this makes it harder for hybrids to pay for themselves in fuel savings because there are no E85 hybrids. Using the model, if E85 and E10 prices were equivalent the maximum costs for hybrid integration would be $1.2 million annually, or would reduce the costs by $200,000 annually. This study simulated $20/MT CO2e and $50/MT CO2e prices assuming the carbon price would have an effect on the total fuel cycle of the fuel consumed by the vehicles. See Table 33 and Table 34 below for results.

Table 33: Additional Cost of Hybrid Passenger Cars with Different Carbon Prices

Scenario Carbon Price	Hybrid Passenger Cars Max Total Cost	(No funding, EIA Low) Max Cost/MT CO2e Abated
No Carbon Price	$1,400,000	$510
20$/MT CO2e	$1,360,000	$494
50$/MT CO2e	$1,290,000	$470

Table 34: Additional Cost of Hybrid Buses with Different Carbon Prices

Scenario Carbon Price	Hybrid Buses Max Total Cost	(Funding, EIA High) Max Cost/MT CO2e Abated
No Carbon Price	($4,150,000)	($373)
20$/MT CO2e	($4,400,000)	($395)
50$/MT CO2e	($4,760,000)	($428)

3.5.3.3 Institutional Barriers

The DTS Ethanol Initiative

DTS has an initiative to buy E85 vehicles. Although, E85 vehicles reduce our dependence on foreign oil, the environmental impacts of corn farming, and the unintended consequences of food crop biofuels are externalities that are not incurred in the price we pay for E85. Further, this E85 initiative makes it more unlikely that DTS will purchase hybrids because E85 hybrids are not available, and because the price of E85 is cheaper than the price of E10, which makes the hybrids less attractive financially.

DTS GVWR Requirements

DTS currently requires some of its pick-up trucks to have a gross vehicle weight rating (GVWR) of 8,600 lbs[35]. There is no hybrid option, presently, to meet this requirement. The closest is the Silverado Hybrid, which has a GVWR of 7,100 lbs[36]. Because this study was unable to determine why DTS has this high GVWR requirement, it was unclear which pick-up trucks needed this capacity and which could do with less.

Lack of VMT Data

DTS does not keep track of its annual vehicle miles travelled per vehicle. As a result, this study had to estimate VMT based on the best available information.

3.5.4 Uncertainties

Life-cycle fossil fuel requirements and emissions intensities were taken from the most recent GREET model, as produced by Argonne National Laboratory. There are limitations in this approach. For instance, the emissions factors GREET offers do not incorporate emissions from land-use change. One presentation by Argonne National Laboratory suggested adding 30 g CO2e/MJ of E100 harvested in the Midwest. The addition of such emissions to the model increases the annual potential savings by hybrids to 0.26%[37].

Another uncertainty is the life-cycle of the vehicles themselves. The study did not model the manufacturing and disposal of vehicles only the use-phase. Some experts believe, the manufacturing of batteries, required by hybrid vehicles, makes hybrid vehicle manufacturing more energy intensive and therefore more emissions intensive than a non-hybrid vehicle.

Future fuel and vehicle costs also contribute to uncertainty. The Energy Information Agency, a US Federal agency, predictions for fuel prices over the next decade or so predict that the price DTS pays for fuel could vary about $0.20/gal. Considering the past decade, these EIA projections seem non-volatile and conservative. In terms of funding for hybrid busses, U-M can not apply for funding directly, but can receive funding through the Clean Energy Coalition (CEC) who is the coordinator of the Department of Energy's Clean Cities initiative for Southeastern Michigan. Presently DTS is receiving funding from CEC for the entire incremental cost of four hybrid buses. DTS is replacing four buses with hybrid buses because four buses needed to be replaced. It is unclear if funding will be available the next time buses will be replaced.

Several vehicles will not be replaced for several years at which time other hybrid options may exist, including a hybrid minivan, which would significantly improve the energy and emissions savings for the fleet. Also, as production increases the hybrid premium may decrease as manufacturing the technology becomes better understood. This future reduction in hybrid premiums was not modeled. On the same note, the fuel economy of non-hybrids is expected to increase as newer, stricter CAFE standards are implemented. If the fuel economy of non-hybrid vehicles improves at a faster pace than hybrid vehicles, then hybrids become less attractive.

Finally, this study assumed the Silverado Hybrid could replace any pick-up with an engine size of 4.0-6.0L. This assumption may be poor if certain pick-ups under this category of engine size have other operational requirements that the Silverado does not meet. DTS requires certain pick-ups to have gross vehicle weight rating (GVWR) of 8600 lbs[35]. The Silverado Hybrid has a GVWR of 7100 lbs[36].

4 INTEGRATION & CONCLUSIONS

4.1 IA Sustainability Themes

Each of the energy strategies examined in this report will contribute directly to the goal of climate change mitigation, one of the sustainability themes identified in Phase I of the project. Fossil based energy resource consumption also has major environmental impacts on human health and ecosystem health. Consequently, implementation of renewable energy technologies will dramatically reduce these negative impacts. Hybridization of vehicles in the campus fleet would improve human and ecosystem health locally by reducing air pollutants from the combustion of fuels around the campus. The transformation of U-M's energy system is critically important in raising community awareness about sustainability issues and for gaining recognition of our leadership in sustainability. Conventional energy resources and related carbon emissions are also heavily emphasized in sustainability assessment and rankings of university campuses conducted by nongovernmental and governmental organizations.

4.2 Alignment with Other IA Action Plans

There are several aspects of the energy action plan that may interact with actions plans from other IA teams. Recommendations from the Transportation Team regarding changing bus routes could alter carbon savings from bus hybridization. Recommendations from the Building Team to adopt sustainable practices during renovation projects could lead to reductions in energy demand, which along with the action plans presented in this report could contribute to reductions in GHG emissions. Possible synergies also exists between the geothermal applications for heating campus sidewalks as explored by the Land & Water team.

4.3 Ten Year Objectives

The Intergovernmental Panel on Climate Change found that maintaining CO_2 equivalent concentrations at 445 to 490 is necessary to keep global temperature from rising more than 2.4^{o}C and avoid the worst affects of climate change. To achieve this by 2050, global GHG emissions will need to decrease 50 to 85% from year 2000 GHG emissions [38]. A recent piece of climate legislation, the American Clean Energy and Security Act of 2009, which passed in the U.S. House of Representatives (but not the Senate) mandated GHG reductions of a magnitude large enough to achieve this goal. It proposed a cap and trade system to achieve a 20% reduction of GHG levels by 2020 and an 83% reduction by 2050 compared to 2005 levels. We believe that these scientific and legislative frameworks are necessary when thinking about how these energy action plans can map to the climate goal for the University of Michigan.

While this report focuses mainly on reducing GHG emissions by increasing the supply of renewable energy used on campus (i.e., the supply side), the other main consideration is the overall demand for energy (i.e., the demand side). Managing energy demand is a significant consideration. The Planet Blue operations teams continue to retrofit buildings with energy-saving equipment and procedures and to change occupant behaviors through education.

Reducing energy demand through efficiency and conservation efforts in the existing building is even more important when taking into account future growth of the University buildings and facilities. The addition of the North Campus Research Complex and the C.S. Mott Children's Hospital and Von Voigtlander Women's Hospital to the U-M facilities will lead to new energy demands. These additional demands make achieving an absolute GHG reduction even more challenging.

The Energy Team has had initial discussions with several key campus operational staff regarding the level of reduction in GHG emissions. As an exercise, the operational staff were informally surveyed to gauge what they thought was an appropriate GHG reduction goal. The majority of the group expressed support for a 15-20% reduction in total GHG emissions from 2005 levels by 2020. They believed that 5-10% of the reduction should come from a drop in overall energy demand. This reduction includes the addition of future U-M facilities. The group also felt that a 10-15% GHG reduction should come from the renewable energy action plans described in this report. Using this 10-15% reduction in GHG emissions from the supply side of energy is a useful guideline for determining which of the action items to recommend for possible implementation.

4.4 Prioritization of Strategies

To understand the relative advantages and disadvantages of the various strategies, the team was asked to rank each energy strategy on a scale of 1 (lowest) to 5 (highest) for different criteria. The following matrix (Table 35) shows these rankings using economic, environmental, and social considerations. (Note: a low ranking is preferred for economic criteria, but a high ranking is preferred for the environmental and social criteria. Color coding is added to aid in understanding—red is least desirable and green is the most desirable.)

Table 35: Prioritization Matrix for Energy Action Plans

Legend: 1-Lowest, 5- Highest. Note: In the case of Economic Aspects, a '1' is the best outcome, but for the other aspects, a '5' is the best outcome.	Economic Aspects			Environmental Aspects			Social Aspects		
Energy Team Recommendations	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Visibility	Learning/Research Opportunities
Geothermal (Central)	2	3	3	5	4	3	4	3	4
Solar Thermal (Pre-heat)	2	5	4	5	4	3	4	4	4
Solar Thermal (DHW Boost)	2	5	3	5	4	3	4	4	4
Biomass (Central)	4	1	4	5	4	3	4	3	4
Biomass (North)	4	1	4	5	4	3	4	3	4
PV (Roof)	3	2	2	5	4	3	4	4	4
PV (Parking Lot)	5	1	2	5	4	3	4	5	4
Wind Turbine	3	2	3	5	4	3	4	3	3
Renewable Energy Credits	1	4	1	5	4	3	4	2	3
Hybrid Passenger	3	4	1	5	4	3	4	3	3
Hybrid Buses	1	4	5	5	4	3	4	5	3

For the economic aspects, the ranking is provided based on the quantitative analysis done for this project. These economic values are summarized in the appendix. The major environmental benefit from each of the action plans is a reduction in GHG emissions through the reduction in fossil fuel combustion. This reduction will also have some beneficial impact on human and ecosystem health. For example, air pollutants from burning coal contribute to respiratory problems like asthma and increase acidification in lakes and rivers. In the case of hybrid vehicles the improvement in air quality would be achieved locally.

Each of the energy strategies require additional equipment and thus require additional materials to be manufactured. While this was not explored quantitatively in this project, the additional material resources required to produce the equipment is expected to be more than offset by the reduction in fossil fuels consumed and the byproducts from their extraction. This leaves a net reduction in the University's material footprint from these action plans.

The greater the visibility of the respective technology, the more it is expected to contribute to a greater community awareness of the University's efforts to sustainability. The solar technologies could be observed from ground level in several areas and are widely recognized and understood by the general public. Thus, they would probably have a significant impact. Hybrid vehicle technology is also widely viewed as a sustainable technology, and thus, buses labeled as hybrid would also raise awareness. Using physical signage as well as the University website, awareness could be increased for technologies hidden from view.

Finally, the addition of these technologies should provide opportunities for education as the number of students and courses focusing on sustainability continue to grow. Through tours, course content, and research projects, students would benefit from having these resources available.

4.5 Recommendations

Based on the analysis conducted in this project, the feedback from operational staff, and the various scientific and legislative frameworks dealing with climate change, the Energy Team recommends that the University **adopt a stretch goal of reducing GHG emissions levels by 25% compared to the University's 2005 levels within the next decade**. We recommend that the following strategies be considered for reaching this goal (in order of ranking):

- **Energy Conservation:** The University should strive to reduce absolute energy demand by 10%. Given the future growth in the campus in terms of additional buildings and facilities, existing operations will have to reduce GHG emissions by even more than 10%. The work of the Planet Blue Operations Team serves as a model for achieving these reductions, but their resources and efforts should be increased to reach this goal.
- **Biomass:** After a 10% reduction in overall energy demand, a 15% reduction in GHGs from renewable energy sources is required to achieve our stretch goal. Of the technologies investigated that have the potential to achieve a significant reduction, biomass power was the most cost effective option. A full scale biomass conversion of the CPP would be very difficult given the logistics of transporting and processing biomass on the Central Campus although opportunities exist for replacing one or more boilers with a biomass compatible option. It would be more feasible to construct a facility on the North Campus which could provide heat and power to the North Campus and potentially the Medical Campus and the North Campus Research Complex. The analysis showed that a plant sized to meet 100% of the North Campus heating demand could reduce GHGs by about 15%. Additional operational efficiencies can be achieved by centralizing the heating systems on the North Campus.
- **Geothermal:** Given the reasonable payback period compared to other renewable options, geothermal systems should be implemented as a strategy for heating water to be used either for heating and cooling on the North Campus and/or pre-heating water for steam generation for the CPP or possible North Campus power plant. Given that this is a very scalable technology, the University should conduct a pilot project to gain expertise for future installations.
- **Hybrid Buses:** Whenever funding can be located to offset most or all of the cost premiums, the University should purchase hybrid buses. This can result in immediate cost savings, but the overall GHG reduction is relatively small.
- **Solar Thermal:** Solar thermal systems are more cost effective than PV systems and are the preferred strategy for harvesting solar energy on the campus roof space.
- **Photovoltaics:** Use PV on targeted sites on roofs and parking lots as a visible demonstration of the University's commitment to sustainability.
- **RECs**: In addition to efforts on the Ann Arbor campuses, renewable energy credits should be used as needed to meet GHG reduction goals.

4.6 Issues for Further Analysis

All strategies presented in this report will require much more detailed engineering analysis to better quantify the energy potential and cost of specific installations or purchases. This initial analysis is useful in beginning to understand the relative potential of the individual strategies and to help prioritize them. The particular uncertainties associated with each strategy are identified within the respective section. Among these uncertainties, the availability and price of biomass is especially significant given the team's recommendation to pursue a biomass facility on North Campus. Since this strategy, among those recommended, has by far the greatest potential to reduce GHG emissions and will require a significant financial investment, it is important to understand the biomass resources that the University can acquire.

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APPENDICES

A. LIST OF TEAM MEETINGS

Team Meetings

Meeting Date	Meeting Topics(s)	Additional Staff Attending
September 24, 2010	Assign Action Plan Areas to Student Team Members	Andy Berki
October 4, 2010	Discussion of Project Scope	Andy Berki
October 11, 2010	Discussion of Requests to Operational Staff	
October 18, 2010	Discussion with Operational Personnel on Campus Energy System	Andy Berki, Yoshiko Hill, Bill Verge
October 25, 2010	Questions Posed to Operational Staff	Andy Berki, Yoshiko Hill, Bill Verge, Steve Woldt
November 1, 2010	Team Member Status Updates and Reminding Project Timeline	Andy Berki, Yoshiko Hill, Steve Woldt
November 8, 2010	Project Administration and Discussion of Team Presentations	Yoshiko Hill, Bill Verge, Steve Woldt
November 15, 2010	Team Member Presentations: Energy Capacity Estimates	Yoshiko Hill, Bill Verge
November 22, 2010	Team Member Presentations: Cost Estimates	Andy Berki, Bill Verge, Steve Woldt
November 29, 2010	Team Member Presentations: Carbon Savings	Andy Berki, Yoshiko Hill, Bill Verge, Steve Woldt
December 6, 2010	Presentation on Geothermal, Discussion of Decision Making Process and Report Completion	Andy Berki
December 13, 2010	Prioritization of Strategies and Discussion of Campus Goals	
December 14, 2010	Presentation and Discussion with Operations Staff on Priorities and Recommendations	Terry Alexander, Andy Berki, Yoshiko Hill, Keith Johnson, Kris Kolevar, Rich Robben, Jay Russell, Bill Verge, Steve Woldt

External Meetings

Meeting Date	Meeting Topic(s)	Energy Team Members	Operations Staff
October 7, 2010	Past and Future PV Projects and Analysis on Campus	Clarie Santoro	Andy Berki
October 21, 2010	Geothermal Applications on North and Central Campus	Jarett Diamond, Patty Liao	Jay Russell
October 22, 2010	PV on Campus Roofs	Claire Santoro, Gaurang Sethi, Patty Liao	Wade Fields, Dave Stockson
October 28, 2010	Biomass Integration and Campus Hot Water Supply	Sethi Gaurang, Patty Liao, Dan Wilson	Bill Verge
November 4, 2010	Solar Collector on CPP	Sethi Gaurang, Patty Liao	Kim Borregard
November 5, 2010	Current Campus Vehicle Fleet	Robb De Kleine, Matt Segraves	Keith Johnson

B. BIOMASS

B.1 Assumptions

Table B.1: Assumptions Used in Biomass Analysis

Parameter	Quantity
Energy content of natural gas	1010 Btu per standard cubic foot
Energy content of biomass	8,500 Btu per dry pound
Efficiency of biomass-to-syngas conversion	70%
Efficiency of CFB boiler	75%
Natural gas price (2010)	$7.25 per MMBtu
CO_2 emissions from natural gas	0.05339 metrics tons CO_2 per MMBtu
CO_2 emissions from trucking biomass	0.3725 lbs. of CO_2 per ton-mile
Growth rate for natural gas prices	3.5% per year
Growth rate for purchased electricity prices	3.5% per year
Growth rate for biomass prices	3.5% per year
Growth rate for North Campus energy demand	0.5% per year
Growth rate for labor costs	2.5% per year
Cost for hot water pipe installation	$520 per linear foot
Cost for electric duct installation	$141 per linear foot

B.2 NPV Savings With Biomass

The biomass gasification equipment at the CPP is assumed to have a useful lifetime of 30 years. Using a discount rate of 5%, total net present value (NPV) savings over 30 years are shown in below.

Table B.2: NPV Savings with Biomass Gasification System (2010 $)

Carbon Price	$25/ton Biomass	$50/ton Biomass
5% Discount Rate		
No Carbon Price	435,000,000	238,000,000
$20/metric ton	508,000,000	310,000,000
$50/metric ton	617,000,000	419,000,000

The CHP plant on North Campus is assumed to have a useful lifetime of 30 years. Using a discount rate of 5%, total net present value (NPV) savings over 30 years are shown in the table below.

Table B.3: NPV Savings with Biomass CHP Plant (2010 $)

Carbon Price	$25/ton Biomass	$50/ton Biomass
5% Discount Rate		
No Carbon Price	221,000,000	173,000,000
$20/metric ton	261,000,000	213,000,000
$50/metric ton	320,000,000	272,000,000

B.3 Equipment Figures

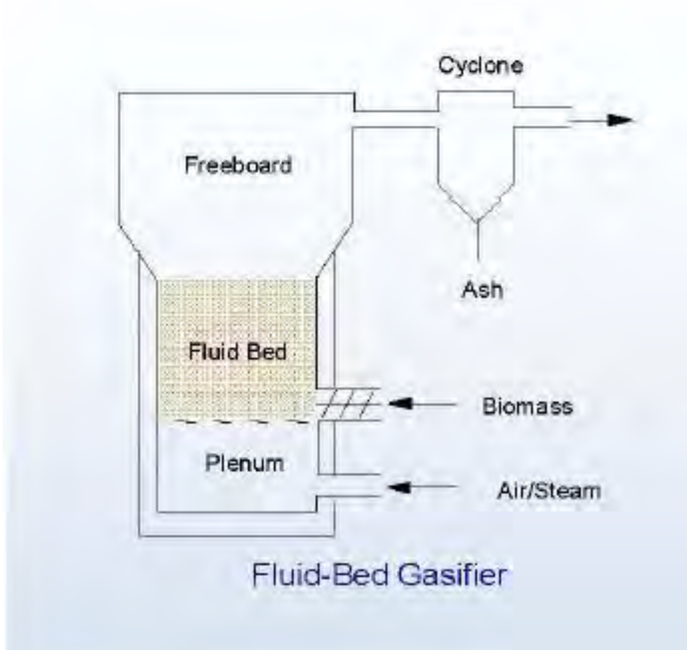

Figure B.1: Fluidized Bed Gasification System

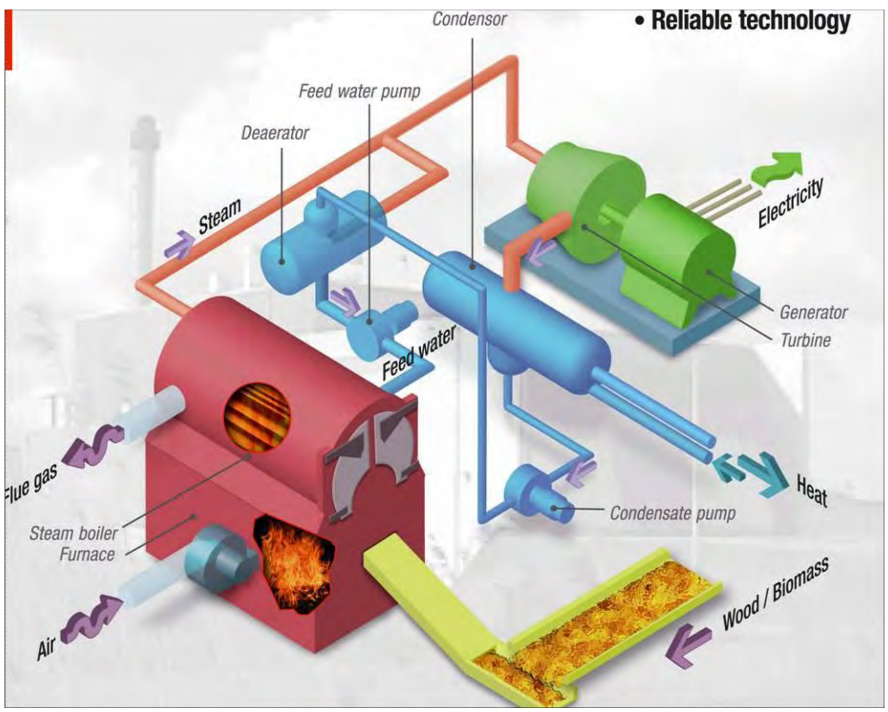

Figure B.2: Biomass CHP Plant

C. GEOTHERMAL

C.1. List of Proposed North Campus Heating and Cooling Districts

District 1

Code	Building Name
5092	Computer Science & Eng (CSE) Building*
0448	Electrical Engineering & Computer Science
0414	Environmental & Water Research Engineering Building
0400	Lay Automotive Lab
0397	Robert H. Lurie Engineering Center
0407	G.G. Brown Laboratory
0447	Herbert H. Dow Building
0429	Industrial & Operations Engineering Building

*CSE is currently not part of the District 1 heating zone, but would be connected to it as part of this proposal.

District 2

Code	Building Name
0425	Aerospace Engineering - Plasma Research
0422	Aerospace Engineering - Propulsion Laboratory
0423	Aerospace Engineering - Pumping Station
0424	Engineering Programs Building
0395	Francois Xavier Bagnoud Building (FXB)

District 3

Code	Building Name
0421	Aerospace Engineering - Wind Tunnel Laboratory
0416	Engineering Radiation Laboratory No. 1
0417	Engineering Radiation Laboratory No. 2
0415	Naval Architecture & Marine Engineering

District 4

Code	Building Name
0404	Michigan Memorial Phoenix Laboratory
0403	Cooley Memorial

C.2 Parameters of the Cost Model

Table 1: Summary of Key Parameters Used in Costs Analysis

GSHP cost	\$788 per ton cooling capacity[1]
Optimal borehole depth	300 ft.
Borehole linear ft. per ton cooling	150 ft./ton
Borehole cost per linear ft., including HDPE pipe	\$5.00 per ft.
Borehole center-to-center offset	15 ft.
Heating COP (GSHP only, not system COP)	4.9
Cooling EER (GSHP only, not system EER)	25.8[2] (COP_{cool}=7.56)
Natural Gas cost	\$8.42 per MCF
Electricity Cost	\$0.095 per kWh
Heating cost savings vs. base case (includes credit from simultaneous cooling)	44%
Cooling cost savings vs. base case (includes credit from simultaneous heating)	26%

C.3. COP with Cooling Towers

The McQuay *Geothermal Heat Pump Design Manual* suggests that greater cooling energy savings may be achievable when the GSHP is used in tandem with cooling towers[3]. In this circumstance, using a cooling EER of 36 (and a corresponding system COP_{cool} of 8.97), the energy cost savings achieved by a GSHP jumps from 20% to 43%.

Table C.2: System COP and Operational Cost Savings

Operating Mode	**GSHP COP**	**System COP**	**Operational Cost Savings vs. Base Case**
Heating	4.9	4.17	34%
Cooling	7.56 (for EER=25.8)	6.43	20%
Cooling (+cooling towers)*	10.55 (for EER=36)	8.97	43%

*assuming negligible energy use for cooling towers

C.4. Additional Carbon Calculations and Payback Period Results

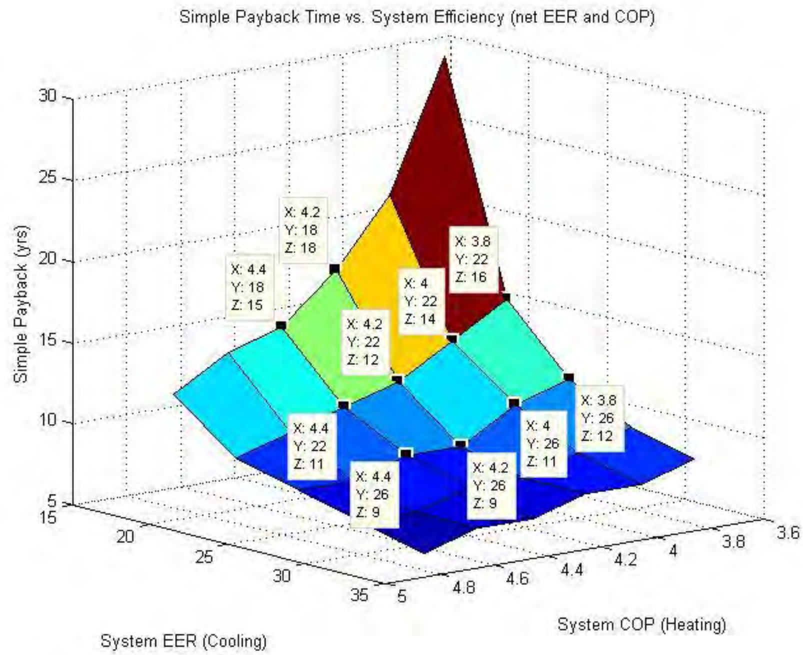

Figure C.1: Simple payback times for 1x capital investment scenario at various intermediate *system* efficiencies (net EER and COP include estimated pumping energy losses). An arbitrary selection of datapoints are highlighted to assist interpretation of the figure.

Table C.3: Cost/Resource/Emissions Comparison A Cooling EER = 25.8 ($COP_{cool,sys}$= 6.43) and Heating COP = 4.9 ($COP_{heat,sys}$=4.17)

Cooling			Base Case		Alt Case							
Rated System Capacity (tons)	Capital Cost	Ann. Output @90% load for half year (ton-h)	Elec Used (NCCP) (kWh)	Elec Cost ($)	Elec Used (GSHP) (kWh) COPcool,sys = 6.43	Elec Offset (kWh) from GSHP cooling	NG Offset (MCF) from simult heating	Elec Savings ($)	NG Savings ($)	Total Energy Cost Savings ($)	CO2 Avoided (MTCO2) (Purchased Elec)	CO2 Savings (MTCO2) (CPP Elec)
200	$307,600	788,400	495,696	$47,091	431,915	63,781	416.27	$6,059	$3,505	$9,564	69.22	56.70
400	$615,200	1,576,800	991,392	$94,182	863,831	127,562	832.54	$12,118	$7,010	$19,128	138.45	113.40
800	$1,230,400	3,153,600	1,982,785	$188,365	1,727,662	255,123	1,665.07	$24,237	$14,020	$38,257	276.90	226.80
1600	$2,460,800	6,307,200	3,965,569	$376,729	3,455,323	510,246	3,330.15	$48,473	$28,040	$76,513	553.79	453.59

Heating			Base Case		Alt Case							
Rated Capacity (tons)	Capital Cost	Ann. Output @90% load for half year (x10^6 BTU)	NG Used (85% eff Boiler) (MCF)	Gas Cost ($)	Elec Used (GSHP) (kWh) (COPheat,sys = 4.17)	Cooling Elec Offset (kWh) from simult cooling	Net Elec Used	Net Elec Savings ($)	NG Savings ($) from GSHP heating	Total Energy Cost Savings ($)	CO2 Avoided (MTCO2) (Purchased Elec)	CO2 Savings (MTCO2) (CPP Elec)
200	$307,600	9,461	11,130	$93,718	665,739	18,474	684,212.37	$(647,265.12)	$93,718	$32,227	627.35	578.85
400	$615,200	18,922	22,261	$187,435	1,331,477	36,947	1,368,424.75	$(1,294,530.23)	$187,435	$64,455	1,227.72	1,157.70
800	$1,230,400	37,843	44,521	$374,870	2,662,955	73,895	2,736,849.50	$(2,589,060.47)	$374,870	$128,910	2,455.44	2,315.41
1600	$2,460,800	75,686	89,043	$749,741	5,325,910	147,789	5,473,698.99	$(5,178,120.94)	$749,741	$257,819	4,910.88	4,630.82

Table C.4: Simple Payback Calculation for Comparison A

Capital Cost per ton	Cooling Cost Savings per ton	Heating Cost Savings per ton	Simple Payback (yrs)		Simple Payback (2x capital costs) (yrs)	Simple Payback (3x capital costs) (yrs)
$ 1,538.00	$ 47.82	$ 161.14	**No C Tax**	**7.36**	**14.72**	**22.08**
			$20/MT CO2 Tax	**5.64**	**11.29**	**16.93**
			$50/MT CO2 Tax	**4.18**	**8.36**	**12.54**

D. SOLAR
D.1. List of PV Assumptions

General Assumptions

- Solar Radiation for Detroit, MI, Latitude+15º: 4.0 kWh/m2/day annual average[4]
- Panel Efficiencies and Cost per Watt:

	Panel EfficiencyError! Bookmark not defined.	**Price per WattError! Bookmark not defined.**
Thin film	.08	$ 1.37
Monocrystalline	.19	$ 2.27
Polycrystalline, cast	.14	$ 1.80
Polycrystalline, ribbon	.13	$ 1.80
CdTe	.10**Error! Bookmark not defined.**	$ 0.93**Error! Bookmark not defined.**

- System efficiency of 0.8 to account for losses from snow, inverter, and wiring
- System lifetime of 20 years (a conservative estimate; usually ranges to 30 years)
- Module cost equals 50% of system cost, which includes all parts, specifically inverters, batteries, and wiring as well as installation**Error! Bookmark not defined.**
- Electricity purchase price for UM of $0.08/kWh**Error! Bookmark not defined.**
- Baseline annual electricity consumption from 2009**Error! Bookmark not defined.**: 570,441,000 kWh
    - Purchased electricity: 437,000,000 kWh
    - Generated at Central Power Plant: 133,441,000 kWh
- Carbon factors of purchased and generated electricity**Error! Bookmark not defined.**:
    - Purchased: 730.2E-6 MT CO2/kWh
    - Generated: 254.4E-6 MT CO2/kWh
- Baseline emissions from 2009 of 591,698 metric tons CO2**Error! Bookmark not defined.**
- NPV and payback period calculations use 5% discount rate
- Payback assessed with carbon prices of $0, $20, and $50 per MT CO2

List of Roof-Mounted PV Assumptions

- Total General Funds Roof Areas[5]: 4.119 million sq ft
- Priority List Buildings, Areas, and Replacement Years[5]:

Priority Buildings for PV	Area (sq ft)	Replacement Year
North Campus Recreation Building	111,946	2023
Angell/Mason Hall	61,737	2015
School of Education (South Roof)	32,600	?
Univ Hospital[6]	60,000	?
Taubman Medical Center[6]	90,000	?

- Assume 75% of roof space for priority buildings is used for PV panels

Parking Lot PV Assumptions

- Parking lot areas taken from Transportation Team GIS data:

Campus Region	Parking Lot Sq Ft
Central	35,857
North	4,770,709
Medical	695,999
South	2,604,751
Total	*8,107,317*

- Assume 50% of lot area is covered in panels
- Construction costs for poles or carports not included in parking lot PV system costs

D.2 Additional PV Results

Rooftop PV

Annual Carbon Savings			
	Savings (MT CO2/year)	Percent of Emissions	Cost per MT
minimum generation	1,695	0.29%	334
maximum generation	12,408	2.10%	233

Annual Savings ($)		maximum generation	minimum generation
No Carbon Fee	Savings ($/year)	1,359,442	185,666
	Simple Payback (years)	42.59	81.40
$20/MT CO2	Savings ($/year)	1,607,594	219,557
	Simple Payback	36.02	68.83
$50/MT CO2	Savings ($/year)	1,979,822	270,394
	Simple Payback	29.25	55.89

Parking Lot PV

Annual Carbon Savings (MT CO2)				
	Central	Percent of Emissions	All Campus	Percent of Emissions
thin film	142	0.02%	32,134	5.43%
monocrystalline	338	0.06%	76,317	12.90%
polycrystalline, cast	249	0.04%	56,234	9.50%
polycrystalline, ribbon	231	0.04%	52,217	8.82%
CdTe	178	0.03%	40,167	6.79%

Annual Savings ($)						

	No Carbon Fee		$20/MT		$50/MT	
	Central	All Campus	Central	All Campus	Central	All Campus
thin film	$15,572	$3,520,726	$18,414	$4,163,399	$22,678	$5,127,407
monocrystalline	$36,982	$8,361,725	$43,733	$9,888,072	$53,859	$12,177,592
polycrystalline, cast	$27,250	$6,161,271	$32,224	$7,285,948	$39,686	$8,972,963
polycrystalline, ribbon	$25,304	$5,721,180	$29,923	$6,765,523	$36,851	$8,332,037
CdTe	$19,464	$4,400,908	$23,017	$5,204,248	$28,347	$6,409,259

Simple Payback (Years)						
	No Carbon Fee		$20/MT		$50/MT	
	Central	All Campus	Central	All Campus	Central	All Campus
thin film	49	49	41	41	34	34
monocrystalline	34	34	17	17	14	14
polycrystalline, cast	37	37	24	24	19	19
polycrystalline, ribbon	39	39	25	25	21	21
CdTe	27	27	33	33	27	27

NPV Payback periods for all technologies, all carbon costs, both rooftop and parking lot scenarios are >100 years

D.3 Solar Thermal Assumptions

- Considering that 75% (to allow for safety perimeters and access pathways) of the roof space of these priority buildings can be covered by solar thermal collectors and this represents the most realistic scenario.
- We assume that it will be more efficient to fix solar panels at an inclination of close to 60 degrees (“Latitude+15 degrees”), even though the average annual Solar Radiation/ Insolation for panels fixed at “Latitude-15 degrees” would be higher. This is because of higher insolation achieved in the winter months for solar panels at the former inclination. (NREL)
- The ambient average monthly temperatures have been assumed as taken from the monthly data. (NREL)
- The Domestic How Water Loop (DHW) which circulates water at a temperature of around 120 degrees Fahrenheit (outlet temperature) is considered to be the heat sink of the hot water heated.
- Inlet temperature of water should be 60 degrees Fahrenheit in order to maximize efficiencies of the technologies and consequently higher cost savings from savings in Natural Gas consumption as well as higher cuts in carbon dioxide emissions. Yes, the overall amount of water heated might be higher if the temperature difference is 30 degrees Fahrenheit instead of 60 degrees Fahrenheit, but that would primarily be because of more water being heated in the summer months (with higher insolations) and some of the winter months will have negative efficiencies, hence making the Solar Thermal installation redundant and not being able to meet any of the hot water requirement in those months at all. So overall, as for all solar thermal systems there would be better

efficiencies in a system with a higher temperature difference and hence a lower inlet temperature.

- Heat exchanger (between water and the working fluid- propylene glycol) efficiency of 90%.
- Natural Gas at the Central Power Plant produces 101,000 Btu/ccf of Natural Gas.
- The price of Natural Gas purchased is $7.25/MMBtu.
- Natural Gas has 118.8 pounds of CO2 emissions/ MMBtu associated with it.
- Total GHG emissions in 2009 were 591,698 metric tons of CO2e.
- Average figures for slope, intercept, area of collector and amount of fluid have been used for efficiency and other calculations from the SRCC website for the Glazed Flat Plate Solar Thermal manufacturers. (SRCC)
- Although most manufacturers claim a life of 35 years for Flat Plate Solar thermal technologies, and guarantee anywhere between 10 to 20 years, we have assumed a project life of 25 years.
- The antifreeze needs to be replaced every 5 to 8 years in general. (assumed 5 years in order to be conservative)
- A 50-50 ratio of Propylene-Glycol to Water has been assumed in the Anti-freeze, in order to make sure that its freezing point is lower than the record low temperatures observed in Michigan. (Box)
- The amount of anti-freeze has been assumed to be 1.5 gallons/collector. The average from SRCC data comes to be around 0.96 gallons/collector for Flat Plate collectors. A higher amount is assumed in order to include the amount flowing in the pipes carrying the anti-freeze to & from the solar collector to the DHW loop.
- Discounting Factor of 4% has been assumed.

D.4 Solar Thermal Cost Assumptions

- The capital cost has been assumed to be $24/sq.ft for Flat Plate technologies. (USDA) The figure of $8/sq.ft for the panel costs has been increased by 3 times in order to incorporate the installation costs, costs of engineering. BOS.
- The cost of replacement of Propylene Glycol has been assumed at $1159.30/ 55 gallon drum.
- The cost of disposal for the anti-freeze solution has been assumed at $2/gallon of anti-freeze.
- The O&M costs have been limited to the replacement cost for the anti-freeze. There might be additional costs for replacements of pumps and even pipings (in case of corrosion caused due to conversion of Propylene Glycol to Glycolic Acid). Plus, labour charges for annual inspection and 5 yearly replacement of anti-freeze haven't been included in the O&M costs.

D.5 Additional Solar Thermal Calculations

The following Payback Periods & IRRs were calculated for the Flat Plate technology in the (as per the assumptions & costs mentioned above) for the following scenarios:

Carbon Tax	**Without discounting**		**With Discounting**	
$/metric ton CO2	Payback Period	IRR	Payback Period	IRR

0	14	5%	22	1%
20	13	7%	17	2%
50	11	9%	14	5%

D.6 Discussion of Solar Thermal Technologies

Depending on the costs, usage, requirements and the climatic conditions, both solar thermal technologies – Flat Plate as well as Evacuated Tube – ~~,~~represent potential trade~~-~~offs. Though evacuated tube systems tend to be more expensive, they are likely to be more cost-effective because solar radiation is scarcer at this latitude, so increasing the efficiency of the system will be necessary.

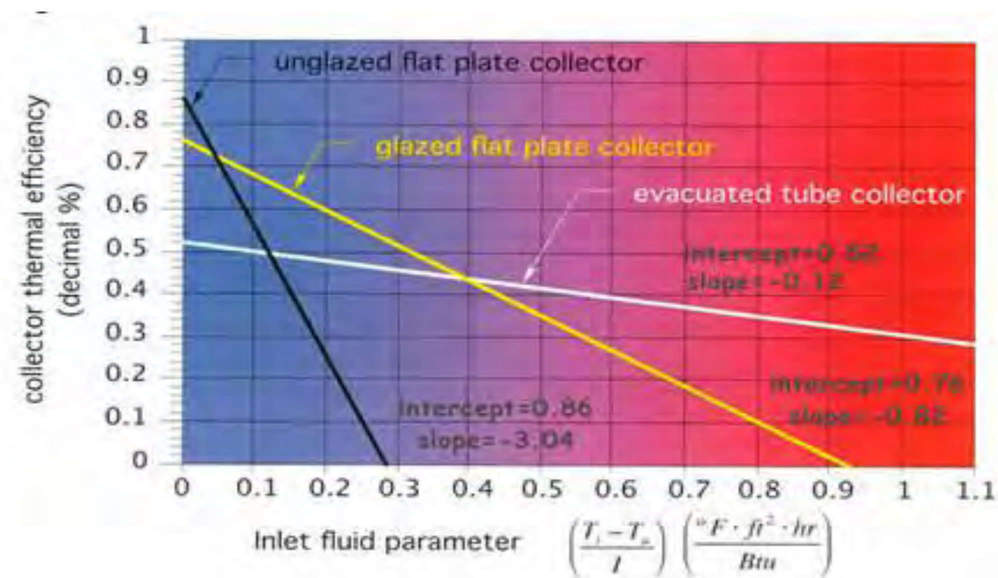

Figure D.1: Sample Comparison of Flat Plate v. ETC7

A point to be noted from the above graph is that the efficiencies of both the Flat Plate as well as the Evacuated Tube technology ~~go down~~drop with an increase in ~~Temperature~~ the difference between the inlet temperature & the ambient temperature (for fixed monthly values of insolation). Thus having a lower inlet temperature of water and hence a lower temperature difference would make the system more efficient~~,~~ and consequently ~~be~~ able to produce more heat.

Even though the benefits in the section above suggest that a Flat Plate Technology would be more efficient under the assumptions, it is to be noted that because of the steeper negative slope of the Flat Plate technology (as can be seen in the graph above), its efficiencies come out to be negative in two of the coldest winter months (December & January) with high temperature differences (right part of the above graph), hence rendering the Flat Plate technology unusable in those months. But they are more efficient than the evacuated tube– overall and in the summer months, when temperature differences between inlet & ambient temperatures are lower (in left part of the graph above).

Thus, having an Evacuated Tube technology and, inletting water at a lower temperature would be more efficient considering the Michigan climatic conditions and the fact that the solar thermal system is expected to produce hot water throughout the year.

An indirect system simply means that the system will use an antifreeze heat transfer fluid rather than heating water directly. This is required for Michigan's climate in order to avoid freezing of the fluid during the winters. An antifreeze solution like propylene glycol (non-toxic) can be used as the heating fluid. The heating fluid then transfers the heat to the pool water or domestic hot water in the heat exchanger.

E. HYBRIDS

E.1. DTS Vehicles by Fuel-Type and Use-Type and Hybrid Replacement

Vehicles by Fuel-Type and Use-Type	Number of Vehicles	Number of Vehicles That Can Be Replaced by a Hybrid
Ethanol Vehicles (E85)	545	218
Unleaded Cars	81	45
Unleaded Trucks	352	124
Biodiesel Buses	62	60
Biodiesel Trucks	34	0
Total	1074	447

E.2. Hybrid Options

Year	Function	Make	Model	Engine Specs	MPG City	MPG Hwy	MSRP
2010	Sedan	Chevrolet	Tahoe	Hybrid 6.0 L 332 HP	21	22	$50,720.00
2010	Truck	Chevrolet	Silverado	Hybrid 6.0 L 332 HP	21	22	$38,340.00
2010	SUV	Ford	Escape	Hybrid 2.5 L 153 HP	34	31	$29,860.00
2010	Sedan	Ford	Fusion	Hybrid 2.5 L 156 HP	41	36	$27,950.00
2009	Bus	GM	Gillig	Hybrid	4.75	N/A	$600,000.00

Source: EPA, AATA

E.3. City to Highway Driving Ratios by Use-type

Use-Type	City	Hwy
Sedan	75%	25%
Truck	95%	5%
Bus	100%	0%

Source: Keith Johnson (Director DTS)

E.4. Annual VMT Assumptions

- Sedans and Trucks: Our best estimate is that 20% of vehicles are resold with 80-100K mi and 80% are resold with 20-30K mi →
- **Sedan Annual VMT** = (0.2 * 90,000 mi + 0.8 * 25,000 mi) / 5 yrs[i] = **7,600 mi/yr**
- **Truck Annual VMT** = (0.2 * 90,000 mi + 0.8 * 25,000 mi) / 7 yrs[ii] = **5,429 mi/yr**
- Buses: UM-OSEH publishes an annual environment report with total energy consumption by UM bus fleet →
- **Bus Annual VMT** = 41,445,286,250 BTU/yr[8] * (1 UM Bus Fleet / 60 Buses) * (1 gal B20 / 126,670 Btu/gal B20**Error! Bookmark not defined.**) * 3.6126 Mi/gal[9] = **19,700 mi/yr**

E.5. LHV and WTW Data by Fuel-Type

Fuel-Type	LHV (Btu/Gal)	WTW Fossil Fuel Input Factor	WTW Emissions (g CO2e/MJ)	WTW Emissions (MT CO2e/gal)
Gasoline	116090	1.35135	95.9	0.011741
E100	76330		69.4	0.005589
ULSD	129488	1.17922	95.3	0.013020
B100	119550	0.21930	26.9	0.003397
E10	112114	1.14161	93.2	0.011026
E85	82294	0.74633	73.4	0.006370
B20	126670	1.00880	81.6	0.010909
B50	124519	0.69926	61.1	0.008029

Source: Argronne National Laboratory, GREET Model

E.6. UM Transportation WTW Fossil Fuel Requirements

Fuel Type	Gal	WTW Fossil Fuel Requirements (Gal Gas Eq)[iii]
E10	341396	389740
ULSD	57500	67805
B20	283407.6	285902
E85	121549.3	90716
Total	N/A	834163

E.7. DTS Fuel Prices per gallon

Fuel Type	E10	E85	B20
Price	$ 2.14	$ 1.78	$ 2.48

Source: Keith Johnson, Director DTS

[i] See Appendix 7, sedans are resold after 5 years.
[ii] See Appendix 7, trucks are resold after 7 years.
[iii] See Appendix 5 for WTW Fossil Fuel Input Factors

E.8. Vehicle Lifetime and Resale Value

Use-Type	Sedan	Sedan Hybrid	Truck	Truck Hybrid	Bus	Bus Hybrid
Vehicle Lifetime (yrs)	5	5	7	7	13	13
Resale Value (fraction of Purchase Price	0.35	0.4	0.3	0.35	0.035	0.04

Source: Keith Johnson, Director of DTS

E.9. DTS Purchase Price Calculation

Based on previous sales data from 2010 Ford Fusions, DTS pays 80% of MSRP for Non-Hybrids and 87% of MSRP for Hybrids

Source: Keith Johnson, Director of DTS; Yahoo Autos

E.10. The Effect of Carbon Price on Fuel Prices

Scenario		Price of Fuel	
Carbon Price	E10	E85	B20
No Carbon Price[iv]	2.14	1.78	2.48
20$/MT CO2e	$2.36	$1.91	$2.70
50$/MT CO2e	$2.69	$2.10	$3.03

[iv] This is the DTS fuel price as of October 2010.

E.11. Replacement Schedules

Replacement Schedule Carbon Savings (MT CO2e)

Vehicle Type	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
E85	80	124	159	199	206	208	208	208	208	208	208
E10 Sedans	21	26	31	50	73	73	73	73	73	73	73
E10 Trucks	73	73	88	112	161	171	177	177	177	177	177
B20 Buses	71	71	157	185	271	442	642	713	727	813	856
Total	246	295	435	547	711	893	1100	1171	1185	1271	1314
% FY 2009	0.04%	0.05%	0.07%	0.09%	0.12%	0.15%	0.19%	0.20%	0.20%	0.21%	0.22%

Replacement Schedule Costs (no discounting, average EIA fuel price projections, no funding for passenger cars, funding for upcharge of buses, resale values are the difference in resale values between the hybrid and the non-hybrid)

Passenger Cars	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capital Costs	($989,223)	($279,175)	($460,331)	($706,453)	($326,393)	($873,867)	($309,627)	($641,505)	($465,988)	($295,904)	($867,806)
Resale Value	$0	$0	$0	$0	$0	$316,960	$159,369	$320,014	$238,702	$156,192	$445,949
Fuel Savings	$56,514	$90,961	$124,867	$180,585	$211,710	$241,642	$261,846	$276,684	$275,062	$281,025	$280,840
Total	($932,709)	($188,214)	($335,464)	($525,868)	($114,683)	($315,266)	$111,588	($44,806)	$47,775	$141,313	($141,018)

Buses	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capital Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Resale Value	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel Savings	$24,636	$25,840	$60,026	$73,954	$112,745	$191,045	$284,563	$320,954	$332,524	$374,503	$396,239
Total	$24,636	$25,840	$60,026	$73,954	$112,745	$191,045	$284,563	$320,954	$332,524	$374,503	$396,239

Replacement Schedule Costs (NPV discounted at 5%, average EIA fuel price projections, no funding for passenger cars, funding for upcharge of buses, resale values are the difference in resale values between the hybrid and the non-hybrid)

Passenger Cars	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Captial Costs	($942,117)	($1,195,337)	($1,592,989)	($2,174,189)	($2,429,927)	($3,082,020)	($3,302,066)	($3,736,262)	($4,036,642)	($4,218,302)	($4,725,691)
Resale Value	$0	$0	$0	$0	$0	$236,520	$349,781	$566,379	$720,248	$816,137	$1,076,874
Fuel Savings	$53,823	$136,327	$244,192	$392,760	$558,640	$738,957	$925,046	$1,112,317	$1,289,624	$1,462,149	$1,626,350
Total	($888,294)	($1,059,010)	($1,348,797)	($1,781,430)	($1,871,287)	($2,106,543)	($2,027,240)	($2,057,566)	($2,026,770)	($1,940,016)	($2,022,466)

NPV Buses	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capital Costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Resale Value	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel Savings	$23,463	$46,901	$98,753	$159,595	$247,934	$390,494	$592,727	$809,962	$1,024,310	$1,254,222	$1,485,895
Total	$23,463	$46,901	$98,753	$159,595	$247,934	$390,494	$592,727	$809,962	$1,024,310	$1,254,222	$1,485,895

E.12. EIA Fuel Price Scenarios at DTS Rate

Fuel Type	2009 Price	Low Oil Price[10]			High Oil Price [11]		
		5 yr	*7 yr*	*13 yr*	*5 yr*	*7 yr*	*13 yr*
E10	2.14	$2.11	$2.12		$2.35	$2.32	
E85	1.78	$1.76	$1.77		$1.92	$1.92	
B20	2.48			$2.47			$2.62

F. Technology Summary Table

	Geothermal (Central Campus-Palmer)	Geothermal (North Campus-NCCP)	Solar Thermal (Pre-heat)	Solar Thermal (DHW Boost)	Biomass (Central)	Biomass (North)	PV (Roof)	PV (Parking Lot)	Wind Turbine	RECs	Hybrid (Cars)	Hybrids (Buses)
System Description	1600 Ton System (using best-in-class GSHP)	800 Ton System (using best-in-class GSHP)	Power Center, UG Sci Building	Remaining Solar Thermal Priority Buildings	Replace 100% of natural gas consumed at Central Power Plant	Meet 100% of heating demand, and 60% of annual electricity demand	Priority Buildings	50% of all campus lot area	Two 1.5 MW Turbine	Additional 3% RECs		w/ Funding for Hybrid Upcharge
Environmental Impact												
Annual Renewable Energy Generated (or Non-renewable Energy Conserved)												
--Electricity (MWh)	-4,700	-2,300	--	--	139,000	55,600	5,510	105,000	7,800	13,500		
--Heat (MMBtu)	92,000	46,000	13,100	19,500	2,840,000	728,000	--	--			4,000	10,000
Annual GHG Reductions (metric tons of CO2 eq.)	5,100	2,700	707	1,053	181,000	87,100	4,030	76,300	5,719	9,858	458	856
% of FY 2009 CO2 Emissions (591,698 metric tons CO2 eq. in 2009)	0.86%	0.46%	0.12%	0.18%	30.70%	14.70%	0.68	12.9	1%	1.70%	0.08%	0.14%
Economics												
Capital Costs (in millions)	$4.92	$2.46	$0.63	$2.30	$76.90	$39.80	$19	$285	$6	$0.27	$0.28-$0.99	$0
Annual Operating Net Savings (or Net Costs)	$ 334,000	$ 167,000	$ 95,000	$ 141,000	$8,200,000 to $15,300,000	$6,070,000 to $8,010,000	$ 441,000	$ 8,360,000	$ 510,000	$ -	$ 228,000	$ 220,000
Simple Payback (yrs.)	15	15	7	16	5 to 10	6 to 8	43	34	10-11	None	None	0

[1] Energy Information Administration. "Geothermal Heat Pump Manufacturing Activities 2008." October 2009. http://www.eia.doe.gov/fuelrenewable.html
[2]US DOE, Energy Efficiency & Renewable Energy, "FEMP Energy-Efficient Products: How to Buy an Energy-Efficient Ground Source Heat Pump" http://www1.eere.energy.gov/femp/procurement/eep_groundsource_heatpumps.html
[3] McQuay International. *Geothermal Heat Pump Design Manual-AG 31-008*. 2002.
[4] NREL. 30-year average of monthly solar radiation, 1961-1990, for Detroit, MI. [Cited Dec 2010.] Available from: http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/sum2/state.html
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[8] UM-OSEH. University of Michigan-2009 Annual Environmental Report Raw Data Overview. Accessed: 2010 Oct. Available From: http://www.oseh.umich.edu/09AERrawdata.html.
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[10]EIA. Annual Energy Outlook 2010: Low Energy Prices. Accessed: 2010 Oct. Available From: http://www.eia.gov/oiaf/aeo/aeolowprice.html .
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Campus Sustainability Integrated Assessment - Comment and Idea Submission

Proposal Title:	**Electronic submission of dissertations (digital dissertations)**	*Year:*	2010
Submitted By:	Mr Douglas Kolozsvari	*Submitted On:*	9/17/2010
Organization:	University of Michigan	*Proposal ID:*	727
Department:	Urban & Regional Planning	*Accepted?*	☐
Topics:	Culture; Energy; Other	*Funded?*	☐

Description:

Currently Rackham requires students to submit three hard copies of their dissertations. Many other universities have switched to an entirely electronic dissertation submission process. These digital dissertations save massive amounts of paper and energy. It also avoids the use of toner, which can have adverse health effects on users. This is low-hanging fruit that just makes sense in an age where people prefer reading dissertations online. It requires a cultural change on the university's part, but would be well received by many of its students and faculty.

For more info: http://www.berkeley.edu/news/media/releases/2009/12/10_E-dissertations.shtml

GRAHAM ENVIRONMENTAL SUSTAINABILITY INSTITUTE

Campus Sustainability Integrated Assessment - Comment and Idea Submission

Proposal Title:	**Limit the use of gas powered leaf blowers**	*Year:*	2010
Submitted By:	Ms Kathlelen Smith	*Submitted On:*	8/11/2010
Organization:	University of Michign	*Proposal ID:*	682
Department:	Alumni Assocition	*Accepted?*	☐
Topics:	Energy	*Funded?*	☐

Description:

Why does the U-M constantly use those gas powered blowers to blow grass clippings and leaves off the sidewalks?

Push brooms, rakes and gloves worked fine for many years and we should set an example and go back to them.

1 EXECUTIVE SUMMARY

During Phase II, the Transportation Team focused on providing implementation ideas that could aid current and future sustainability efforts by operations staff. While the Energy Team focused on technologies that provide lower environmental impact in both electricity generation and transportation, we focused on techniques that can reduce vehicle-miles traveled and promote the utilization of lower impact modes by the U-M community. Our investigation found some goals for the short-term (increasing parking-rate differentiation & establishing a transportation survey) and some longer-term approaches (transit integration, shifting parking payment systems). Furthermore, some approaches do not include a goal date because further investigation into earlier steps will be required to accurately set goal dates for these more advanced solutions.

Our first prioritized recommendation is to **Restructure Parking Fees on Campus***:* Better utilization of existing parking capacity as an alternative to the construction of new capacity; Providing for growth of the University while minimizing growth in vehicle-miles traveled for the University commute; Reducing barriers to occasional transit use, walking, or cycling by car commuters; Ensuring that trips that prioritize close-in parking have such parking available when needed; Cost savings associated with any parking structures forgone or parking subsidies reduced. We have found three major steps toward restructuring from short-term to long-term:

- **Increase Parking-Rate Differentiation by 2013**: increasing fee differentiation sufficient to spur move even utilization throughout the system;
- **Reduce Parking Subsidies by 2015**: subsidies are often thought of as a tool to encourage particular behaviors, and the subsidies surely encourage drive-alone commuting;
- **Shift from Monthly or Annual Parking Payment**: annual parking payments regularize parking revenue and allow commuters to pay and forget but it discourages occasional commuting by walking, cycling, or public transit

Our second prioritized recommendation is to **Optimize Campus-oriented Transportation and Land Use to improve the alternatives to automobile reliance**. We found five major implementation areas that can promote reduced carbon emissions and air pollution from cars and buses; reduced fuel, parking, and maintenance costs for commuters; reduced parking and bus costs for U-M; reduced traffic congestion and associated time savings; Increased physical activity and community health:

- **Increase U-M Bicycle Mode Share:** Reduced carbon emissions and air pollution from cars and buses; reduced fuel, parking, and maintenance costs for commuters; reduced parking structure and bus costs for U-M; Reduced traffic congestion and associated time savings; Increased physical activity and community health.
    - o **Develop campus bicycle master plan, contract for bicycle services, expand parking facilities by 2013**
    - o **Open bicycle service center, institute bicycle rentals by 2015**
    - o **Develop intercampus bikeway network, open card-swipe bicycle sharing system**
- **Enhance Pedestrian Facilities:** Reduced carbon emissions and air pollution from cars and buses; reduced fuel, parking, and maintenance costs for commuters; reduced parking and bus costs for U-M; reduced traffic congestion and associated time savings; Increased

physical activity and community health; Enhance campus vitality and opportunities for interaction.

- **Initiate planning process for diversifying land uses; begin adding sidewalks, ADA-compliant curb ramps by 2012**
- **Continue planning process, complete sidewalk network, improve street crossings by 2015**
- **In cooperation with City, consider pedestrian extensions and transit mall development**

- **Further Integrate Campus Transit:**
  - **Pilot AATA, U-M transit integration by 2014:** move one or two U-M routes into AATA control, ideally combining routes to test transit commutes to campus.
  - **Fully integrate U-M transit into AATA:** Change low ridership lines to AATA to increase route ridership and integrate on campus routes to go further into the community minimizing transfers during commutes, more sustained federal funding for switching to hybrids or fuel cell buses;
- **Simplify the U-M Campus-Airport Connection:**
  - **Increased promotion of campus-airport transit by 2012**
  - **Establish a direct campus or downtown to airport link by 2014**
  - **Integrate a U-M to airport link into U-M transit**
- **Unify Goods Movement:**
  - **Establish the level of current courier-use by 2012:** current levels of private courier-use are unknown; therefore, total expenditure and extent are unknown.
  - **Integrate courier service into campus mail service by 2015:** possible savings from use of ‗in-house' courier service over private services.

Our third prioritized recommendation is to begin to **Track Transportation Habits of Campus Stakeholders by 2012:** U-M has limited knowledge on where community members are commuting from and how they are commuting. U-M's transportation expenditures are significant long-term investments in fixed physical infrastructure, so transportation system development conducted with limited knowledge of current and future trends comes at a heavy cost. A regular transportation survey could avert tens of millions of dollars in unnecessary spending at a minimal cost.

2 INTRODUCTION

This report contains suggested implementation strategies whose schedules will depend greatly on the master planning timelines and/or more specific study. It also contains a discussion of the specific barriers associated with each idea. Some ideas may not directly save money since some benefits are not currently considered budget line items, however, overall benefits and cost savings are possible across many departments. For example, eliminating the parking subside will accrue savings for multiple units.

3 ACTION PLAN

3.1 Prioritized Recommendation A: Restructuring Parking Fees

Faculty and staff commuting to the University of Michigan constitute a significant share of the environmental impact of the operations of the campuses. While precise estimates of faculty and staff commuting habits are unavailable, roughly 15,000 vehicles belonging to faculty and staff are parked each day at the University of Michigan (based on Parking and Transportation Services vacancy counts), and a large majority of commuters to the University of Michigan drive alone to work (**Error! Reference source not found.**). While many of the factors shaping this commute are beyond the control of the University, one signifcant factor remains squarely within University control: provision of and charging for parking. Parking policies have been shown to have significant influence over travel behavior, including mode choice, the feasibility of mixing and matching modes, and the demand for parking by at any given location.[i] With such a large number of automobile commuters to the University of Michigan, change in policies or incentive structures for commuting can have a significant impact on the University's overall environmental impact. This section analyzes current parking pricing policies and their outcomes, and proposes alternatives that can simultaneously ease parking shortages, facilitate commuting by multiple modes, and reduce the presure for construction of costly parking structures.

Table 3-1: Distribution of Commuters to U-M Campuses by Mode, 2000[ii] (Note: Data are for the census tracts containing the respective campuses. The boundaries of the Central and Medical campus tract follow those campus' boundaries closely; others reported in this table contain non-University territory as well).

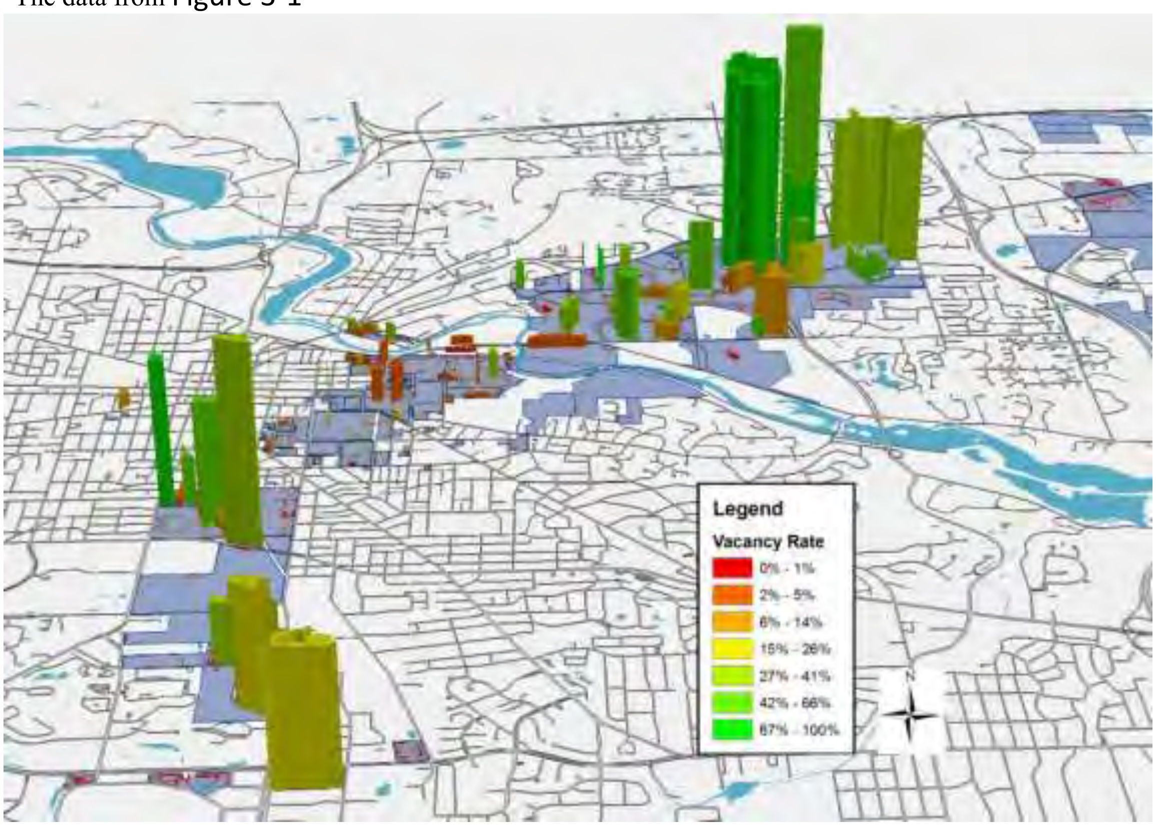
Campus	Drive Alone	Carpool	Bus	Bicycle	Walk
East Medical Campus	84%	11%	1%	0%	1%
North Campus	74%	8%	5%	1%	11%
Central+Medical Campus	59%	11%	9%	3%	18%
South Campus	58%	15%	3%	3%	18%

3.1.1 Technical Guidance

3.1.1.1 Parking Vacancy Analysis

A snapshot of the current parking situation on the University of Michigan campuses (Figure 3-1) reveals a distinct pattern of parking vacancies on the central and medical campuses, with ample vacancies in many (though not all) areas of North and South campuses[1]. This is reflected both in the differences in vacancy rates between the central and peripheral areas (represented in the red-to-green color scale) and in total spaces available (represented by the heights in the figure). Whereas Central and Medical Campus structures are virtually at capacity, vacancies on North Campus, South Campus, and the North Campus Research Complex (NCRC) range between 20% and 67% (Table 3-2). Over 2,500 spaces go unused in these more peripheral locations; this total goes to 4,300 when physical parking spaces at NCRC that have not yet been incorporated in the U-M parking system are included. By comparison, the average central campus parking structure contains about 650 spots.

[1] The data from Figure 3-1



are replicated in Figure 3-2 where columns replace the shape of the parking facilities' footprint; this is to emphasize that height, rather than volume represent parking vacancies.

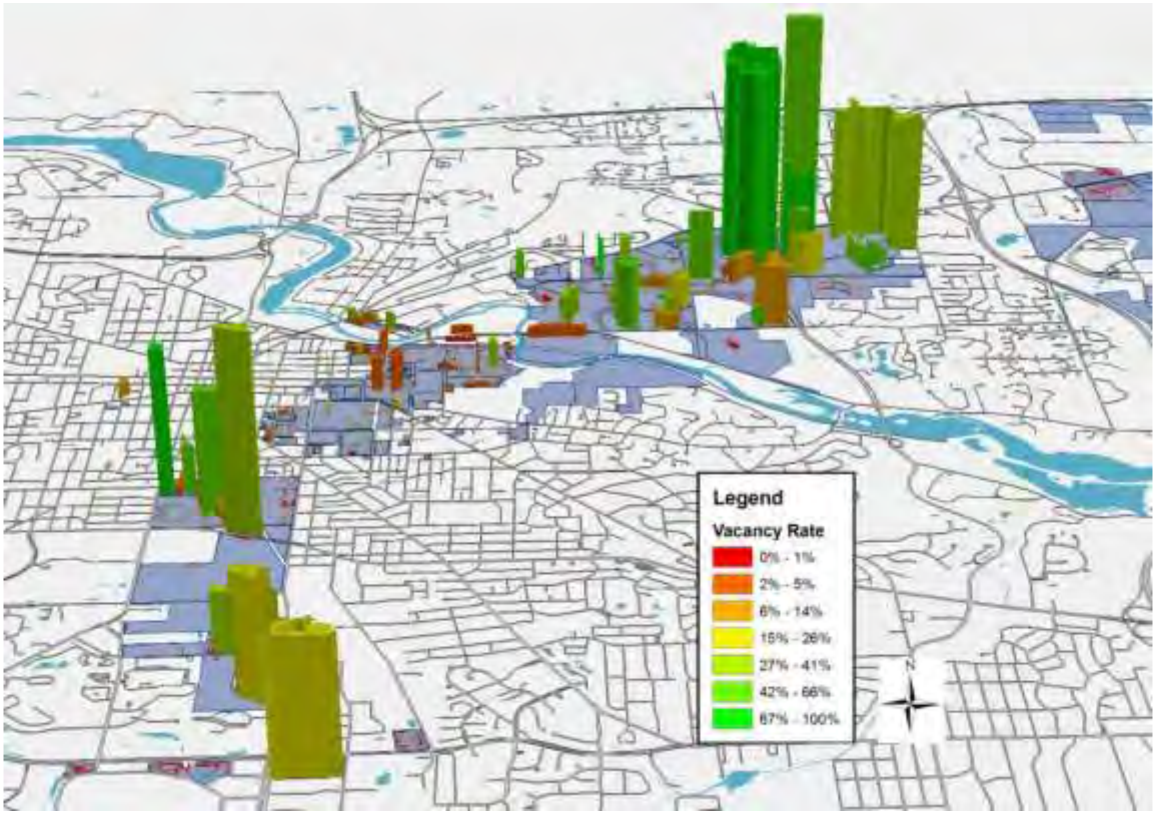


Figure 3-1 Parking Vacancy by Location at the University of Michigan, September-October 2010. (Heights represent total vacancies at the site; color represents vacancy rates)[iii].

At one level, the heavy demand for central parking is not surprising. The Central and Medical campuses contain the highest density of U-M employment, and drivers seek to park close to their destinations. But this result is not merely a function of location but of prices as well. Ann Arbor residents are familiar with the phenomenon of homeowners within walking distance of the Michigan Stadium selling parking in their front yards on football game days. The market price for parking drops with distance from the Stadium; even a remote location will fill up if its operator prices according to its distance. The University of Michigan parking system has taken steps toward distance-sensitive pricing of parking. Parking lots are priced according to color tier (gold, blue, yellow, orange) with the closer-in parking tending to be more expensive than that at more peripheral locations. Nevertheless, price differences are not enough to avoid the phenomenon of excess demand at the center coupled with unused supply at the periphery. In part this is a function of the relative flatness of the pricing structure. For example, Fletcher Structure, near the heart of Central Campus, is mostly rated ―blue" and averaged about 2.6% vacancy rate in September 2010. The Hoover Street lot on South Campus, lying over one mile southeast of the Diag, is also rated ―blue" and is hence priced identically to the Fletcher Structure. The combination of its ―blue‖ price and peripheral location leads to a vacancy rate of over 43%.

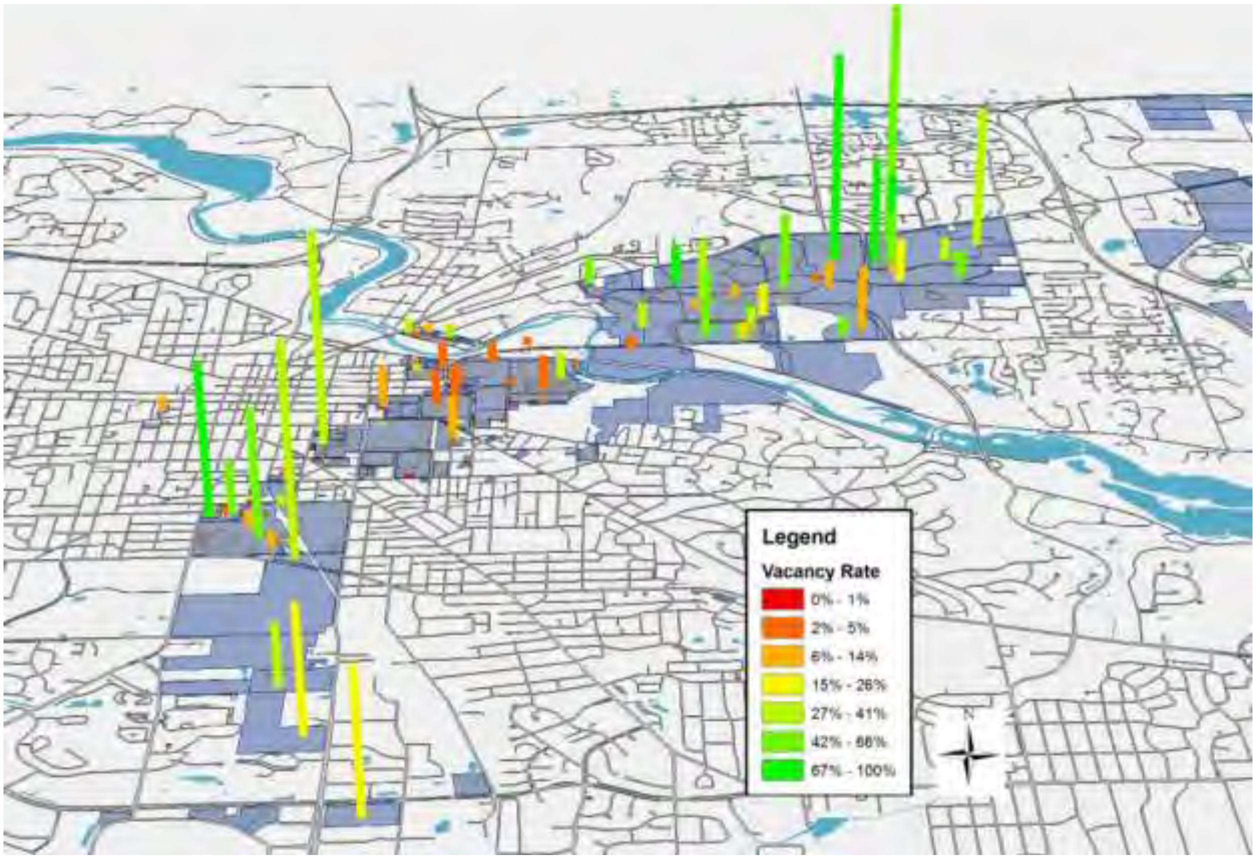


Figure 3-2: Parking Vacancy by Location at the University of Michigan, September-October 2010. (Heights represent total vacancies at the site; color represents vacancy rates).[iii]

Table 3-2: Vacant Spots at in University of Michigan Parking Facilities, Sep-Oct 2010.

Campus	Total Spots Counted	Vacancy Rate	Vacant Spots	Vacancy Rate July, 2010
Central Campus	4334	11%	462	20%
Medical Campus	6122	4%	243	9%
South Campus	3351	28%	949	30%
North Campus, excluding NCRC	4339	20%	874	34%
NCRC	1141	67%	763	No data
Total Vacant Spots outside of Central and Medical Campus			2586	

Likewise, the Space Research building lot near Hayward and Draper on the North Campus, at a distance of 2.5 miles from the Diag, is also rated ―blue"; its average vacancy is nearly 53%. There are currently plans for expansion of University activities in many of the areas of underused parking supply; thus many of the vacancies observed in 2010 may diminish over time. Some capacity will also be used for remote patient parking for the Medical Center. Given the magnitude of vacancies, however, it is likely that an imbalance in occupancy across the U-M parking system will continue into the future.

Part of this imbalance is expressed in heavy pressure on Central and Medical Campus parking, in terms of daily demand, difficulty of finding a spot for midday parkers, and notably pressure to construct parking structures. ―We are in the midst of a parking structure building boom that the University has not seen since the 1960's," stated the (then) Director of Parking and Transportation Services in 2006[iv] (Senate Assembly minutes, April 12). The result was a major structure project virtually every intervening year since 2006. The financial cost of these structures has been high. Construction costs in for parking structures have increased much faster than inflation; the currently planned structure at Fuller Road is estimated to cost $44,000 per spot ($43 total construction costs between U-M and the City of Ann Arbor, 977 spaces planned).[v]

Parking expansion entails significant sustainability impacts as well. By design, parking structure expansion expands the number of cars traveling to central areas of campus. University parking bordering neighborhoods tends to exert negative local environmental impacts together with significant controversy. And heavy reliance on parking capacity expansion as a transportation policy tends to reduce the attractiveness—both relative and absolute—of walking, cycling, and transit use as means to reach the University of Michigan campuses; the attractiveness of all these modes is enhanced when more travelers choose them.

3.1.1.2 Parking Net Revenue Analysis

The continued pressure on Central and Medical Campus parking is, in large measure, a function of the subsidies and cross-subsidies implicit in the University of Michigan parking policy. These are analyzed in the following section.

Table 3-3: Estimated Annualized Costs of Parking Provision in U-M Lots and Structures[vi].

	Lot		Structure	
	BRW Estimate 1995	In 2010 Dollars	BRW Estimate 1995	In 2010 Dollars
Land Area and Value	$143 (=$1400 capitalized at 8% for 20 years)	$166	$122 (=$1200 capitalized at 8% for 20 years)	$194
Construction Costs	330	$518		$1,743
Operation & Maintenance	50	$68		$204
Direct Costs/Spot/Year		$ 752		$ 2,141

In 1995 the consulting firm BRW prepared a report on U-M parking issues, providing estimates of the annualized cost of providing parking in U-M lots and structures. Costs used in the following analyses are costs reported in the BRW report, rendered in 2010 dollars. These probably represent a very conservative estimate of the true cost of the U-M parking system; the BRW study reported the construction cost of space in a parking structure to be under $15,000 when rendered in 2010 dollars, considerably lower than the $44,000 costs reported above for the planned Fuller Road structure[2].

Using the conservative figures reported in Table 3-3, parking permit prices, occupancy rates, and the ratio of permits sold to spots available, it is possible to calculate net revenues for each parking facility within the U-M system. This is the equivalent of imagining each parking facility as its own independent profit (or loss) center. This enables an analysis of the subsidies and cross-subsidies implicit in the current pricing structure. The analysis is conducted in three steps:

- Unit contribution treated as revenue to the parking system, land costs excluded. When a U-M faculty or staff member purchases an annual parking permit (of any color level), his or her unit is billed $142 on top of the amount that the individual pays.[3] Thus the entire parking system revenue equals the individual contribution plus the unit contribution ($629+$142=$771 for an annual blue permit, the most common). Figure 3-3 depicts net revenues by parking facility while treating the $142 as revenue to the parking system and not accounting for the cost of land. In the figure color represents the net revenue per spot, and the height of the bars represents total net revenue (whether positive or negative) for the facility.

- Several phenomena are observable in this figure. First is the significant cross subsidy implicit in the current structure of parking charges. Centrally located structures are associated with significant negative net revenue; this is partly offset with positive net revenues from heavily used peripheral lots. Thus in general, parkers in more peripheral lots are subsidizing structure parkers in more central locations. Second, even remote lots can show negative net revenue when they have high vacancy rates, as is the case with some of the lightly used remote lots of North and South Campuses. Third, even under the conservative cost assumptions used here, net losses are greater than net gains for the parking facilities in the U-M system.

[2] Partly countervailing the inflation in construction prices has been a decline in the cost of capital reported at 8% in the 1995 report.
[3] This practice is mandated by U-M Standard Practice Guide 601.21 C.

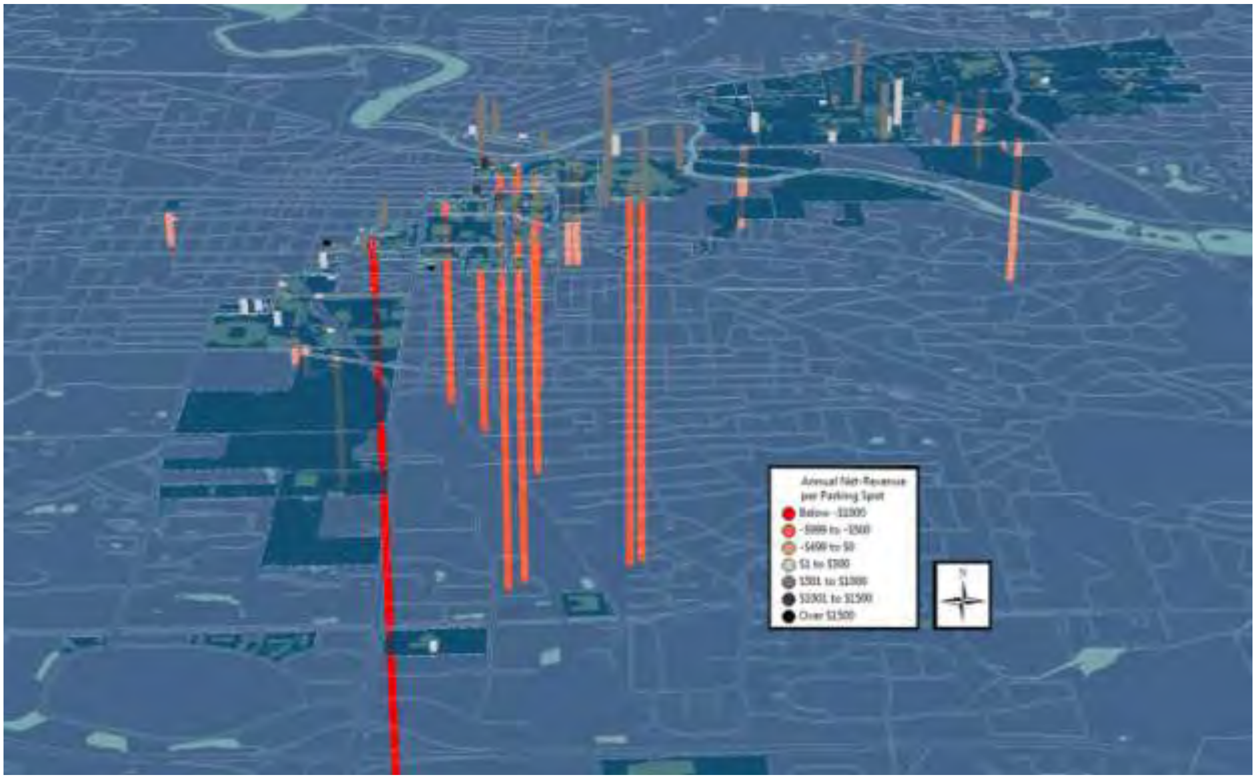


Figure 3-3: Net Revenue of U-M Parking Facilities, 2010 ($142 unit subsidy treated as parking revenue, land costs excluded)

- Unit contribution treated as cost to the University, land costs excluded. Figure 3-4 depicts net revenue per facility when the $142 unit contribution is treated not as revenue to the parking system, but as a subsidy to the individual's permit—and hence a cost to the University. Land is still treated as costless in this figure. Not surprisingly, the magnitude of the net losses increases when compared to Figure 3-3.

- Unit contribution treated as cost to the University, land costs included. The analyses above do not account for the cost of land, in line with the budget model of the University of Michigan. Figure 3-5 seeks to account for the opportunity cost of land devoted to parking uses; this analysis sends most U-M parking facilities further into the red.

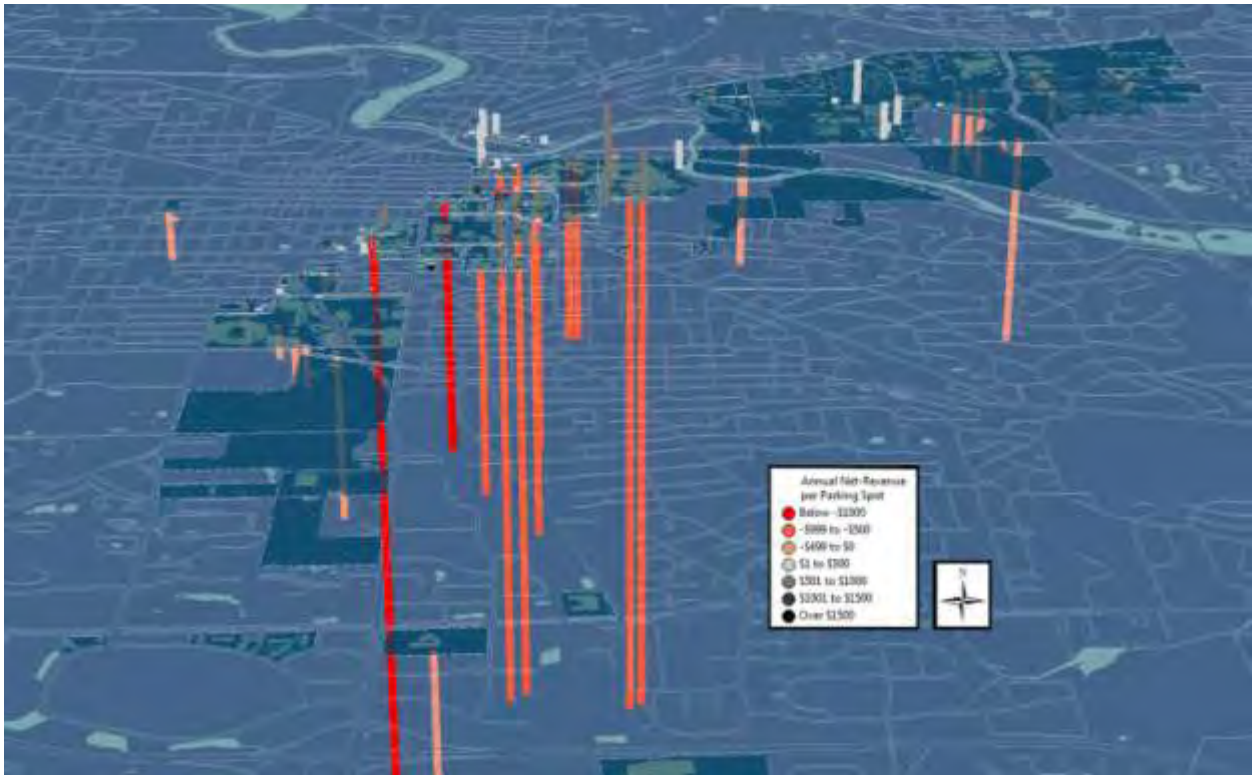


Figure 3-4: Net Revenue of U-M Parking Facilities, 2010 ($142 unit subsidy treated as cost to U-M, land costs excluded)

In sum, there are at least three subsidies to parking within the U-M system:

- The mandated $142 unit contribution to each annual parking pass;
- No accounting for the opportunity cost of land. (This holds across academic and facilities functions at the University but is especially significant with land-intensive uses like parking);
- Cross-subsidies flowing from parkers in peripheral lots to parkers in central structures.

The analyses above suggest a fourth implicit subsidy as well. Figure 3-3, which does not account for the cost of land and treats the $142 unit contribution as revenue to the parking system still shows net losses (of over $5m annually) to the U-M parking system as a whole. With a functional life of 30-40 years,[vii] the early parking structures at the U-M campus will be due for replacement in the near term. The above analysis suggests that, particularly with the rapid increase in the costs of construction, the University will be hard-pressed to finance the replacement of older structures from revenues generated from the parking system alone.

Both total number of parkers at the University of Michigan and their distribution over space is in part a function of these subsidies. Revision of the subsidy policy, whether incremental or comprehensive, could simultaneously ease parking shortages in central areas, facilitate regular or occasional commuting by non-automotive modes, and make better use of the parking capacity that the University has already developed. Perhaps most significantly, by easing pressure for further development of parking structures in central areas, such adjustments can allow, in a more fiscally sustainable fashion, for the further development and growth of the University without increasing car commuting to campus. The following section discusses options for the reform of U-M parking policy to seek to achieve these goals.

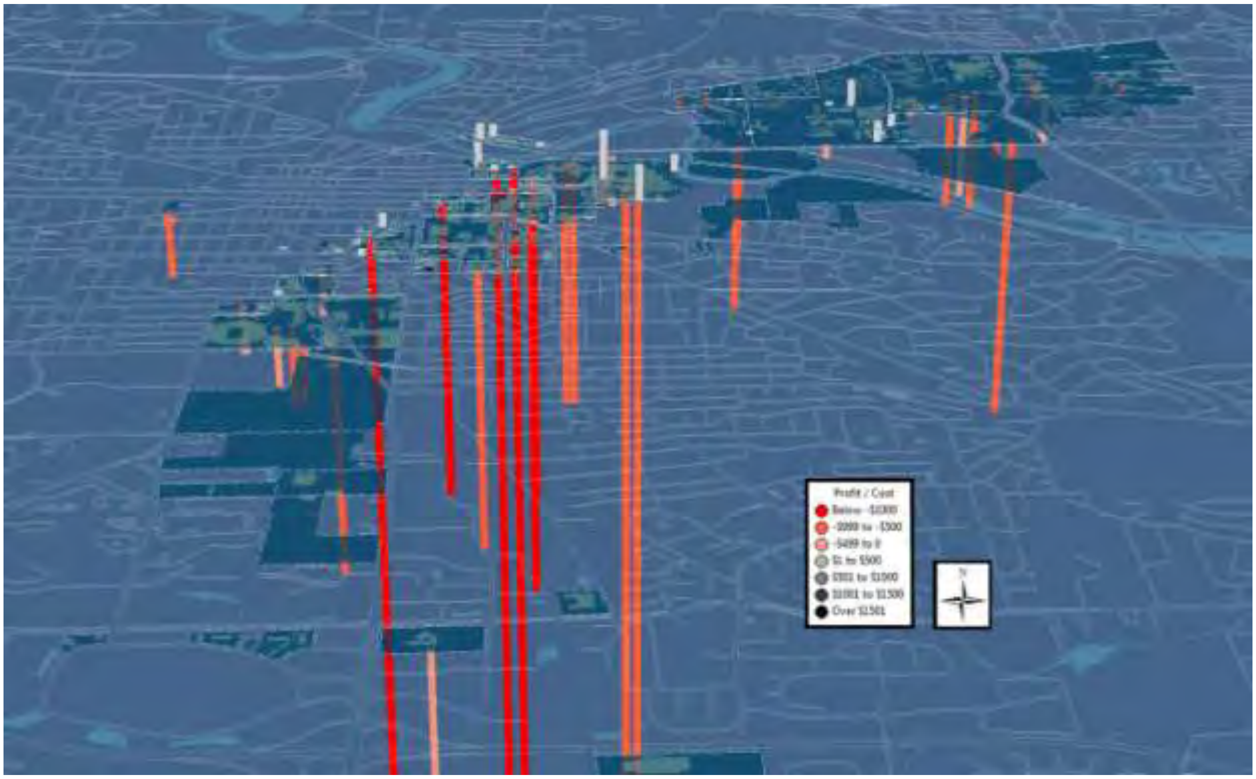


Figure 3-5: Net Revenue of U-M Parking Facilities, 2010 ($142 unit subsidy treated as cost to U-M, land in included in costs)

3.1.2 Costs and Benefits

Potential benefits of the reforms to parking policy below include:

- Better utilization of existing parking capacity as an alternative to the construction of new capacity;
- Providing for growth of the University while minimizing growth in vehicle-miles traveled for the University commute;
- Reducing barriers to occasional transit use, walking, or cycling by car commuters;
- Ensuring that trips that prioritize close-in parking have such parking available when needed.
- Cost savings associated with any parking structures forgone or parking subsidies reduced.

Depending on which option or combinations of options below are chosen, implementation costs could include:

- Outfitting of more parking facilities with automatic vehicle identification systems for both parking payment and provision or real-time information on available spots;
- Short-term disruptions as parkers adapt to the new system;

Possibly greater volumes of commuters on the campus bus system as more choose remote parking options. This may necessitate additional bus service. Peak demand on the campus bus system is at 9:00 am and 3:00 pm, however (Figure 3-38); this may leave some excess capacity for morning and afternoon commuters.

3.1.2.1 Policy Options

Following are possible policy directions to promote these four goals. The directions described below are consistent with each other and could be combined for more comprehensive reform.

3.1.2.1.1 Policy #1: Increase Parking-Rate Differentiation

The purpose of the multi-tiered system of faculty and staff parking instituted in the 1990s was to provide faculty and staff with a range of parking choices: higher-priced close-in parking, and lower-priced remote parking. Some of the remote parking is walking distance from major campus destinations; other requires a ride, often on the U-M campus bus system. The system worked remarkably well in spreading parking volumes away from the central areas and making better use of existing parking capacity in peripheral areas. But the fee differentiation that was introduced was not sufficient to spur utilization throughout the system; moving towards that would require greater differentiation in parking pass rates as one moves from higher volume areas in the core to areas of lower demand in the periphery. This could be accomplished in part under the current structure of annual or continuous parking payment with a revision in the rates for each tier (and possibly some reclassification of parking facilities into tiers). In the extreme, some remote lots currently showing very low parking volumes might be converted to free park-and-ride lots for faculty and staff. This conversion would offer the side benefit of an easy option for occasional parking for people who usually commute by other modes.

It may be, however, that price differentiation adequate to spread parking volumes throughout the system will also requires price increases in central areas. One rule of thumb is to set parking prices at a level that generates 85% occupancy.[viii] This ensures both that parking is available where it is needed and that drivers do not need to search for parking in multiple locations, a common behavior that can add significantly to congestion and emissions in urban areas.

Another possibility is to provide greater non-price incentives for selecting remote parking. For example, some units have purchased a ―blue pass" for the department; this is used by people who park remotely (or do not buy a parking pass at all) on days when their work requires easy access to blue lots. This could be a publicized program and could even be structured as an incentive: for each X employees purchasing a yellow or orange pass (or possibly foregoing parking permits altogether) the unit receives a ―departmental blue pass" for sharing among its faculty and staff.

3.1.2.1.2 Policy #2: Reduce Parking Subsidies

Subsidies are often thought of as a tool to encourage particular behaviors, and the subsidies described above surely encourage drive-alone commuting at the U-M campuses. If encouraging driving is not seen as consistent with the University's sustainability goals, reducing these subsidies can be an appropriate policy response. The most clear and obvious subsidy is the mandated $142 unit contribution. This may be reduced or eliminated, or alternatively may be retained for certain classes of parking (presumably in more remote locations) and may be scaled back for central areas where volumes exceed capacity.

The policy option of eliminating or reducing the mandated $142 unit contribution would lead to savings to the unit. The U-M parking system as a whole needs to maintain current revenue levels in order to provide for the upkeep and debt service of existing structures; elimination or reduction in the unit contribution could lead to some declines in revenue as some previous pass holders decline to purchase the pass. One possibility would be for deans and unit heads to guarantee parking system revenue after the elimination of the mandated unit contribution; presumably this could be accomplished with a portion of the unit savings from the elimination of the contribution.

3.1.2.1.3 Policy #3: Shift from Monthly or Annual Parking Payment

Most U-M faculty and staff parkers currently purchase unlimited campus parking automatically each month. This system has its advantages: revenue to the parking system is regularized; individuals find the mode of payment convenient in that they can set it up and then forget about it. But continuous payment for unlimited parking has significant disadvantages as well. It discourages occasional commuting by walking, cycling, or public transit; once the pass has been purchased, rational commuters may simply drive every day in order to get their money's worth out of their investment; the marginal cost of parking becomes zero. By contrast, daily or hourly parking payment would remove that barrier to mix-and-match commuting; when the commuters prefer to park they have that option available, but on days when other modes are feasible for them, they can save money by choosing transportation alternatives. Thus the decision on how to travel is broken up from an annual decision into a series of daily decisions.

For drivers, this can extend to the decision on where to park. Some days demand close-in parking because of schedule, load, need for midday access to one's vehicle, or other reasons. On other days, remote parking is perfectly acceptable and might be chosen if the money savings were sufficient. Currently one chooses one's parking priority for the year—whether Gold, Blue, Yellow, or Orange. A shift to daily or hourly payment for parking allows assignment of priority flexibly to the trip, rather than to the commuter in a fixed fashion. Thus a person who usually likes to save money by parking remotely may, on a particular day, need easy car access; daily or hourly parking payment can readily accommodate that need. The reverse is also true: current Gold or Blue pass holders may have some trips for which lower priority parking is adequate. When parking is paid for by the year, individuals lack the incentive to adjust their parking locations to their needs for that day; as a consequence spots can be unavailable even for people who have urgent parking needs. In this way, daily or hourly payment for parking can reduce barriers to an efficient match between one's daily parking needs and parking locations.

An additional benefit of daily or hourly parking payment is the ability to differentiate parking rates between on-semester and off-semester times. Parking vacancies vary significantly between these two times (Table 3-2); this implies that the cost of serving a parking need during the school year is significantly higher than during the summer. Differentiating prices between on- and off-semester times would have the additional benefit of lowering average parking prices for staffers who commute daily throughout the year compared to many faculty who curtail their commuting to campus during summer and vacation times.

3.1.3 Barriers to Implementation

The most significant obstacle to any of these reforms is anticipated faculty and staff resistance to changing parking arrangements, and in particular to reducing subsidies. The benefits would need to be carefully conveyed: faculty and staff can have a spot where they want when they need it; they can save money by parking remotely or using transportation alternatives, whether occasionally or frequently; and the reforms can promote both the environmental and fiscal sustainability of the University. It may be, however, that a small-scale demonstration project can serve both to expand the U-M's base of experience and begin to build faculty and staff support. For example, one structure or lot on each campus could be devoted to daily parking—perhaps a facility currently experiencing relatively high vacancy rates. Daily rates would be set to be comparable to the daily cost of parking for permit holders in the same tier. Commuters who drive to campus on a daily basis would not be likely to choose such an option, but many less-than-daily parkers would find it worthwhile. Such a demonstration could begin to convey to a subset of the faculty the benefits of a greater range of transportation options at U-M.

Another approach to overcoming the political obstacle would be to gauge potential faculty and staff acceptance of a package of parking reforms with a survey. The survey would need to be carefully structured as a series of tradeoffs; for example pairing any costs to the individual with benefit in terms of increased range of choice, increased certainty of finding a spot when it is needed, or improved quality of non-automotive transportation options.

A shift to daily or hourly parking payment could lead to greater day-to-day variations in the numbers of parkers seeking to park at any given facility. In particular, winter-weather days when school is in session already demonstrate greater parking demand than others; these fluctuations could increase if all faculty and staff had equal access to parking on these days. This could be seen as a benefit of daily parking payment; the regular pedestrian or cyclist to campus may be at least as deserving of access to parking as the auto commuter on such days. But parking structures would likely fill up earlier in the day than they do currently; the danger is that later arrivals expecting a spot in their usual structure might find none. One approach to this problem would be price differentiation; prices could be set in such a way that these commuters would find a premium (and premium priced) spot available in their usual structures; should they wish to avoid the cost of a premium spot, they will find more economical parking at remote locations. This process could be facilitated with web-based data on real-time parking availability throughout the U-M system.

Reductions in subsidies to the parking system threaten to affect lowest-paid staff more than others. Apart from their low incomes, they may have factors that impede adaptation to increasing parking prices including inflexible job schedules, household duties, and long-distance commuting. Other universities have geared parking pricing to salaries, with lower paid individuals paying less for parking than their higher-salaried counterparts. This has the desirable effect of concentrating subsidies where they are needed, leaving the institution freer to recoup parking costs from higher-paid individuals and to structure payment in ways that encourage efficient use of the system.

Another negative consequence of some of these shifts could be greater faculty and staff parking on Ann Arbor city streets to avoid parking charges, thus potentially exacerbating town-gown frictions. The City of Ann Arbor has effectively implemented zonal parking systems in the area of the University in response to just this possibility; if need be, these could be broadened to forestall the threat of university parkers in Ann Arbor neighborhoods. Moreover, the severest town-gown conflicts may be those over the development of parking structures themselves; to the extent that effective utilization of existing capacity reduces the pressure to expand parking structures in central areas, it may avoid conflicts of this nature.

3.1.4 Uncertainties

In any shift in parking pricing it will be impossible to predict the precise response of commuters. Such was the case when the current tiered system was put into place; it succeeded in shifting many commuters to more remote lots, but the results were not known until the reforms were put into place. In any future reform, prices may need to be adjusted after a trial period that reveals the extent of commuter response to the shift.

3.2 Prioritized Recommendation B: Optimize Campus-oriented Transportation and Land Use to improve the alternatives to automobile reliance

3.2.1 Implementation Idea #1: Increase U-M Bicycle Mode Share

3.2.1.1 <u>Benefits and Costs</u>

Increasing bicycling is a cost-effective strategy to increase the economic efficiency, environmental sustainability, and human health benefits of the U-M transportation system. U-M lags peer institutions in bicycle mode share, and the limited bicycle facilities it currently provides are inadequate to meet existing demand. Based on the experience of other campuses, the development and implementation of a bicycle master plan—including bikeways, parking, service facilities, and a bicycle-sharing program—would significantly increase the amount of U-M bicycle travel within 10 years. This mode shift would derive primarily from local trips (under 5 miles, and especially those from 1 to 3 miles) otherwise made via transit, cars, and walking.[4]

Shifting local trips to bicycling from transit and single-occupancy vehicles would provide a range of benefits to U-M. Reduced demand for additional parking facilities and bus service would generate direct savings for U-M, reducing capital and operating costs for U-M Parking and Transportation Services (PTS). Since bicycling offers an accessible form of moderate regular exercise, increased bicycling can also improve community health and reduce health care costs for community members. Mode shift would also reduce carbon emissions and other air pollution.

A bicycle master plan would guide focused spending on phased, mutually reinforcing strategies for increasing bicycling. Larger long-term investments could be preceded, as necessary, by initial short-term measures designed to demonstrate demand. Establishing a bicycle service center might, for example, cost $200,000,[5] but this step could be preceded by a contract with the Common Cycle bicycle repair nonprofit, which currently provides similar services at an off-campus location. A policy on incorporating bicycle parking into new construction could be instituted in the short term at no expense, while retrofits of existing parking facilities could be pursued over the long term. Development of an intercampus bikeway network of bike lanes and off-street paths would proceed through gradually connecting existing facilities on City streets and U-M properties, as described in the 2009 PTS ―Building a U-M Bikeway Blueprint: An Outline for the U-M Bicycle Master Plan[ix].‖ The following table suggests one possibility for a comprehensive, phased U-M bicycle investment strategy, which could be implemented in stages as demand is demonstrated and funding identified.

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[4] Bicycle sharing systems in four major European cities caused mode shift from transit (34-65% of shift), walking (20-37%), and personal motor vehicles (6-10%). Since Ann Arbor's transit systems are less developed, mode shift to bicycling might derive more heavily from the walking and personal vehicle modes. City of Portland (OR), ―Portland Bicycle Plan for 2030,‖ January 2010, 78.

[5] Michigan State University established the MSU Bikes Service Center in an existing facilities building for less than $200,000. Chris Machielse, interview with Tim Potter, MSU Bikes.

Phase	Capital Investments	Approximate Cost
Short-term (0-1 years)	Develop campus bicycle master plan, contract for bicycle services, expand parking facilities	$100,000-$200,000
Mid-term (1-3 years)	Open bicycle service center, institute bicycle rentals	$200,000-$500,000
Long-term (1-10 years)	Develop intercampus bikeway network, open card-swipe bicycle sharing system	$2,000,000-$10,000,000

While the capital costs for an intercampus bikeway circulation network would substantially exceed previous U-M spending on bicycle transportation, many of these costs could be shared in cooperation with other entities. In the past, the City of Ann Arbor and U.S. federal government, in addition to U-M, has funded bicycle infrastructure in the campus area. It is likely that federal funds could provide a majority of capital funding for U-M bicycle infrastructure, especially an intercampus bikeway network. Operating costs would be limited, consisting primarily of periodic maintenance and bicycle service center operation. With the potential to serve tens of thousands of commuters daily, at minimal operating costs and capital costs only a fraction of U-M parking facility construction expenditures, bicycle investments are likely U-M's best local transportation buy.

3.2.1.2 Technical Guidance

Implementation of a bicycle master plan offers substantial returns because current U-M bicycle infrastructure is underdeveloped, and current bicycle use is accordingly low. A comparison of bicycle commute mode share data from leading peer institutions with 2000 U.S. Census data for the U-M Central and Medical Campus (

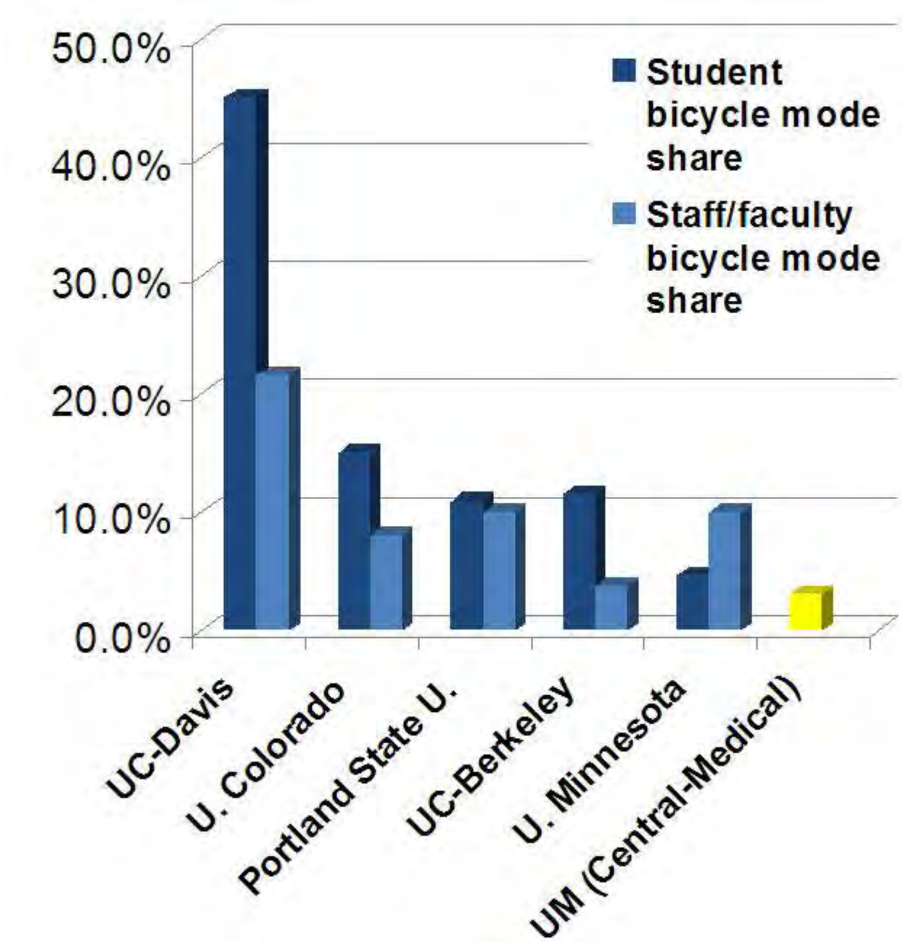


Figure 3-6) indicates that U-M substantially lags these peers, all major state universities in urban settings, in the proportion of commuters who travel by bicycle. (The Census does not differentiate between student and staff commuters.) Climate is not the major determinant of bicycle commute rates, as the discrepancy between rates at the nearby Davis and Berkeley campuses of the University of California suggests, and the Minnesota and Colorado data indicates that less temperate winters are not responsible for the much lower U-M figure. Rather, the most important factor is the institutional support for bicycle transportation on campus and in the surrounding municipality. Comparison of U-M with a larger set of bike-friendly peer institutions shows that U-M lacks most of the bicycle policies, facilities, and services that they employ (Table 3-4). U-M could significantly increase bicycle mode share through coordinated investment in these areas and synergy with the City bikeway system. Best practices at peer institutions can provide a guide for a U-M campus bicycle master plan to implement bicycle circulation, parking, service and rental facilities

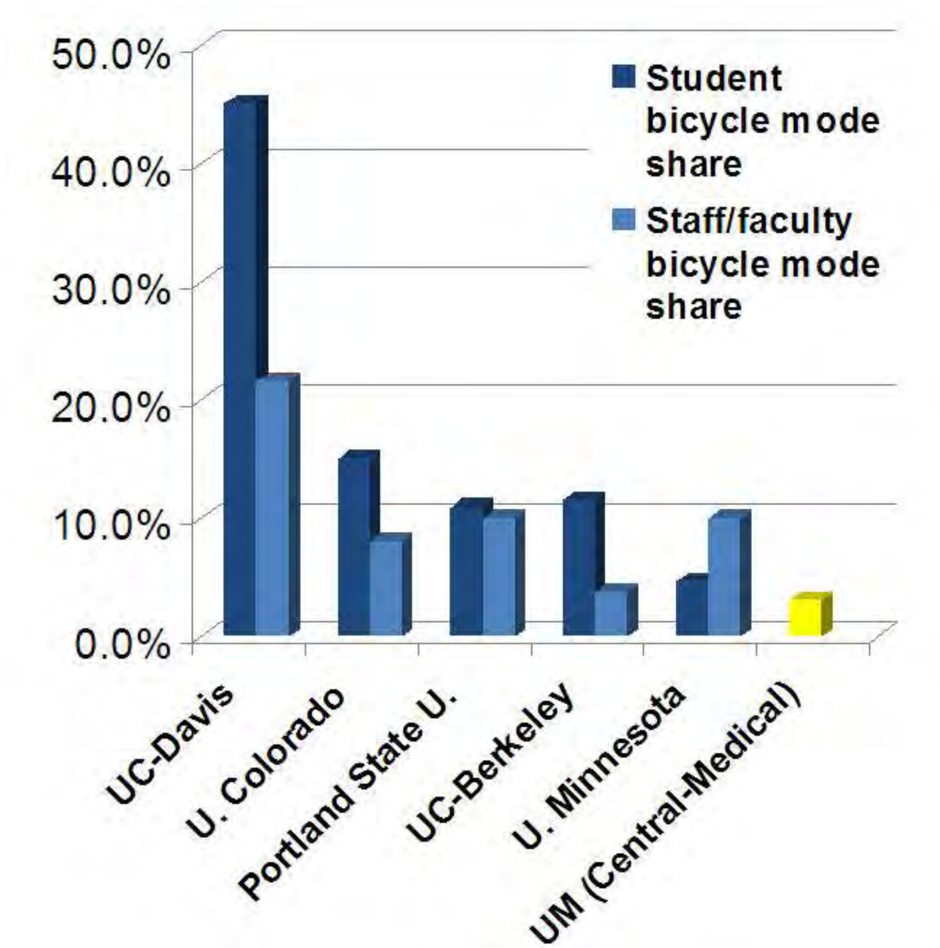


Figure 3-6: Campus bicycle commute modeshare for U-M and bike-friendly peers (c. 2000s). U.S. Census data does not differentiate between student and staff U-M commuters.

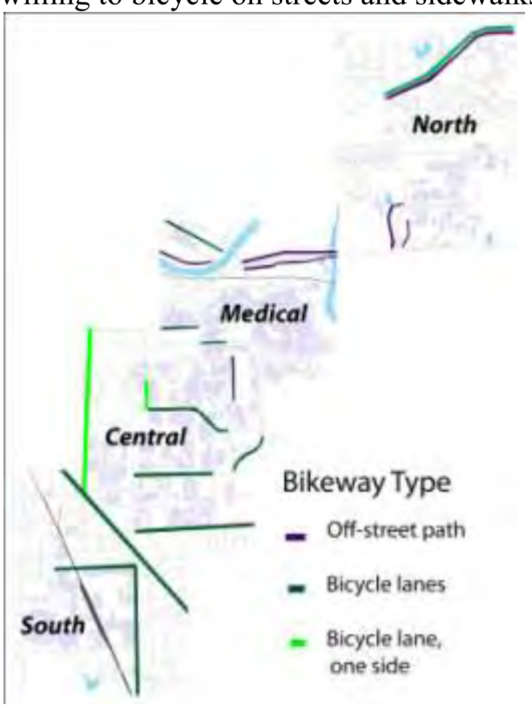
3.2.1.2.1 *Planning*

As with any transportation initiative, a comprehensive planning process for bicycle improvements can ensure the most efficient use of resources. Peer institutions undertake coordinated bicycle improvements by integrating bicycles into ongoing master planning or through a stand-alone bicycle master plan (UC-Berkeley, University of Texas-Austin, Michigan State). A stand-alone bicycle master plan is necessary in many cases because past planning has not addressed bicycle transportation. While recent U-M campus plans have considered ―non-motorized connections," they have not specifically addressed bicycle transport as distinct from pedestrian travel, a basic prerequisite for effective bicycle transportation strategies.[x] [xi]A bicycle master plan could focus on bicycle improvements spanning multiple campuses. Planning would be substantially assisted by regular surveys of community travel patterns (see Section 3.3). Because U-M has not previously planned systematically for bicycle circulation, a bicycle master plan would offer the surest route to efficient prioritization and phasing of campus bicycle investments.

3.2.1.2.2 *Circulation Facilities*

To provide convenient access to destinations, transportation infrastructure must take the form of a comprehensive network, not a disconnected set of isolated facilities. Despite some recent improvements, bicycle facilities surrounding U-M still take the latter form. Development of a comprehensive bicycle circulation system, based on an intercampus bikeway connecting the U-M campuses, would likely form the most critical component of a U-M bicycle master plan. It would also present the greatest challenges, including substantial capital costs. However, these could be shared with other government units, and the development of a comprehensive bikeway system would enable a shift in commuter traffic from the more costly single-occupancy vehicle and transit modes, ultimately reducing U-M transportation expenditures.

The City of Ann Arbor has begun development of a bikeway system, but this remains fragmentary, and U-M has yet to do likewise, severely limiting bicycle access to the U-M campuses. In 2007, the City of Ann Arbor adopted a plan for a comprehensive bicycle circulation network comprised of on-street bicycle lanes and off-street paths, and lanes have now been added to a number of City streets. However, as shown in the figure below, none of these streets provide full connections between the U-M campuses. Moreover, since U-M has not adopted a similar plan, its campuses remain islands within the City of Ann Arbor network. As a result, bicycle access to U-M campuses is possible only for the limited number of commuters willing to bicycle on streets and sidewalks already crowded with cars and pedestrians.



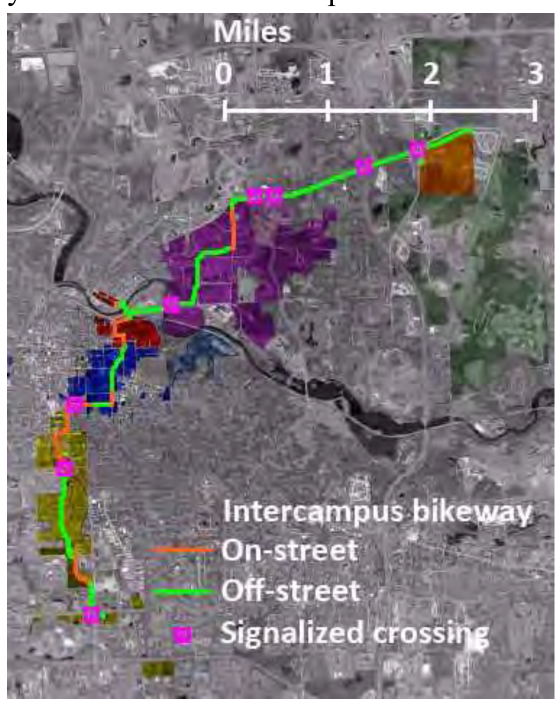


Figure 3-7. (Left) Existing bicycle facilities in the U-M area are fragmentary, and separated bikeway facilities connecting the campuses are notably absent. Shown are on-street lanes and major off-street paths.
Figure 3-8. (Right) Potential intercampus bikeway proposed in 2009 PTS report. Such a bikeway would provide a valuable ―trunk line" in the larger local bicycle transportation system.

The absence of comfortable separated bikeways, and in particular the resulting competition with cars for road space, is a powerful deterrent to bicycle travel. Sidewalk-riding bicyclists surveyed by the Ann Arbor Downtown Development Authority (DDA) in 2010 ―always or frequently cited fear of riding in the roads due to cars traveling at high speeds," as well as ―poor bike lanes.” A majority of all respondents, street-riding and sidewalk-riding, described ―a need for additional bike lanes and improved, well-maintained bike lanes.”[xii]

In addition, by pushing bicycle traffic to sidewalks, the absence of separated bicycle facilities impedes pedestrians as well as bicyclists. In 2003, after members of the DDA Citizen‘s Advisory Council grew ―increasingly frustrated and alarmed” by conflicts between bicyclists and pedestrians on sidewalks, the DDA commissioned a study to resolve these conflicts. It concluded by noting the importance of separated U-M bikeways in providing an effective solution to the problem: ―As the city continues to move in the direction of separate facilities for bikes and pedestrians, the gap between what is expected behavior from bikes and pedestrians on campus as opposed to what is expected in town will continue to widen…To alleviate this problem, it is recommended that the University pursue a policy of separation of facilities, not only to provide continuity between the City and the University, but for the safety of bicyclists and pedestrians on campus as well.” Although U-M has since worked with the City to add bicycle lanes on some local streets, it has not yet pursued bicycle-pedestrian separation where no lanes exist.



Figure 3-7 (Left) the absence of separated bicycle facilities promotes sidewalk riding on South State Street.
Figure 3-8 (Center) Bicycle-pedestrian conflicts are not limited to the areas of densest pedestrian travel.
Figure 3-9 (Right) Even where bicycle lanes exist, the lack of a comprehensive circulation system generates unpredictable behavior, leading to conflicts as seen here on S. University Ave.

By filling in the gaps in the current bicycle circulation network with on-street lanes and off-street paths, in cooperation with the City, U-M can seamlessly integrate campus bicycle transportation with the City network and make bicycling the most attractive mid-range (1-3 mile) transportation option for a broad range of community members. A 2009 outline for a U-M bicycle master plan prepared for Parking & Transportation Services built on the study by proposing the connection of existing facilities to form an intercampus bikeway network.[xi] Two corridors meriting particular attention are Glen and Fuller Road, connecting the U-M Central, Medical, and North campuses, and South State Street, the major north-south corridor on Central Campus. It is likely that improved off-street paths providing for bicycle-pedestrian separation would best facilitate bicycle travel on Fuller, a four-lane boulevard. Two-lane State Street would benefit from on-street facilities, which U-M, the City, and the Downtown Development Authority could work together to provide. Removing on-street parking from one side of State would allow for on-street lanes, and the development of a State Street transit and bicycle mall could be considered as a long-term opportunity.

Figure 3-10 South State Street.

Figure 3-11 Fuller Road.

Whatever the precise outline of a U-M bicycle circulation system, it would require separation of bicyclists and pedestrians in high-traffic locations. Walking and bicycling are different modes, which cannot mix effectively in such areas. The absence of separated bicycle facilities encourages sidewalk-riding behavior, which endangers pedestrians and bicyclists, “frustrat[ing] and alarm[ing]” residents.[xiii] Not all bicycle traffic can be separated, but separated bikeways on major corridors would significantly speed bicycle circulation and divert it from pedestrian spaces. In conjunction with an intercampus bikeway network, U-M could designate the Diag a peak-hour bicycle dismount zone, as peers have done in their central pedestrian spaces. However, such restrictions on bicycle traffic are unfeasible without effective bypass routes.

3.2.1.2.3 Parking Facilities

Although bicycle parking has been the focus of past U-M bicycle investments, existing bicycle parking capacity is often inadequate to meet existing demand, especially on Central Campus. Provision of bicycle parking has been uneven and sometimes absent in major recent U-M building projects. Secure and sheltered parking is under development, and bicycle lockers have been provided for some time on request, but the vast majority of U-M bicycle parking is fully exposed to rain, snow, and theft. A cohesive bicycle parking policy and program would do much to ensure appropriate facilities throughout the system.

An October 2010 campus-wide survey of bicycle parking found that while bicycle parking volumes vary among campuses, dozens of Central Campus locations experience shortages of bicycle parking, and others are deficient in other respects, as indicated by an October 2010 campus-wide survey (Figure **3-13**). To encourage use of this mode, bicycle parking should meet peak demand. Its absence impedes bicycling and mars campus aesthetics, as bikes are locked to trees, poles and other landscape elements, and its installation might be a short-term U-M priority. Basic bicycle parking is inexpensive, but its effective provision may require a centralized system by which building managers and users can report deficiencies and see them rapidly addressed through a dedicated bicycle-parking fund. However, any new parking would need to conform to intended bicycle circulation patterns as established in a master plan. Adopting uniform bicycle parking standards for new construction, as done by the City of Ann Arbor and the University of Oregon, would significantly reduce the need for costly retrofits. While most recent U-M construction includes bicycle parking facilities, these have not always been sufficient to meet demand, or been optimally sited. The City of Ann Arbor bicycle-parking ordinance would provide a useful model for U-M.[xiv]

Figure 3-12 Informal overflow bicycle parking mars campus beauty and can block walkways.

U-M can also realize significant short-term gains by exploiting opportunities for covered bicycle parking. Since bicycles' moving parts are exposed to the elements, bicycle parking should be sheltered from rain and snow where possible to prevent damage. Shelter is particularly important for long-term residential parking (Class C in the City of Ann Arbor typology). U-M can leverage existing building overhangs as sites for inexpensive sheltered parking, as recently done at the Hatcher Graduate Library. Elsewhere, additional covered shelters and secured facilities may be constructed over the long term. Michigan State University also offers warehouse bicycle storage over winter and summer breaks.[xv xvi]

However expansive, bicycle-parking facilities will not be effective if they are not properly maintained. Bicycle impoundment is currently the task of a single U-M DPS officer; so many months often pass before abandoned bicycles are removed, impeding others from parking there. U-M could benefit from exploring a new bicycle impoundment protocol empowering building managers to report and/or remove abandoned bicycles after appropriate notification.

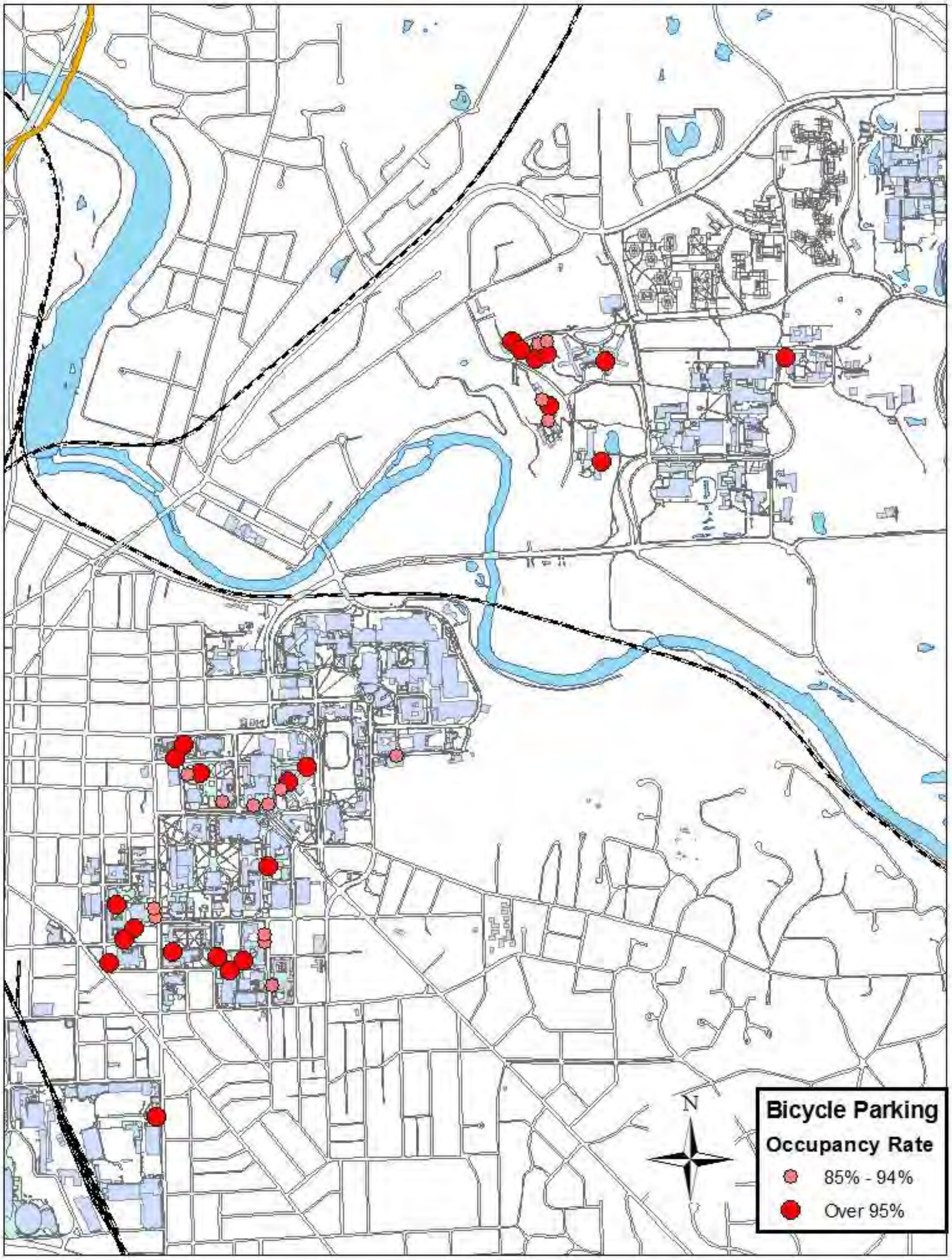


Figure 3-13 An October 2010 campus-wide bicycle parking survey found that demand exceeded the recommended 85% of capacity at dozens of locations, concentrated in areas of Central Campus and the North Campus Baits Houses.



Figure 3-14 When exposed, bicycle parking is vulnerable to the elements, as well as theft.
Figure 3-15 Some U-M bicycle parking is improperly installed, impeding use.
Figure 3-16 Newly installed Graduate Library bicycle parking beneath building overhang.

3.2.1.2.4 Other Services

In addition to bicycle circulation and parking facilities, peer institutions offer a range of other bicycle services. In particular, bicycle service centers and modern bicycle rental systems can significantly expand the accessibility of bicycle transportation. As with bicycle circulation and parking facilities, implementation of bicycle services and rentals can be phased to ensure the most effective use of funds.

Bicycle-supportive transit buses can also significantly expand the accessibility of bicycle transportation. Over the past decade, they have become the standard in American cities and universities. By allowing more effective bicycle and transit trip linking, they significantly expand the utility of both modes. The U-M bus garage is too small to house full-size buses with front-mounted bicycle racks, preventing their installation on U-M buses.[xvii] However, U-M could add racks to the smaller hospital shuttles as an interim solution. Because of the limited capacity (2-3) of transit bicycle racks, bicycle-sharing systems as described below can facilitate linked trips far more effectively, but transit bicycle racks would represent a significant improvement nonetheless.

An increasing number of US universities operate bicycle service facilities for community members, including 7 of the 10 bicycle-friendly peer institutions detailed in Table 3-4. Like other vehicles, bicycles require periodic maintenance and repair. Many commercial bicycle businesses primarily serve high-income customers, putting their services beyond the reach of students. A U-M bicycle service facility could provide affordable service and maintenance for U-M bicyclists without competing in the bicycle retail market.[6] Some university-sponsored bicycle service centers resemble a traditional bicycle shop, charging a fee for services rendered, while others charge a flat membership fee, providing both repair services and a workspace so members can perform their own repairs if desired. The second option might be preferred by U-M because of the proximity of other bicycle shops, its reduced staffing requirements, and resulting potential for financial self-support.

Demand clearly exists for a facility at U-M. During its 2008-9 period of operation, the East Quad Bike Co-op—run by student volunteers on a $120 budget from an 8 x 12‘ basement room—repaired between 250 and 400 bicycles[xi]. While EQBC‘s leaders have graduated, Ann

[6] Portland State University‘s downtown service center, the PSU Bike Hub, ―has received positive support from area bike shops, and looks forward to maintaining these mutually beneficial relationships." Both the PSU Bike Hub and the MSU Bikes Service Center also refer users to local bicycle retailers; Potter, Tim, MSU Bikes Service Center Manager, telephone interview with Chris Machielse, 2010.

Arbor‘s Common Cycle nonprofit bicycle repair program will likely show greater longevity. U-M staff and other Ann Arbor residents in addition to students run EQBC, and it has serviced more than 400 bicycles and raised over $5,600 since its 2010 founding[xviii] [xix]. U-M could immediately introduce bicycle services to campus by contracting with Common Cycle to bring its mobile repair stand to campus on a periodic basis. The University of Texas at Austin uses a similar mobile bicycle service trailer[xx]. Over the long term, U-M might partner with Common Cycle to provide more extensive services, and construct a permanent repair facility at a Central Campus location.



Figure 3-17 (Left) MSU Bikes Service Center front desk. *msubikes.org*
Figure 3-18 (Center) U-M East Quad Bike Co-op (EQBC).
Figure 3-19 (Right) Common Cycle mobile service center. *CommonCycle.org*

Portland State University‘s service center also originated as a student initiative, and might provide an instructive example. Unlike EQBC and Common Cycle, it received university support from its founding. Over the past six years, it became a full-service membership-based workshop that gained 1,100 members and more than $100,000 in sales in its first six months, and it is expected to be self-supporting by 2012[xxi]. The new service center was built in to a new campus recreation center, so initial capital costs are difficult to assess, but MSU‘s conversion of a 2000-square-foot facility required an investment of under $200,000.[xxii]

Bicycle rental programs are also an increasingly common among American universities. Most of the leading bike-friendly peer institutions compared offer long-term or short-term bicycle rentals, often through a bicycle service center. Rentals may be as long as one semester or as short as one hour. Impounded bicycles often provide a ready source of bicycles and components for these programs, and once a bicycle service center is established, U-M could successfully pursue these relatively inexpensive opportunities in the short term.

Over the long term, a modern ―bicycle sharing” system, using computerized bicycle docking stations for short-term rentals, could significantly accelerate an increase in U-M bicycle mode share. The system remains among the more costly potential U-M bicycle investments, but also among the most potentially transformative. While costly, such a system could eventually handle a large proportion of the U-M commuter population.

Saint Xavier University in Chicago has implemented modern bicycle sharing, and the University of Minnesota is now served by the Twin Cities bicycle sharing system, however, the large initial investment presents a barrier. Michigan State University opted for restricting rental service locations to the MSU Bikes Service Center itself rather than initiate a $500,000 system[xxii]. In relative terms, however, this expenditure is equivalent to the cost of a single new hybrid-electric bus, or 20 new structured parking spaces[xxiii] [xxiv], and it could also take advantage of federal transportation funding. Moreover, the U-M campuses are uniquely suited for bicycle sharing. U-M consists of two major nodes, Central and North Campus, connected by a high-capacity transit corridor. As suggested by the heavily used bicycle parking at U-M's Central Campus Transit Center[xxv], many community members already link bicycle and transit trips. The availability of bicycles at both ends of this commute would enhance both modes. The absence of secure or sheltered parking facilities for privately owned bicycles at most on-campus and off-campus housing provides another advantage to bicycle sharing. However, the system would be most effective in conjunction with a cohesive circulation network as described above.

3.2.1.2.5 Education and Outreach

Many peer institutions provide bicycle education for community members, often through a bicycle service center. Neither U-M student orientation sessions nor the DPS currently provide information on bicycle safety. U-M could provide regular courses on safe riding and effective maintenance through a bicycle services center. Since women and people of color have been historically underrepresented in the US bicycle commuter community, special attention might be given to encouraging their participation, in part through a diverse bicycle service staff.[xxvi] For example, the PSU Bike Hub offers a regular, well-attended women's bicycle repair night.[xxvii]

3.2.1.3 Barriers to Implementation

The chief barrier to development and implementation of a bicycle master plan is funding. Although bicycle facilities are far less costly than transit and automobile infrastructure, U-M lacks a dedicated funding source, although U-M Parking and Transportation Services has sometimes set aside funding for bicycle parking facilities in the past.[xvii] At peer transportation units and the general fund have financed bicycle facilities. Numerous opportunities exist for federal funding of bicycle infrastructure in cooperation with the City of Ann Arbor. A bicycle program might also require additional staff to aid implementation.

3.2.1.4 Uncertainties and Concerns

Development and implementation of a U-M bicycle plan should significantly increase bicycle mode share. However, the precise magnitude and nature of the mode shift is unknown, especially as limited data is available on current U-M transportation patterns. U-M does not conduct a regular survey of faculty and staff transportation patterns, and U-M has not previously surveyed student transportation patterns. Based on the experience of other universities, however, and U-M's currently low bicycle mode share, a substantial increase of bicycle mode share in ten years appears reasonable given full implementation of the bicycle system described above, including modern bicycle sharing facilities. A regular transportation survey would be an essential tool for tracking progress towards these goals.

Table 3-4 Bicycle Programs at U.S. Universities: U-M and Leading Peer Institutions

	UOE	UCD	UM	MSU	PSU	UTA	UCB	UWM	UC	UV	U-M
Policies											
Transport survey		X	X	X	X	X	X		X	X	
Bicycle planning	X	X	X	X	X	X	X			X	
Bicycle staff	X		X	X	X	X		X			
Circulation Facilities											
On-street lanes	X	X	X	X	X	X	X	X	X	X	X
Dismount zone(s)	X	X	X			X	X			X	
Off-street lanes	X	X	X	X					X		
Parking Facilities											
Basic parking	X	X	X	X	X	X	X	X	X	X	X
Bicycle lockers	X	X	X		X	X		X			X
Secure parking	X	X			X		X	X			2011
Services											
Transit bike racks	X	X	X	X	X	X	X	X		X	
Service center*	X		201 1	X	X	X		X	X		
Bike rental/sharing	X		X	X		X			X		
Bicycle education	X	X		X	X						

*Staffed centers only.

UOE – University of Oregon-Eugene
UCD – University of California-Davis
UM – University of Minnesota, Twin-Cities
MSU – Michigan State University
PSU – Portland State University
UTA – University of Texas, Austin
UCB – University of California, Berkeley
UWM – University of Wisconsin-Madison
UC – University of Colorado at Boulder
UV – University of Virginia

3.2.2 Implementation Idea #2: Enhance Pedestrian Facilities

Pedestrian circulation is the most sustainable local transportation mode. Central Campus is among the most pedestrian-friendly environments in the region and a key asset to U-M. However, deficiencies persist, and U-M campuses lack sidewalks in a number of locations. To improve the safety and attractiveness of pedestrian circulation, U-M can complete its basic pedestrian system and explore opportunities for enhancing pedestrian travel on major through streets, as well as encouraging pedestrian travel through building design. Because pedestrian trips are typically shorter than bicycle trips, and U-M's pedestrian circulation system is substantially complete in high-volume areas, opportunities to shift transit and car trips to pedestrian travel are more limited than for bicycle travel.

3.2.2.1 Costs and Benefits

Pedestrian circulation is the most efficient and sustainable mode of local transportation (0.5 miles or less), since it generates no pollution, involves physical activity, and imposes minimal capital and operating costs. The U-M Central Campus is among the most pedestrian-friendly environments in the region and a key asset to U-M. Other U-M campuses, however, are far less pedestrian-friendly environments, since available services in and around them are few and far between. The almost total dominance of automobile-based transportation at the U-M East Medical Campus (95%; see Table 3-1), located in an exurban environment outside the Ann Arbor city limits, offers a dramatic illustration of the role of land use in transportation patterns. To increase and enhance pedestrian travel, U-M can gradually plan and implement land use changes that put more diverse services within walking distance of the campus community, especially on the North Campus. In the short term, it can enhance the safety and comfort of pedestrians throughout its campuses by improving and expanding pedestrian facilities.

Adopting a plan for a greater diversity of land uses on North Campus would impose no additional capital costs on the University, instead providing a guide for future U-M investment that could make the best use of investments in buildings and other facilities. Pedestrian improvements to the campuses could be phased, and those involving City streets would require development in cooperation with the City and Downtown Development Authority, creating opportunities for funding from additional sources. The following table suggests a potential guide for phased implementation. It should be noted that the full value of Central Campus as a pedestrian-friendly environment is challenging to calculate using current methods.

Phase	Capital Investments	Approximate Cost
Short-term (0-1 years)	Initiate planning process for diversifying land uses; begin adding sidewalks, ADA-compliant curb ramps	\$200,000-\$500,000
Mid-term (1-3 years)	Continue planning process, complete sidewalk network, improve street crossings	\$500,000-\$3,000,000
Long-term (1-10 years)	In cooperation with City, consider ped. extensions and transit mall development	\$5,000,000-\$10,000,000

3.2.2.2 Technical Guidance

Pedestrian travel is affected by a number of factors. Land use patterns are perhaps the most critical element; where nearby places to go do not exist, pedestrian travel will invariably be limited. Provision of basic infrastructure, the presence of bicycle and motor vehicle traffic, and building design are also important factors, as are building design.

3.2.2.2.1 Diversifying Land Use

Pedestrian commute rates on the Central Campus are nearly double that of the North Campus area and eighteen times that of the East Medical Campus area. In large part, the discrepancy reflects the fact that central Ann Arbor features a wide diversity of land uses where places of work, school, residence and consumption are concentrated within walking distance of each other. This diversity is a consequence of the central city‘s evolution in the 19^{th} century, before other transportation modes became easily accessible. The U-M North Campus, by contrast, was planned in the mid-20^{th} century. It reflects that era‘s emphasis on single-use zoning that separated residential, commercial and office uses, and its prioritization of rapid motor vehicle circulation over pedestrian travel. As a result, North Campus is a less pleasant place to live and work, and many needs of campus community members—particularly those for food, leisure, and household goods—can only be satisfied by trips of one mile or greater, usually made via bus or car. Although improved transit and bicycle networks can facilitate access to more distant locations, a more efficient, sustainable, and livable North Campus requires diversifying land uses in conjunction with efforts to connect the campus to its surroundings.

Figure 3-20 (Left) Central Campus: a vibrant pedestrian environment adjacent to local retail uses, and encouraging lingering and interaction. (Right) North Campus gateway: a four-lane boulevard engineered for speed, not lingering, and distant from other uses.

U-M has recognized this problem for some time. The 2008 North Campus Master Plan Update emphasized the need to ―make North Campus a vibrant, around-the-clock destination for the broader community," rather than an isolated enclave almost exclusively dedicated to academic and residential uses.[xxviii] Accordingly, it outlines increases in campus density and a more fine-grained network of streets, which will aid pedestrian circulation. However, a greater mix of uses on North Campus is required to put more destinations within walking distance.

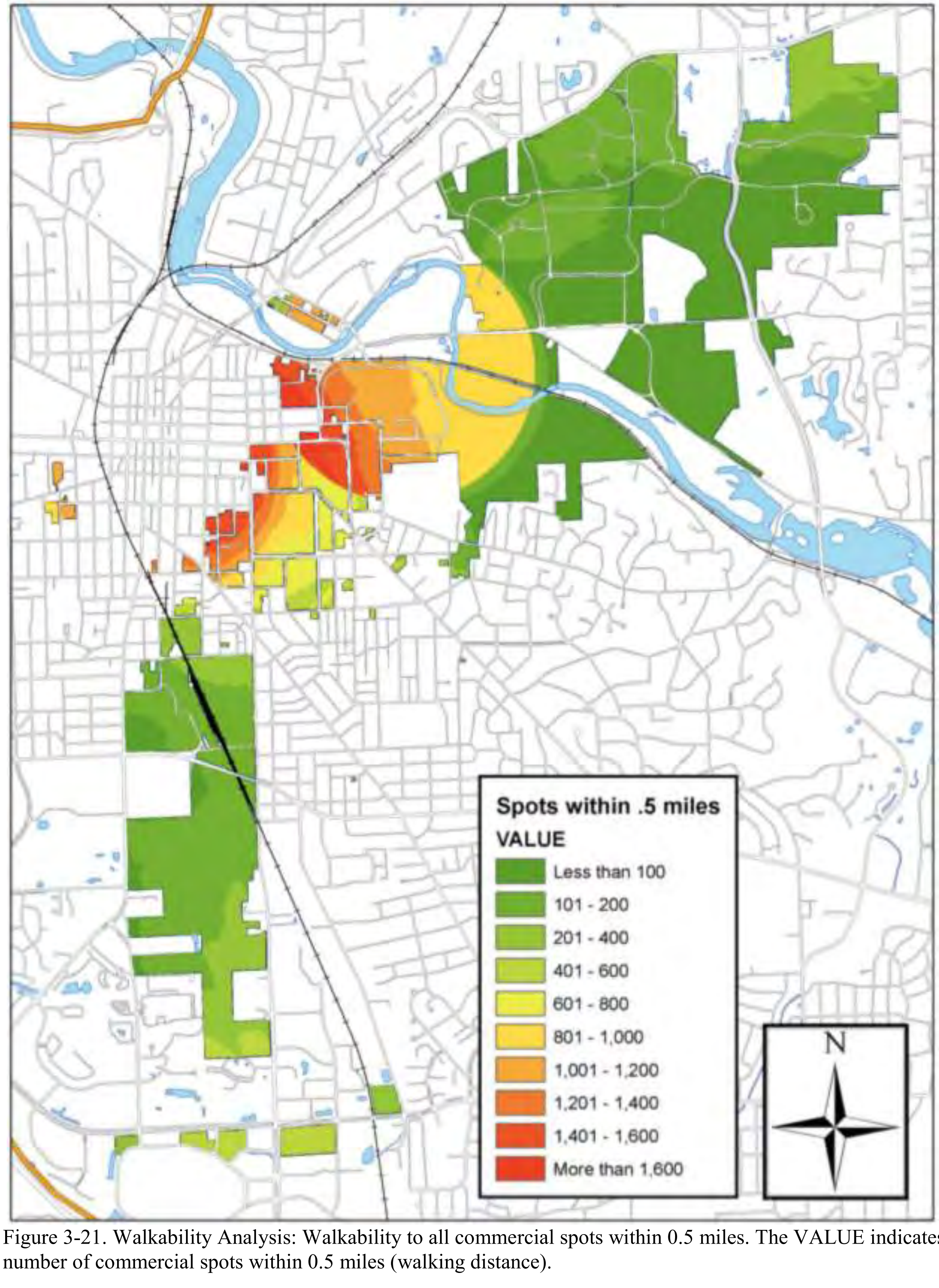


Figure 3-21. Walkability Analysis: Walkability to all commercial spots within 0.5 miles. The VALUE indicates the number of commercial spots within 0.5 miles (walking distance).

Figure **3-21** displays the dramatic contrast in local commercial destinations between the U-M North Campus and Central Campus. Most areas of Central Campus enjoy access to five to fifteen times as many local commercial destinations within the typical walking distance of 0.5 miles. This contrast results from the absence of commercial destinations within North Campus or in the surrounding area, with the exception of the Pierpont Commons on campus and the retail areas on Plymouth Road adjacent to campus at Murfin and Nixon, both of which are greater than 0.5 miles from the North Campus Diag.

Increasing access to commercial destinations and enhancing pedestrian travel on North Campus requires diversifying land uses on North Campus itself. In contrast to the Central Campus, which expanded gradually with successive U-M purchases of land, the North Campus consists of a single, far larger tract. As a result, retail development adjacent to the North Campus is beyond the usual range of pedestrian travel from the North Campus core, and adding new retail on campus is the only viable option for enhancing local access. Clearly, these changes in the built environment can only be implemented over a period of years and decades. The nature of campus development demands a long-term implementation strategy to overcome the current economy and strategies to control non-university community parking on campus. Peer institutions can provide guidance for U-M action.

The University of Wisconsin is beginning to explore public-private partnerships to foster redevelopment on university-owned property[xxix]. To help revitalize the eastern half of its campus, Cornell University replaces buildings that have reached the end of their usable life with mixed-use, higher-density developments, thus intensifying use while retaining its existing footprint[xxx]. Further investigation into campus planning on North and South campus is needed to increase walkability in areas highlighted in green in the analysis above. While these changes cannot occur overnight, and it is unlikely that North Campus will ever match the Central Campus and downtown for their diversity of eating, entertainment, and other retail options, planning in the present is essential to enhance the sustainability of North Campus, and improve the quality of life there for future generations.

3.2.2.2.2 Improving Pedestrian Infrastructure

Local destinations are the precondition for pedestrian travel, the absence of pedestrian circulation facilities is a substantial deterrent even where local destinations exist. Basic pedestrian infrastructure includes circulation facilities, street crossings, and lighting. Such facilities are generally ubiquitous on the U-M Central Campus, but often absent in other areas. A number of North Campus streets lack sidewalks on one or both sides. U-M is gradually filling these gaps in the pedestrian network, but accelerating this process would enhance the safety and attractiveness of the pedestrian mode. On North Campus and elsewhere, many high-volume U-M pedestrian crossings lack striping, curb ramps, and other facilities. Additional crossing facilities at intersections, mid-block crossings, and speed tables could be considered at a number of locations. ADA-compliant curb ramps should be the U-M standard. Adequate lighting is essential for nighttime pedestrian circulation, and U-M might consider installing pedestrian lighting along the Fuller Road corridor in cooperation with the City in conjunction with other projects.

Figure 3-22 Basic pedestrian deficiencies on the U-M campus and adjoining streets include the absence of sidewalks, crosswalk striping, ADA-compliant curb ramps, and adequate lighting.

Appropriate maintenance of pedestrian facilities is critical to their success, especially in winter. The U-M fleet of snow removal vehicles performs superbly in many areas, but others are less well maintained. Since pedestrian travel to campus often involves City sidewalks, U-M could consider partnering with the City to plow major pedestrian corridors adjacent to campus, such as streets near the downtown, where private property owners fail to do so.

Figure 3-23 The U-M fleet of snow removal vehicles effectively removes snow from campus pedestrian routes, but U-M pedestrian travel would benefit from similar maintenance of nearby corridors, both on and off the campuses.

3.2.2.2.3 *Street Conversions*

Over the long term, more substantial pedestrian improvements could be considered at a number of locations in cooperation with the City and Downtown Development Authority. Conversion of sections of Ingalls Street and East University Ave. into pedestrian malls has created some of the University's most iconic pedestrian spaces. The Ingalls Mall, in particular, has become a highly desirable location for community events from the Ann Arbor Art Fairs to the Ann Arbor Summer Festival. With careful planning community-wide planning, other streets too could be enhanced for pedestrian circulation, as well as transit and bicycle travel.

Figure 3-24 Ingalls Mall, formerly Ingalls Street, during the Ann Arbor Summer Festival. ***Let's Save Michigan***

On South University, North University, and portions of State Street, pedestrian volumes greatly exceed automobile volumes, causing congestion at peak hours (Figure 3-26) and frequent crashes (Figure 3-27). Since they bisect the U-M campus, serve as major transit routes, and present significant problems for motor vehicle circulation, consideration might be given to optimizing them for pedestrian, bicycle, and transit circulation, and limiting non-local motor vehicle traffic. Such a program could be approached through a phased implementation process, including the creation of ―festival streets" or ―shared space" at grade with adjoining sidewalks. In the short term, portions of State Street might be closed to non-local motor traffic during U-M football games, as currently being considered for Main Street.[xxxi]

Figure 3-25 (Left) High pedestrian volumes on State Street bisecting Central Campus. (Center) Pedestrian traffic at Hill and State on game day. (Right) Private motor vehicles impede pedestrian and bicycle traffic on South University.

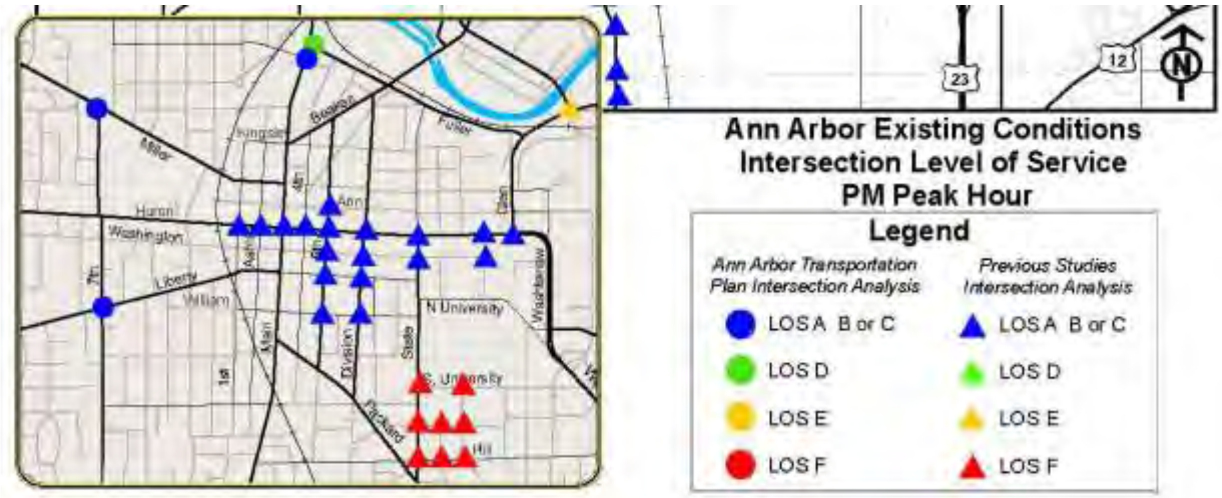


Figure 3-26 Pedestrian circulation dominates motor vehicle circulation at Central Campus intersections (red).[xxxii]

The effect on motor vehicle traffic would require careful evaluation, but the availability of alternate high-capacity corridors (the Fifth and Division couplet, Huron, and Washtenaw) suggests that improvements could be pursued without significant adverse effect. Due to high pedestrian volumes, three intersections on South State Street currently receive an automobile level-of-service (LOS) grade of –F,” the only intersections in downtown Ann Arbor to receive a failing grade (Figure 3-26). The segment of State Street between Liberty and Hill already experiences moderate to severe daily congestions, and city transportation planners forecast that this will continue in any event.[xxxiii] Pedestrians already dominate these streets, though motor traffic continues to endanger pedestrians along them (Figure 3-28). Some on-street parking would be lost in such changes, but Ann Arbor and the University already possess off-street parking facilities, and the storage of empty vehicles may not be the optimal use of major pedestrian corridors.

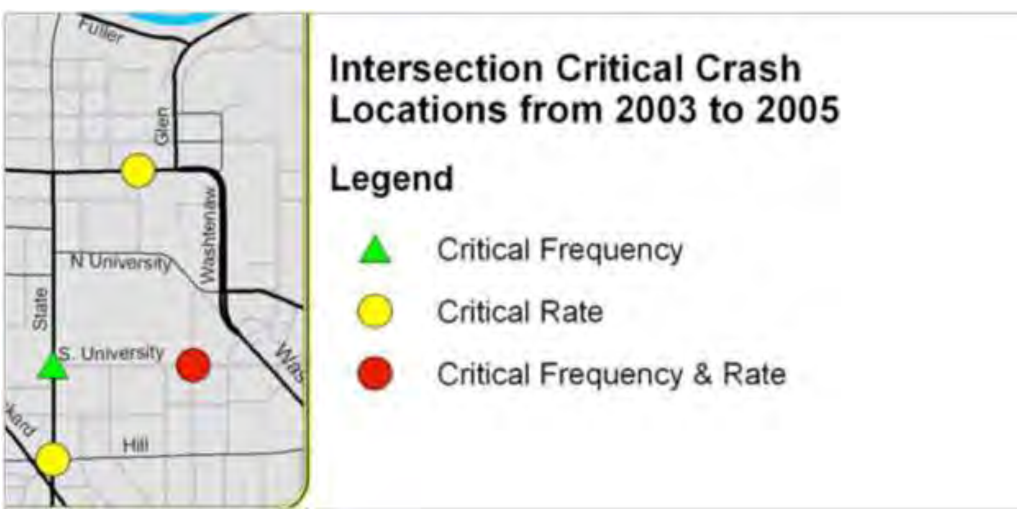


Figure 3-27 From 2003-5, South State experienced 21 crashes at South University and 57 at Hill, making it among the highest-crash corridors in the City. Church Street at South University saw 39 crashes.[xxxiv]

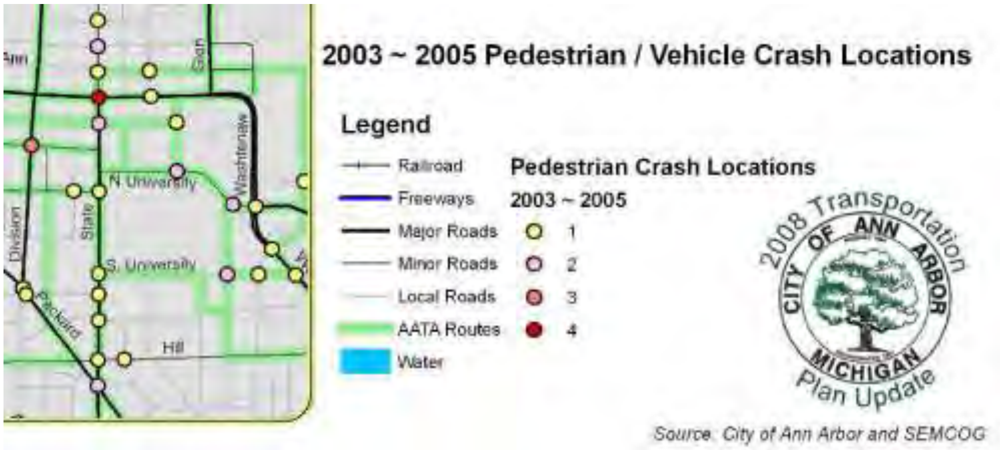


Figure 3-28 Despite their greater volumes, pedestrians remain vulnerable to automobiles on primary streets bisecting campus.[xxxv]

Peer institutions have successfully converted campus through streets into corridors for pedestrian travel, bicycle traffic, service vehicles, and local motor vehicle traffic. Similar action offers U-M an opportunity to enhance community safety and strengthen already robust pedestrian travel. As described above, the establishment of separated bicycle facilities would also reduce conflicts between bicyclists and pedestrians and allow for the creation of dismount zones protecting U-M's central pedestrian spaces from fast-moving vehicle traffic.

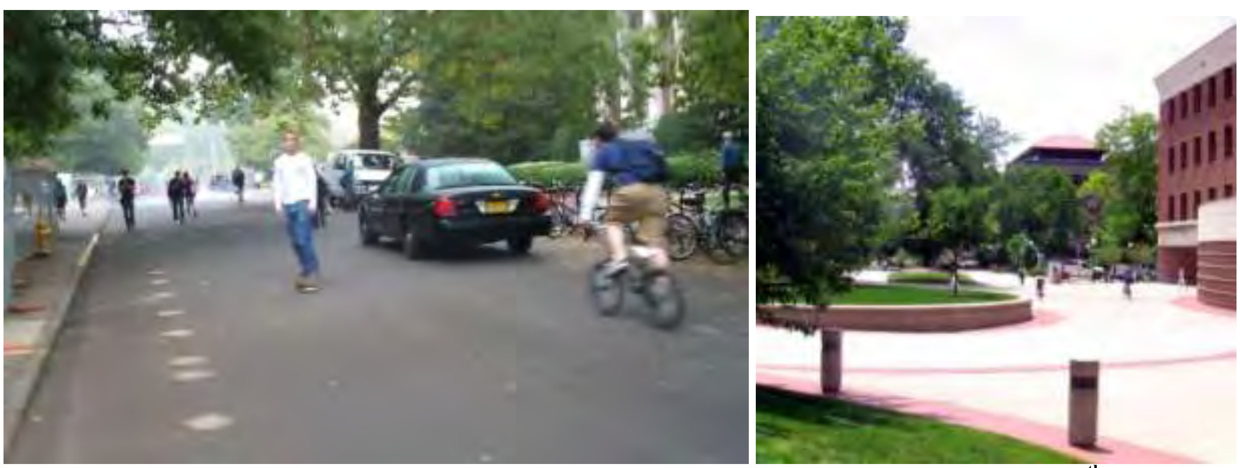


Figure 3-29 (Left) The University of Oregon in Eugene has restricted motor vehicle access on 13th Avenue to service vehicles and local traffic, turning a major through street into a "shared space" for pedestrians, bicyclists, service vehicles and local traffic. (Right) The former East University Street, now a pedestrian mall.

Figure 3-30. Diag. Pedestrians are the lifeblood of the U-M campus. Central pedestrian spaces would benefit from limitations on all types of vehicle traffic, including bicycles.

3.2.2.2.4 Crossings of Major Arterial Streets

U-M pedestrian travel would also be enhanced, and campus safety significantly improved, by improving crossings of major streets. Three high-speed, high-volume arterial streets merit particular attention for the hazards they pose to pedestrians on campus: Huron-Washtenaw, Plymouth, and Fuller. In cooperation with the City, U-M should review opportunities for safer crossing facilities to avert future pedestrian injuries and deaths.

Controlled by the Michigan Department of Transportation (MDOT), the Huron-Washtenaw portion of the I-94 –business loop" is engineered as a small urban freeway, creating a hazardous pedestrian environment bisecting the U-M campus. U-M has constructed two elevated pedways across the road. However, these fail to capture all pedestrian travel, and access from Central Campus to the student housing areas north of Huron remains especially problematic. Improvements to the existing crossings at Ingalls, Fletcher and Glen should be considered in cooperation with MDOT and the City.

Plymouth Road, the five-lane arterial dividing North Campus from retail and residential areas to the north, was in 2003 the scene of a pedestrian-car crash in which two U-M students were killed attempting to cross the road to campus.[xxxvi] Following the incident, U-M and the City cooperated to add two mid-block pedestrian crossing islands, install a new traffic light, and re-engineer pedestrian paths on Nixon between Bishop and Nixon. However, new private retail and residential development has increased pedestrian volumes near the Plymouth-Murfin intersection to the west, and a number of pedestrians now cross the road east and west of the signalized intersection crosswalk. To prevent a recurrence of the 2003 tragedy, U-M should consider partnering with the City to study pedestrian crossing patterns at the intersection and take appropriate action to facilitate safe crossings.

Fuller Road, the four-lane boulevard/ five-lane arterial connecting the North and Central campuses, also presents problems for pedestrians. It is likely that the shape of the roadway will eventually be transformed by a future high-capacity transit system. In the short term, however, U-M and the City should consider additional mid-block crossings near the parking lots east of Cedar Bend Drive. The intersection with East Medical Center Drive and Maiden Lane, near the hospitals, also requires a redesign to enhance pedestrian, bicycle, and transit circulation.

Figure 3-31 Pedestrian crossing Huron St. by U-M Bioscience Research Building.

3.2.2.2.5 *Building Design*

In concert with land use diversity and infrastructure, building design also affects the attractiveness of pedestrian travel, and U-M could consider means to promote pedestrian-friendly building frontage. Pedestrian traffic is significantly affected by building design. Frequently spaced doors connecting buildings to surrounding pedestrian networks are vital. Buildings with active exterior faces, including windows and all-day uses such as cafes, study spaces, and other conveniences, provide a more pleasant pedestrian environment during the day. At night, such active spaces are indispensable for comfortable pedestrian travel, since they provide ―eyes on the street” (or path) and correspondingly enhanced safety. The need for guaranteed rides and safe walking services for nighttime travelers could be reduced if U-M adopted policies encouraging active faces on buildings fronting major pedestrian circulation routes. In new construction, special attention might be given to maintaining pedestrian line-of-sight. Open spaces, easily visible from multiple angles, as opposed to cul-de-sacs and underpasses beneath buildings, do much to promote pedestrian comfort and safety at night.

Figure 3-32 Inactive building faces make pedestrian travel unpleasant, while active faces provide visual interest and enhance safety and comfort of pedestrians at night.

3.2.2.3 <u>Barriers to Implementation</u>

As with bicycle facilities, implementation of pedestrian facilities requires identifying funding. Short-term measures, such as sidewalks, require relatively little planning. Long-term diversification of land uses, by contrast, requires substantial planning but no additional capital investments. The current economy does not favor new real estate investments, and parking from non-University users would require further controls. Building design retrofits are necessarily carried out over the long term, with other major renovations. Street conversion and arterial crossings are a challenging task, requiring the full cooperation and consent of multiple stakeholders, including the City and Downtown Development Authority.

3.2.2.4 <u>Uncertainties</u>

The effect pedestrian improvements and land use diversification can have on pedestrian mode share is difficult to quantify. The timeline for multi-use land-use development is unknown, and much is contingent on national and state economic trends. Yet improving the safety, comfort, and attractiveness of pedestrian travel on U-M campuses can increase its attractiveness as a transportation option. The proliferation of food options at the Plymouth-Murfin intersection suggests the strong demand for pedestrian-accessible retail near North Campus. Surveys of the North Campus community could do much to suggest possibilities for enhancement.

3.2.3 Implementation Idea #3: Further Integrate Campus Transit

"I like taking the bus. It makes me feel like a real commuter." (Overheard on Central Campus)

Ann Arbor currently has two transit operators whose service is largely uncoordinated: the Ann Arbor Transportation Authority and the U-M. The goal of transit policy should be to provide seamless transit mobility both between the Ann Arbor campuses and between campus and the rest of Ann Arbor and Washtenaw County.

Improving efficiencies in existing alternative transportation is crucial to increased use. Transit planning should focus simultaneously on the problem of moving people between campuses and moving people from town to campus. This implies integrating town-to-campus movements with the high capacity corridor (AA Connector[xxxvii]) currently under consideration in the ―Connector Study" sponsored by U-M, the Ann Arbor Transportation Authority, and the Downtown Development Authority. Technologies that improve movement between town and campus (as well as intercampus travel) should be preferred over those primarily oriented towards shuttling passengers between campuses. A high-capacity busway could allow numerous lines throughout the AATA system to utilize the premier level of service such facility would offer, whether they use the entire facility or just segments. By contrast, rail based technologies will offer high-quality service along the corridor but will necessitate transfers to other destinations[xxxviii xxxix].

The U-M should also consider the best institutional design for achieving the goal of integrating intercampus transit movements with transit access between town and campus. Campus bus service got started at the University of Michigan before the founding of the Ann Arbor Transportation Authority. It may be that the two-system design is no longer optimal to serve the needs of transit users to the U-M campuses. Several universities have responded the challenge of integrating transit movements by engaging the municipal provider to provide campus service as well; this integration can lead to spillover benefits, as described below. This integration is consistent with the Washtenaw County Transit Master Plan, which in reference to the Connector states that ―[t]he service being studied would likely replace a number of existing U-M and TheRide bus services, and would encourage further integration of the two operators."[xl]

3.2.3.1 Costs and Benefits

Improving the effectiveness of public transit between town and campus can reduce the share drive-alone alone commuting to the U-M campuses (particularly in concert with other policies referred to in this report) and thereby the environmental impact of the U-M commutes. While the U-M is not a municipal transit provider, its decisions can significantly affect the efficiency of transit movement between town and campus. These decisions include the technology for the high-capacity corridor currently under study, and the extent of institutional transit integration between town and campus.

While transit provision is costly, the options that serve these goals best are not necessarily the costliest, and may entail cost savings. For example, the Ann Arbor Transportation Authority enjoys a significant capital subsidy from the Federal government for buses and the infrastructure needed to support them—a subsidy to which the U-M does not have access. Greater integration of service could imply Federal subsidy for transit infrastructure that is currently borne by the U-M alone. With regard to the high-capacity Connector corridor, bus rapid transit may be lower cost than the rail-based options and, by accommodating bus routes from other parts of Ann Arbor and Washtenaw County, can improve transit mobility throughout the system.

Increasing the appeal and usefulness of the U-M transit system should increase the relative share of public transportation in the U-M commute. More people in the transit system means buses run more full more of the time, which leads to less CO_2 emissions per passenger mile surpassing even car- and vanpools. Since city transit systems have access to federal transportation funding, the extra expense the positive effect on emissions could be increased further simply through continued funding for hybrid and fuel cell buses (see Energy Section). U-M has purchased hybrid buses this year through the Clean Air Coalition funding but only covers these particular purchases.[xli] City-campus integration would allow regular federal funding for expanding hybrid bus passenger miles further reducing CO_2 per passenger mile by 30%[xlii].

Furthermore, reputational benefits could be gained in marketing the integration plan by demonstrating the sustainability benefits mentioned above. AATA and U-M integration would also aid in funding a high capacity transit route in Ann Arbor and across U-M. Integration will make AATA much larger and more eligible for increased federal funding for a high capacity transit route. The similar ridership volumes of AATA and U-M means U-M will have a key role to play in the planning but the economic success of any high capacity transit in Ann Arbor will depend on both AATA and U-M benefiting.

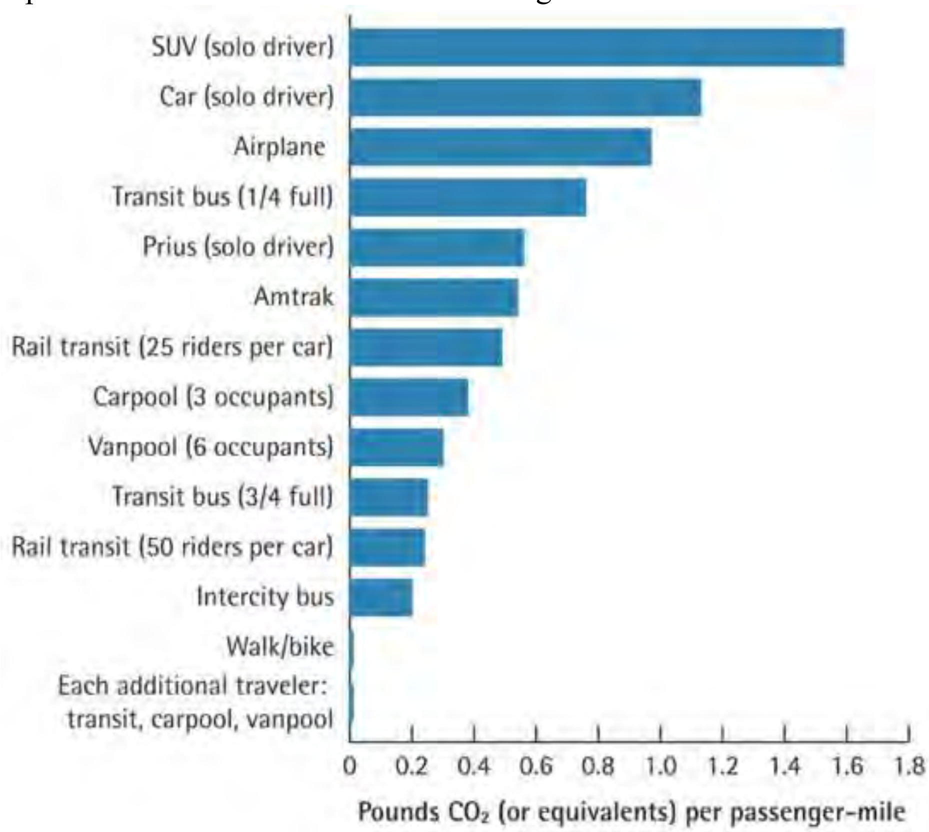


Figure 3-33 Different modes of transportation incur different amounts of emissions per passenger-mile with walking and biking the best and a full transit bus being one of the lease impactful per passenger-mile. (Source: Sight Line Institute)[xliii]

3.2.3.2 Technical Guidance

Improvements in transportation efficiency may be found in combining campus and city systems, perhaps working as a single provider. A transportation planning study points out at the University of Colorado: ―students have very different schedules than the working public. Most student trips do not take place during peak hours, so adding students to the system does not force the transit provider to put additional buses on the road. Instead, students fill buses that otherwise are well below capacity during off peak hours. Thus, a substantial number of student riders can be absorbed at no cost to the provider, while helping with transit agencies' biggest PR problem- empty buses during off peak hours."[xliv] Figure 3-38 shows the average ridership by hour, indicating that this may also be true in Ann Arbor. U-M buses reach their peak at nine and eleven in the morning and continue throughout the day. AATA experiences a peak at eight in the morning and dips in the later morning and early afternoon.

Two peer universities should be referred to in any future analysis of integration: the University of Wisconsin-Madison (UWM) and Michigan State University (MSU). Both schools place in their hometowns is similar to that of U-M, in that they are major economic contributors and represent a large portion of local transit ridership. UWM represents an example of sustained transit system use since Madison Metro/its predecessor was founded before a university system was needed, while MSU could provide many lessons in the smooth transition from a university-run system to a wholly city transit-run system.

The University of Wisconsin-Madison has boasted a city-integrated system maintained for over thirty years. The city buses are run by Madison Metro (a utility of the city) and, therefore, receive a mix of local/state/federal transit funding and fare-box revenue. The University is a major employer in the area, so these routes are well used and very productive for Madison Metro. The current integrated system pass for each UWM community member is currently valued at about $660 per year[xlv], which upon further investigation shows that varying levels of subsidy are used to fund the ‗free-to-rider' integrated system. UWM is a model to look to for after integration and a comparison in the planning improvements over their system.

The Associated Students of Madison (ASM, student government) provides ―free" bus passes to students, Transportation Services provides ―free" passes to employees of the university, and the UW Hospital (also located on campus) provides ―free" bus passes to their employees. The ASM pass is paid for with student fees ($53.76/student). The Transportation Services pass is paid for with parking revenue while the UW Hospital pass is paid for by hospital revenue.[xlvi] Furthermore, the UWM ―campus" bus is paid for 50% from parking revenue and a little less than 50% by student fees. A small percentage is also paid by housing to run a peak express bus to family student housing. Similar distributed transit funding could encourage various U-M departments to more fully utilize services available but this requires further study to finalize. Information gained from UWM, MSU and a pilot program at U-M will make clear the cost or savings associated with an integrated system vs. the current system at U-M.

Peak times are often over capacity. Currently the system handles about 1.5 million rides per year on the five campus-bus routes from the 42,000 students and the UWM+UWM Hospital employees take a little over a million (roughly 17,000 UWM + 3,500 UWM Hosp employees). These ridership levels are also growing every year. Approximately fifteen percent of both students and UWM employees take the bus to campus daily but only eight percent of the hospital employees. Furthermore, the employee pass program may be unsustainable, currently, however, and the university is anticipating the need for a nominal fee for the passes, perhaps $50-$150.

We have presented this information to inform decisions made on transit integration on the strategies and concerns present at peer institutions.

The benefits of a single system serving both town and campus are evident from the Madison route map. Some of the routes serving the campus corridors also extend into the city as shown in Figure 3-34. Routes 11, 27, 28, 38 and 44 should be specially noted because they serve both major on-campus and off-campus transit traffic. By contrast, U-M campus routes serve campus

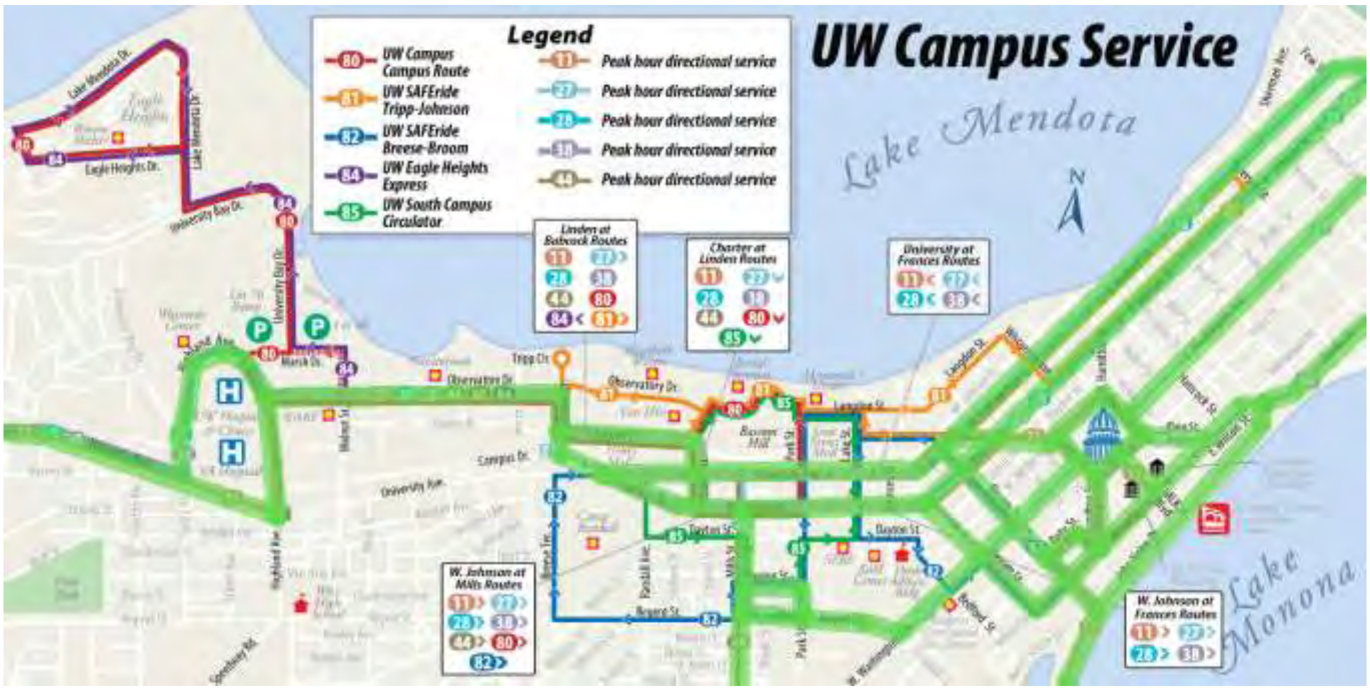


Figure 3-34 Current UWM / Madison Metro service map. Green highlights all routes that pass through campus and city. All routes numbered in the 80s are dedicated campus routes but all other routes on the map extend into the City of Madison, Wisconsin.[xlvii]

territory nearly exclusively (Figure 3-25) thus reducing the potential for transfer-free through movements.

While UWM shows the continued successful of an integrated system, MSU could serve as an example how to make the transition. In August 1999, the Capital Area Transportation Authority (CATA) in East Lansing, Michigan began a regional partnership with Michigan State University, which integrated bus services in the MSU community, East Lansing and Meridian Township. CATA offers all-campus fixed route bus service 24-hour service during the fall and spring semesters in addition to greater Lansing area.[xlviii]

The switchover significantly increased CATA's boardings, trips and passenger miles (Figure 3-35). The process involved a lot of stakeholder engagement including how to appropriately transform union university drivers to city drivers (student drivers were let go). Table **0-1** in the Appendix goes into specific detail of the changes before and after the integration. Figure 3-36 shows how some of the campus routes were integrated into the larger CATA system and expanded service within the campus.

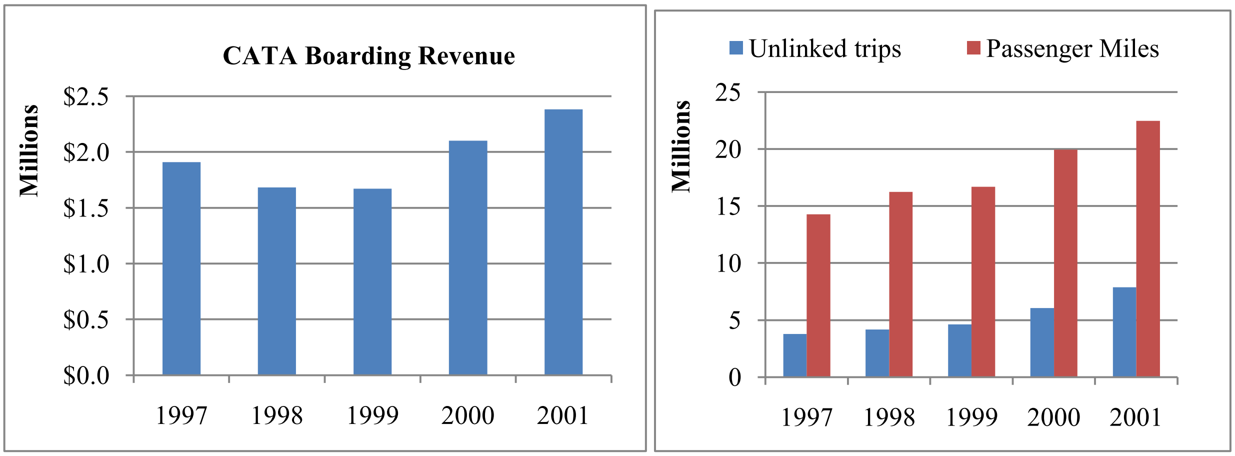


Figure 3-35 Michigan State University Integration occurred in 1999. Integration of MSU campus bus routes into CATA system is shown here with both fares and passenger use; both increased significantly.[xlix]

The experience of these two peer universities and the fact that several other peer institutions use city transit partnerships suggests that there could be major benefits for further integrating AATA and U-M routes. Currently, the MRide program provides good transit access for the U-M community but the transportation team envisions improved economic, environmental and social sustainability through further integration. Figure 3-37 shows both AATA and U-M bus routes. Notably, the overall routes overlap significantly, with multiple buses running along parts of Ann Arbor. In some cases multiple lines serving overlapping segments are needed; in other cases there may be foregone potential for system integration to support seamless transit mobility between town and campus.

Considering both Figure 3-36 and Figure 3-37, the overlap of AATA and U-M buses is even greater than MSU on-campus suggesting there may be many opportunities for combining routes in order to provider higher ridership per bus. Furthermore, taking ridership patterns into account, as shown in Figure 3-38, some bus routes could see a more stable utilization across an average day. Greater utilization across more hours of the day also means greater carbon dioxide and other emissions savings per passenger-mile.

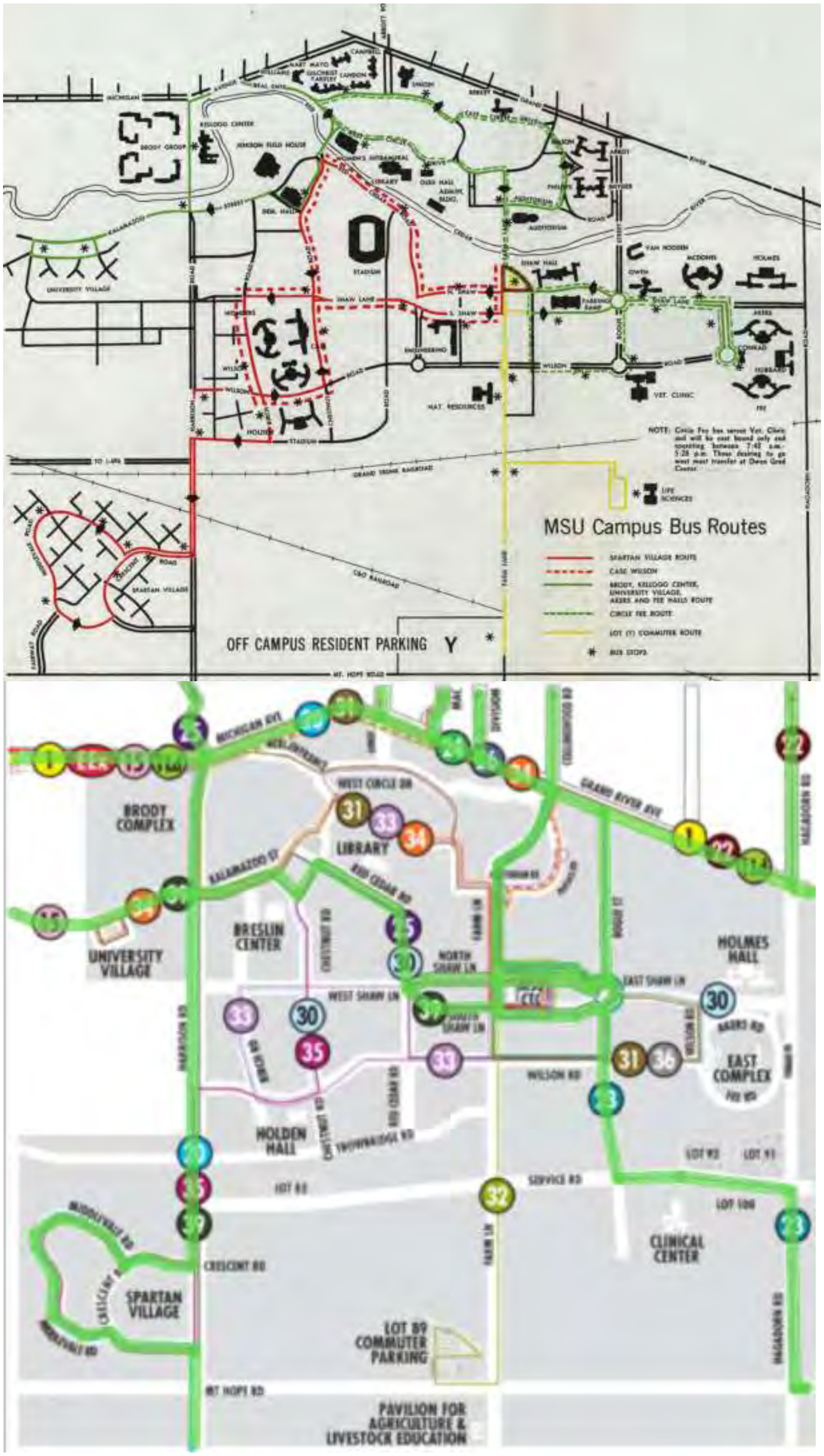


Figure 3-36 MSU transit pre- and post-integration. Green highlights show CATA lines that continue off campus.

Note: MSU-routes are 30-39 and CATA/MSU routes are 1-29. Spartan Village/ Case Wilson Routes split and gained coverage in 30, 35 & 39; Brody Route split among 34 & 39; Circle Fee Route expanded by 31, 33, 36; Lot Y Commuter Route covered by 32.

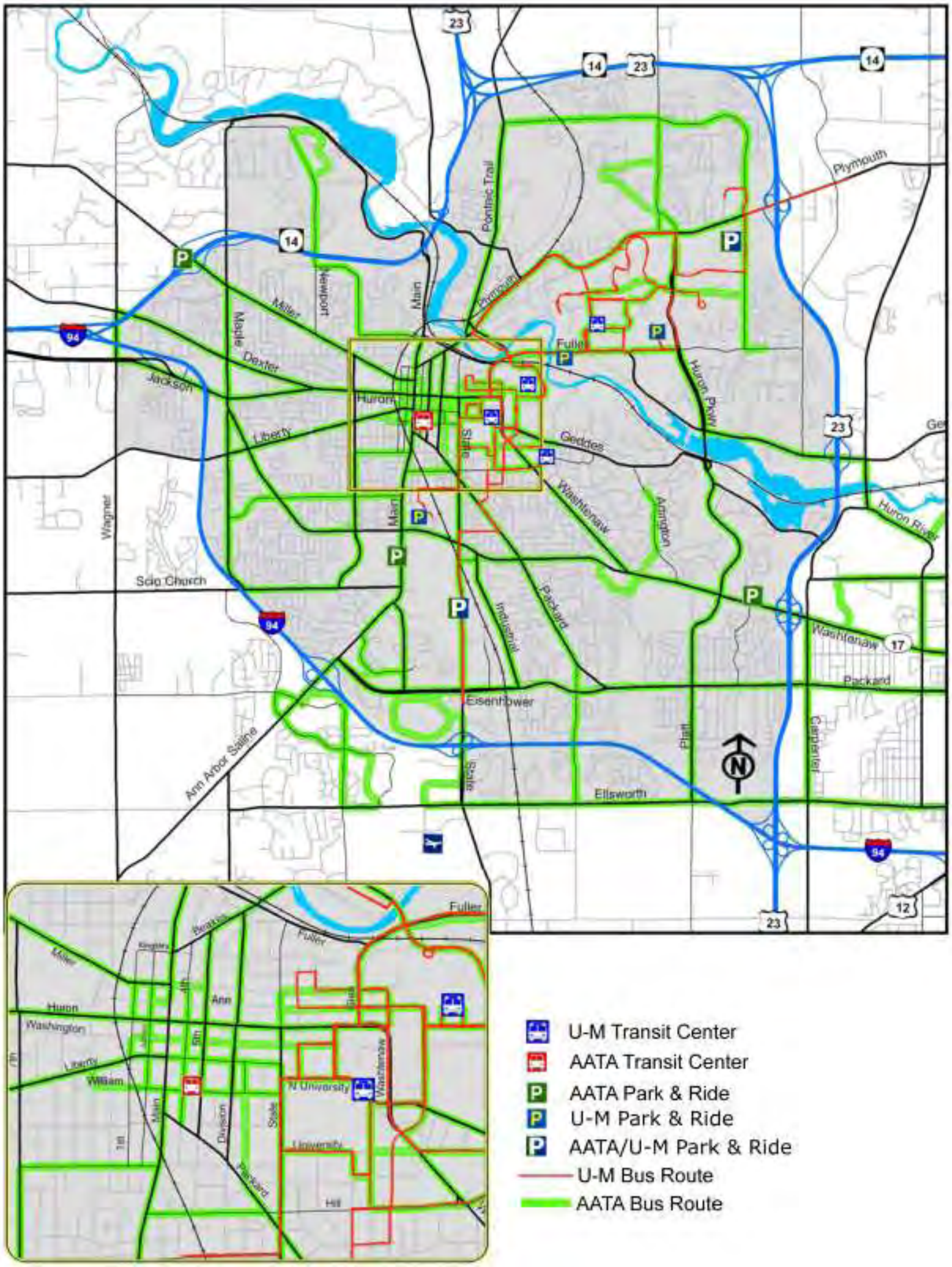


Figure 3-37 Map depicting both AATA and U-M bus routes along with Transit Centers and Park & Ride lots.[1] Notably, the routes overlap significantly. Most importantly, Medical Campus routes overlay AATA routes for a major of their run.

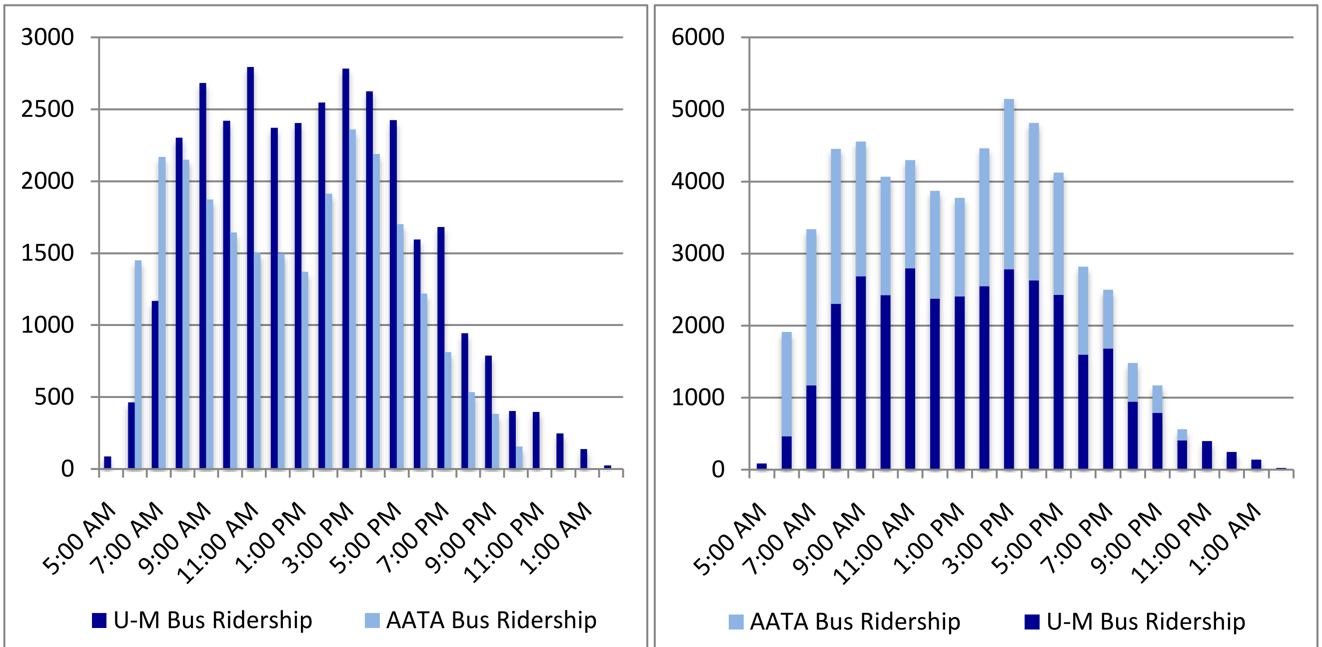


Figure 3-38 (Left) U-M bus[li] vs. AATA bus average ridership by hour[lii, liii] (Right) Estimated integrated U-M bus/AATA bus average ridership by hour

Pilot AATA, U-M transit integration on one route by 2013

Routes with especially low ridership and AATA overlap could be targeted to pilot AATA integration. The Mitchell-Glazier route meets these requirements; therefore, some amount of discussions should be arranged with Chris White at AATA. Discussions would address how AATA would best integrate the stops and traffic into their network without compromising rider experience for either hospital or AATA riders.

Fully integrate U-M transit into AATA (time frame based on pilot programs)

Change low ridership lines to AATA to increase route ridership and integrate on campus routes to go further into the community minimizing transfers during commutes. Considering the routes and current utilization of buses, U-M routes such as the Commuter North/South, North Campus, KMS, Mitchell-Glazier and Intercampus[liv] could all be incorporated into the AATA system with only minor adjustments to current AATA routes along those paths (further study will be needed with information gained from a survey like that in Section 3.3). Other U-M routes would need to remain on-campus-only loops due to rider saturation for those routes. To accomplish this transition, Parking and Transportation Services and AATA Service Development would need to work together to develop a comprehensive plan including route development, employee transition, bus transition, stakeholder engagement and marketing to make this plan work. Some general MSU transition points are listed in Table **0-1**, which should be considered in conjunction with lessons learned in a pilot program.

3.2.3.3 Barriers to Implementation

University of Michigan's current shuttle system functions fairly well, therefore, changing a system that does not seem to be broken may be seen as problematic. However, if the goal is reduce automobile miles traveled and congestion on campus, then a more seamless system between campus and city will allow and encourage transit utilization through convenience, federal funding and economies of scale. Furthermore, there remains possibility for union opposition to the switch over. The U-M hospital system pays for their shuttles between medical campuses; these are lightly used but demanded by the U-M health system.[lv] Some attempts were made by the health system to offer cabs, van-rides, etc. for trips between medical campuses but hospital staff opposed any moves to eliminate the dedicated health system bus routes despite unsustainably low ridership levels.[lvi]

3.2.3.4 Uncertainties

Both MSU and UWM represent analogous situations to that in Ann Arbor in that they are major contributors to the economy of their home cities and constitute a major portion of the transit use. However, the University of Michigan is a much bigger institution with higher ridership than either. Therefore, some uncertainty exists regarding total costs and benefits, and what routes would be most advantageously combined or eliminated to streamline traffic in those areas. However, other peer institutions schools (Table 3-5) regularly integrate their transit needs into the broader transit system for a variety of reasons including economies of scale and smoother connections to the city and other transport options such as the airport (Section 0 Implementation Idea #5: Simplify Campus-Airport Transportation). Furthermore, the MSU example suggests that integration can carry payoffs in terms increased use of transit system-wide.

Table 3-5 A list of U-M peer institutions that use public transit as primary campus-to-campus and campus-to-city connection, all other peer institutions have in-house services.

Peer University	Campus Transit System
University of Chicago	CTA + Limited Campus service between downtown & main campuses
Cornell University	Tompkins Consolidated Area Transit
Michigan State University	Capital Area Transit Authority
University of North Carolina at Chapel Hill	Chapel Hill Transit
New York University	Metro + Med Campus Shuttle
University of Wisconsin-Madison	Madison Metro

3.2.4 Implementation Idea #5: Simplify Campus-Airport Transportation

The generation of vehicle miles travelled and greenhouse gas emissions related to U-M are not limited to the geographic boundaries of campus. Students, faculty, staff, and potential students travel to and from campus. In Southeast Michigan, no comprehensive regional mass transit authority exists, and currently, there is no transit link from U-M to the Detroit Metro Airport (DTW).

Establish a direct campus or downtown to airport link by 2014

The University of Michigan has an opportunity currently to work with local and regional transit providers to enable an affordable, convenient link to Detroit Metro Airport via mass transportation. This is needed to bring the University of Michigan up to a regional transit baseline met by a large majority of its competitor institutions: a public transportation link between the campus and the metropolitan airport (Table 3-6). Out-of-state students are frequent airport users; easy transit connections between airport and campus can send them a message of welcome, particularly during crucial exploratory visits to campus. The proximity of a major international hub airport significantly raises the accessibility of the University of Michigan to the out-of-state student; improved campus-airport transit connections could fill in the missing link.

AATA is currently considering service between Ann Arbor and Detroit Metropolitan Airport (DTW), and is in discussion with Michigan Flyer, a private company that currently provides eight roundtrips daily between the south end of Ann Arbor and DTW for possible expansion of service. U-M could become a key player in these discussions, extending current MRide privileges to university travelers to the airport, and influencing the location and frequency of any future airport service.

3.2.4.1 Costs and Benefits

While plane flights contribute significant greenhouse gas emissions (Figure 3-33), it is important to recognize that members of the U-M community (particularly faculty on business travel and out-of-state students) will travel via plane so long as it is an economically cheap, and fast way to travel long distances. In the meantime, the lack of a transit link from U-M to DTW must be addressed.

AATA has estimated the costs of running an airport service to be roughly $1.6 million annually.[lvii] This estimate is for a service that would run by AATA with hourly frequency from 2 a.m. through 10 p.m. daily; however, it is also possible that AATA would instead choose to offer the service via subcontract with Michigan Flyer, a private operator that is currently providing airport service from the south end of Ann Arbor. Because U-M would not be the provider of the service, capital costs would likely be minimal. If the University of Michigan, however, became the primary user of such a service, it would likely be responsible for a large portion of the operating costs, but it would also reap substantial benefits.

Compared to existing service offered by Michigan Flyer, a service born from cooperation between the University and AATA, and possibly run by Michigan Flyer, would increase the daily frequency from 8 to 18 trips. The integrated service would likely have multiple stops in Ann Arbor, whereas the Michigan Flyer currently stops only at Wolverine Tower. Increased frequency combined with more stop locations greatly improves convenience of motorcoach transportation. If students, faculty, and visitors to the University were able to more quickly and more easily access a transit link between campus and Detroit Metro Airport, they would be more likely to choose mass transit over taxis and private vehicles. For each rider that chooses public transportation, traffic congestion on and around campus will be reduced and aggregate vehicle miles travelled will decrease. Emissions related to travel between campus and the airport would be greatly reduced, representing an improvement to climate health.

Despite the financial costs of partial support for an airport transit link, working with local and regional entities to establish transit between Ann Arbor and Detroit Metro Airport would also offer the University the potential for cost savings. A bulk buy agreement would reduce the marginal cost of round-trip University ridership to $0. If volumes were high enough, the averaged fixed costs of a bulk buy could become less than the existing marginal costs of reimbursing a faculty member for a taxi ride ($49 round-trip[lvii]) or a private vehicle trip (50 cents per mile[lviii] plus at least $8 per day for parking[lix]) to the airport when faculty are travelling on University business.

Increased promotion of campus-airport transit by 2012
The community would also see spillover benefits from this service. U-M would be able to promote community awareness regarding mass transportation through its actions. An integrated airport service would benefit not only University traffic, but also citizens of Ann Arbor who are unaffiliated with U-M that use the service. When compared to its peer institutions, U-M falls behind in airport transit. The majority of U-M's peer institutions are accessible from the airport via some form of mass transportation, and a significant portion of these schools promote these easy-to-use transit links on admissions and recruiting webpages (

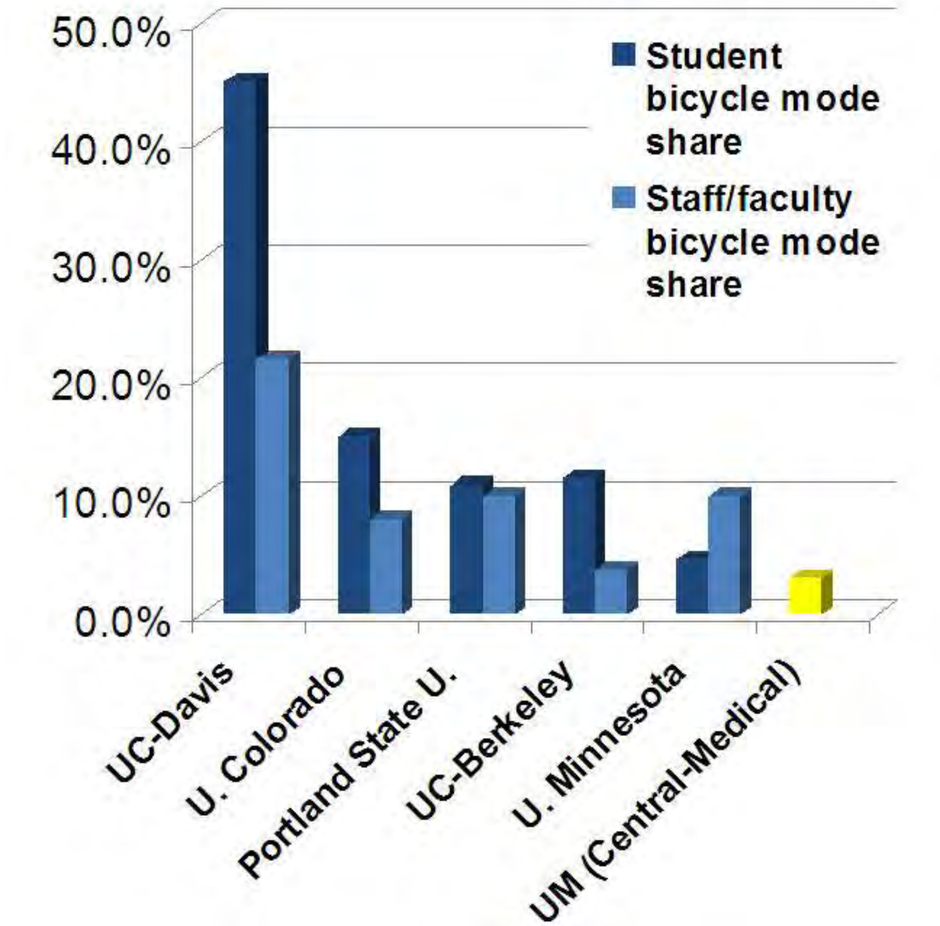


Figure 3-6). Taking the lead on creating a seamless, popular transit route between campus and the airport would also provide U-M a reputational benefit. Reductions in cost, vehicle miles travelled, and carbon emissions will benefit not only U-M and its visitors, but also Ann Arbor at large.

3.2.4.2 Technical Guidance

Establish a direct campus or downtown to airport link by 2014
The MSA airBus has proven to be a success among students travelling to the airport before breaks. Annual ridership rose from 2663 in 2002-03 to 11,659 in 2006-07 as services were extended and operational procedures were improved.[lx] The airBus has proven to be effective at marketing and informing students about the services it offers. In addition, the operations of airBus have incorporated cooperation with the Michigan Union Ticket Office (MUTO) for

ticketing and Student Financial Operations (SFO) for charging fares to student accounts. This cooperation among various units makes the experience for the airBus's customer base more convenient and serves as a model for streamlined operations that promote convenient, affordable transit for students.

Integrate a U-M to airport link into U-M transit

The University of Michigan already has experience with successful mass transit systems. The MRide program is an existing contract between U-M and AATA, which allows faculty, staff, and students to ride on fixed-route AATA buses free by showing a valid MCard. The $1.8 million per year contract is funded both by U-M and by federal funds U-M earns through transit operations.[lxi] This relationship has proven to be mutually beneficial for U-M and the City of Ann Arbor, as U-M affiliates are given free access to local transit and AATA saw increased ridership, which reduces the parking demand, congestion, and pollution related to motor vehicle traffic. Much like MRide, U-M's position as an anchor tenant of an airport service could provide to be a mutually beneficial relationship.

Table 3-6 Comparison of top universities' connections to airport through transit options. Criteria: Airport Mass Transit Exists is defined affirmatively only when a mass transit system is in place that allows members of the respective schools' communities to travel from a nearby or major airport without having to transfer into a different transit system. Transit listed on U website is defined affirmatively if mass transit exists and it is promoted as a way to travel to or visit on prospective student or admissions webpages.

Rank[lxii]	School	Location	Airport Mass Transit Exists	Transit on U website	Comments
1.	Harvard University	Cambridge, MA	Yes	Yes	Served by subway from Logan Airport and from South Station for $2 fare.
2.	Princeton University	Princeton, NJ	Yes	Yes	NJTransit/Amtrak trains can take visitors from Newark Airport to Princeton.
3.	Yale University	New Haven, CT	Yes	Yes	CT Transit bus service G-Route stops at Tweed-New Haven Airport and stops downtown within walking distance of the Yale campus.
4.	Columbia University	New York, NY	Yes	Yes	M60 bus route from LaGuardia goes to campus for $2.
5.	Stanford University	Stanford, CA	Yes	Yes	Caltrain connects Stanford to airports in San Jose & San Francisco
5.	University of Pennsylvania	Philadelphia, PA	Yes	Yes	SEPTA Airport Line Regional Rail stops the University City Station
7.	California Institute of Technology	Pasadena, CA	Yes	Yes	Flyaway bus service from LAX to Union Station in downtown LA. Then requires a light rail transfer and then another transfer to a bus. Shuttle vans from LAX.
7.	Massachusetts Institute of Technology	Cambridge, MA	Yes	Yes	Can get from Logan Airport to MIT by using MBTA subways and/or buses.

9.	Dartmouth College	Hanover, NH	No	N/A	Rental cars & car service only.
9.	Duke University	Durham, NC	Yes	No	Triangle Transit offers bus service from Raleigh-Durham Airport to Duke.
9.	University of Chicago	Chicago, IL	Yes	Yes	Access from Midway & O'Hare to downtown Chicago via train, bus, or shuttle.
12.	Northwestern University	Evanston, IL	Yes	Yes	Service from Midway & O'Hare to campus via the El. O'Hare also enables bus service.
13.	Johns Hopkins University	Baltimore, MD	Yes	Yes	Many public transportation links listed for visitors. Link to MTA allows trip planning, which yields a trip to campus from BWI via light rail and subway.
13.	Washington University in St. Louis	St. Louis, MO	Yes	Yes	MetroLink provides access from Lambert-St. Louis International Airport to campus.
15.	Brown University	Providence, RI	No	N/A	RIPTA bus from TF Green Airport stops several blocks away from campus, and Peter Pan motorcoach from Logan Airport stops several blocks away from campus as well. Not within walking distance for people carrying luggage.
15.	Cornell University	Ithaca, NY	No	N/A	Airport taxi & limousine services only.
17.	Rice University	Houston, TX	Yes	No	Rice recommends using a van service or renting a car. There is Metro bus service from George Bush Intercontinental Airport to campus (1 transfer), but the journey takes 90 minutes to go about 24 miles.
17.	Vanderbilt University	Nashville, TN	Yes	No	Nashville MTA bus routes go to Vanderbilt with one transfer. Driving directions only on VU website.
19.	University of Notre Dame	South Bend, IN	No	N/A	Taxi & rental car only from South Bend Airport. Bus only from O'Hare.
20.	Emory University	Atlanta, GA	Yes	Yes	Train from airport to MARTA, transfer to bus.
22.	University of California – Berkeley	Berkeley, CA	Yes	Yes	BART system allows visitors to get to campus from Oakland International Airport.
25.	University of California – Los Angeles	Los Angeles, CA	Yes	No	Big Blue Bus routes serve LAX and UCLA, but University website directs visitors to drive and take the 405 from LAX. Bus routes with service to UCLA are listed, but not in a visitor-friendly manner.
25.	University of Virginia	Charlottesville, VA	No	N/A	Van services and taxis only from Charlottesville Airport. Driving directions heavily promoted.
29.	University of Michigan	Ann Arbor, MI	No	No	Michigan Flyer offers bus service from DTW, but Ann Arbor stop is out of walking distance

					to campus. Requires transfer to AATA Route 36, which only operates on weekdays. A link to this service is hidden on the Campus Information Centers website.
30.	University of North Carolina	Chapel Hill, NC	Yes	No	Triangle Transit offers passage with one transfer from Raleigh-Durham International Airport, but visitor websites only offer driving directions.
33.	New York University	New York, NY	Yes	Yes	From any of NY's major airports, campus is accessible via routes utilizing bus and subway.
45.	University of Texas	Austin, TX	Yes	Yes	Capital Metro Airport Shuttle route runs between campus and Austin-Bergstrom International Airport.
45.	University of Wisconsin	Madison, WI	Yes	No	Metro Transit bus routes service Dane County Regional Airport and UW-Madison campus. Coach USA offers 10x/day service between O'Hare Airport and Madison.
56.	University of Maryland	College Park, MD	Yes	Yes	Itinerary and fare information listed for visitors arriving via Reagan National, BWI, and Dulles Airports.
64.	University of Minnesota	Minneapolis, MN	Yes	No	Driving directions only promoted; Minneapolis Hiawatha Light Rail and bus system provide transit from MPS Airport to campus.

3.2.4.3 Barriers to Implementation

Having convenient, affordable mass transportation to Detroit Metro Airport will likely require an agreement that includes AATA, Michigan Flyer, Indian Trails, and U-M. Cooperation and negotiation must be undertaken by each of these entities if this frequent transit link is to come to fruition.

Additionally, a culture that favors the convenience of taxis and private vehicles for airport transportation exists on campus. For airport transit to be successful, community support will be required as there may be come economic impacts to the local community vendors such (taxis, etc.) and as U-M seeks to eliminate another $120 million in spending by 2017[lxiii], faculty taking stake in airport service becomes even more critical. There is a potential for cost savings to U-M if faculty travelling on business use this service in lieu of private vehicles and taxi rides, but if the service is implemented and faculty continue to be reimbursed for private vehicle trips to Detroit Metro, the financial costs of transportation to U-M will only increase.

3.2.4.4 Uncertainties

The actual financial cost of operating an 18-trip-daily airport mass transportation link is unknown. AATA's $1.8 million per annum represents a rough estimate. If this figure is close to the actual costs, how the service would be funded is uncertain. U-M would likely be responsible for a large portion of these costs, but the size of this portion is unknown, as is the method used to determine U-M's share of the costs (e.g. bulk buy or unlimited access agreement versus per-use reimbursement).

Additionally, a projected ridership for this service is unknown. Michigan Flyer reports that approximately 27.5 passengers use their existing service between Ann Arbor and the airport daily.[lvii] Increased frequency and better location would likely increase ridership, but a significant increase in ridership would be required for financial sustainability. The extent to which U-M faculty and staff would be willing to use this service for business travel is a critical but unknown piece of information.

A route featuring stops pleasing to both the clientele of both AATA and U-M must be developed before airport transit is implemented. The route must make multiple stops within Ann Arbor, and at least one of these stops should have accommodations for park and ride customers. Where the best stop locations are and how passengers could be accommodated at these locations remain undetermined.

3.2.5 Implementation Idea #4: Unify Goods Movement

The movement of goods at the University of Michigan is currently a decentralized system. Each individual unit within U-M determines how best to procure courier services or how personnel should handle needs to move parcels and letters around campus. The result is a system that in aggregate consists of dozens of parallel efforts. The University of Michigan should create a consolidated courier service operated by Mail Services. A centralized service would be accessible to all units, and would have the potential to create an enormous gain in efficiency of money and resources.

3.2.5.1 Costs and Benefits

Under the current, by-unit system, redundancies in personnel and equipment (mainly vehicles) are created. A consolidated service would remove these redundancies, saving U-M money in aggregate. Because one entity would be responsible for the needs of the entire campus, it would create economies of scale, thus decreasing operating costs; these savings could be passed down to various departments and units that previously used decentralized courier services. Additionally, departments would not be forced to make the decision of whether to engage courier services in general, but rather whether they need courier services on a per-parcel or per-letter basis. (An important distinction, as a department that already has leased a vehicle solely or largely for meeting courier needs then becomes more likely to use this vehicle to deliver its mail, adding to the total vehicle miles travelled on campus.)

When each department is using its own courier, there is no coordination with the courier practices of other units. Rather than having one unit handle the courier needs for the entire campus, each department instead sends an individual or hires a service for its needs, which constitute only a small proportion of the aggregate need of U-M. Thus, couriers who are working under different employers create redundant trips and extra VMT. A consolidated service would end this lack of coordination, thus reducing vehicle miles travelled and traffic volumes (and emissions) related to mail and courier services on campus. Vehicles currently leased for courier services on campus could also be repurposed for academic uses, lowering the opportunity cost of courier services, and reducing the materials footprint of courier transactions on campus.

Departments that currently operate without a dedicated courier could also see rises in staff efficiencies. Sending a staff member out with the sole task of delivering one item fails to employ the synergies or multitasking that would be practiced by a consolidated campus service. Instead, the campus service could pick the item up and deliver it, eliminating the need to send the staff member out to deliver the item.

3.2.5.2 Technical Guidance

Existing Campus Mail services already delivers over 10,000 pieces of campus mail daily.[lxiv] Parcels delivered to campus addresses via USPS are also routed through Mail Services' sorting facility, which reduces the amount of traffic on campus by eliminating the need for USPS drivers to deliver parcels throughout campus.

Establish the level of current courier-use by 2012.

Campus Mail could carry out a survey of departments to assess the total need for courier services. Taking this information an appropriately sized program could be put in place. The survey would also inform the level a savings or efficiencies to be gained.

Integrate courier service into campus mail service by 2015

While significant changes would have to be made to the operations of Mail Services, particularly in the area of prioritizing and sorting mail by time sensitivity, Mail Services is currently the best equipped entity to handle a consolidated courier service because of its existing sorting facility and experience coordinating campus deliveries. For general mail delivery, software has been used to ensure that current delivery practices and routes are efficient, and the same principle could be applied to courier services. Many detailed decisions on building an integrated courier service will need to be based on the courier survey mentioned above.

3.2.5.3 Barriers to Implementation

Mail Services would have to expand beyond centralized service for general mail into the field of immediate-need courier services. There would likely be initial investment costs related to building new capacity and expertise for Mail Services. New software and personnel that are not needed for centralized mail delivery may be required for courier delivery.

Additionally, without a widely distributed survey with a high return rate among department heads, it is difficult to assess the volume of courier services that are currently used on campus. The shared courier service would have to meet the needs of the diverse units at U-M and be more cost efficient when compared with third party vendors or hired work study students to be widely adopted by U-M departments, as mandates are not politically feasible.

3.2.5.4 Uncertainties

The reality of what currently occurs on campus is unknown. Detailed information regarding courier uses and needs would be required to model an effective system, but this information does not currently exist, thus, information gathering will be critical to planning a shared service, as the needs of different departments regarding time sensitivity of shipments and final destinations must be determined. U-M current mail service could be modified to allow for in-house courier services but further investigation of departmental expenditures will be needed to determine a payback period for this project, though once running, a centralized service would almost assuredly decrease operating costs and traffic on campus when compared to the current decentralized systems.

3.3 Prioritized Recommendation C: Track Transportation Habits of Campus Stakeholders

Effective transportation system planning requires data on transportation patterns and trends. Despite the magnitude of the transportation system it operates, U-M does not regularly collect information on community members' transportation patterns, making the task of planning difficult. Examples from peer institutions suggest how an annual or biennial U-M transportation survey might be conducted, enabling data-driven planning and significant cost savings.

3.3.1 Benefits and Costs

U-M's regularly updated sources of transportation data consist primarily of parking system utilization data and the U.S. Census. As a result, limited information exists on student, faculty or staff ―mode split," the proportionate use of different means of transportation. In addition, information on trip origins exists only at the county level. The result is that U-M has limited knowledge on where community members are commuting from and how they are commuting. U-M's transportation expenditures are significant long-term investments in fixed physical infrastructure, so transportation system development conducted with limited knowledge of current and future trends comes at a heavy cost. A regular transportation survey could avert tens of millions of dollars in unnecessary spending at a minimal cost.

3.3.2 Technical Guidance

An annual or biannual community survey would provide an invaluable aid for charting U-M transportation trends. At peer institutions, these surveys are typically administered over e-mail by the university transportation and parking department, sometimes in conjunction with academic units in the transportation field. A graduate student conducts the University of California at Davis campus travel survey.[lxv] At U-M, such a partnership would likely involve Parking and Transportation Services (PTS) and the Taubman School of Architecture and Urban Planning, and/or U-M Transportation Research Institute (UMTRI). A random sample of students, faculty and staff would be required. At Portland State University, separate biannual surveys of students and faculty/staff are conducted in alternating years.[lxvi] Commute surveys can also be combined with other surveys, as in the University of California at Berkeley's transportation and housing survey.[lxvii]

The two most critical survey areas are trip-to-campus mode and trip origin (residence address). Together, these make possible a detailed analysis of community transportation patterns. To capture the rationale for existing patterns, and facilitate a shift to more sustainable transportation modes, additional questions on the reasons for mode choice would be useful as well. A U-M graduate student under the supervision of faculty and staff would perform appropriate analysis of results. Past surveys from the University of California-Davis, Michigan State University, and Portland State University can provide more detailed guidance. A sample of potential survey questions is provided below. Additional questions specific to the U-M parking system might be useful as well.

<u>Sample Transportation Survey</u>

1. How far is your residence from your major place of work or class on campus?
   (less than 0.5 miles, 0.5-1 miles, 1-1.5 miles, 1.5-2 miles, 2-3 miles, 3-5 miles, etc.)
2. What was your major means of transportation *to campus* each day *last week*?
   (live on campus, drove alone, motorcycled, was dropped off, carpool, U-M bus, AATA bus, bicycled, walked, used U-M park and ride, used AATA park and ride, other)
3. What was your major means of transportation *on campus* each day *last week*?
   (drove alone, motorcycled, was dropped off, carpool, U-M bus, AATA bus, bicycled, walked, used U-M park and ride, used AATA park and ride, other)
4. By *term* (winter, spring, summer), how do you usually travel *to* campus?

5. By *term* (winter, spring, summer), how do you usually travel *on* campus?
6. If you drive alone, check up to three reasons why.
   (Saves time, need car at work, weather unpleasant, no transit where I live, etc.)
7. If you use transit, check up to three reasons why.
   (Saves time, saves money, don't own car, can read or work during commute, etc.)
8. What is your residence address?

3.3.3 Barriers to Implementation

Survey design and administration would require cooperation between the U-M units involved. If a student is hired to administer the survey, some additional funds would be necessary as well. However, the task would not require more than a one-semester part-time position each year.

3.3.4 Uncertainties and Concerns

Determining trip origins can be a particular challenge, since some people are reluctant to provide their home address on request. In one Portland State University survey, fewer than half of respondents provided it[lxviii]. However, even this low response rate provided sufficient information for substantial analysis, and U-M could consider incentives to promote full responses.

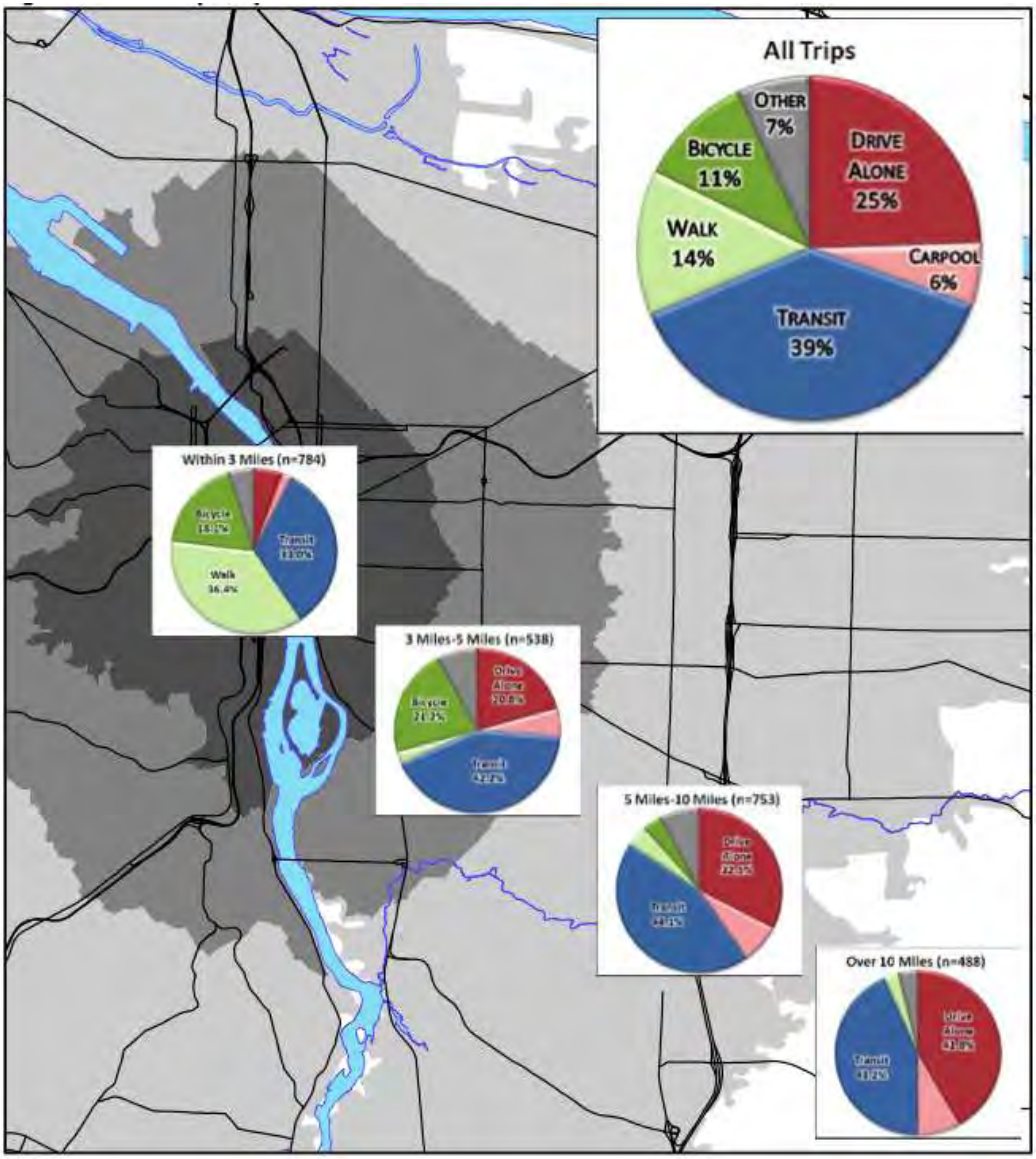


Figure 3-39 An example of information that could be gained by an annual survey, PSU's Mode Split by Distance. Portland State University

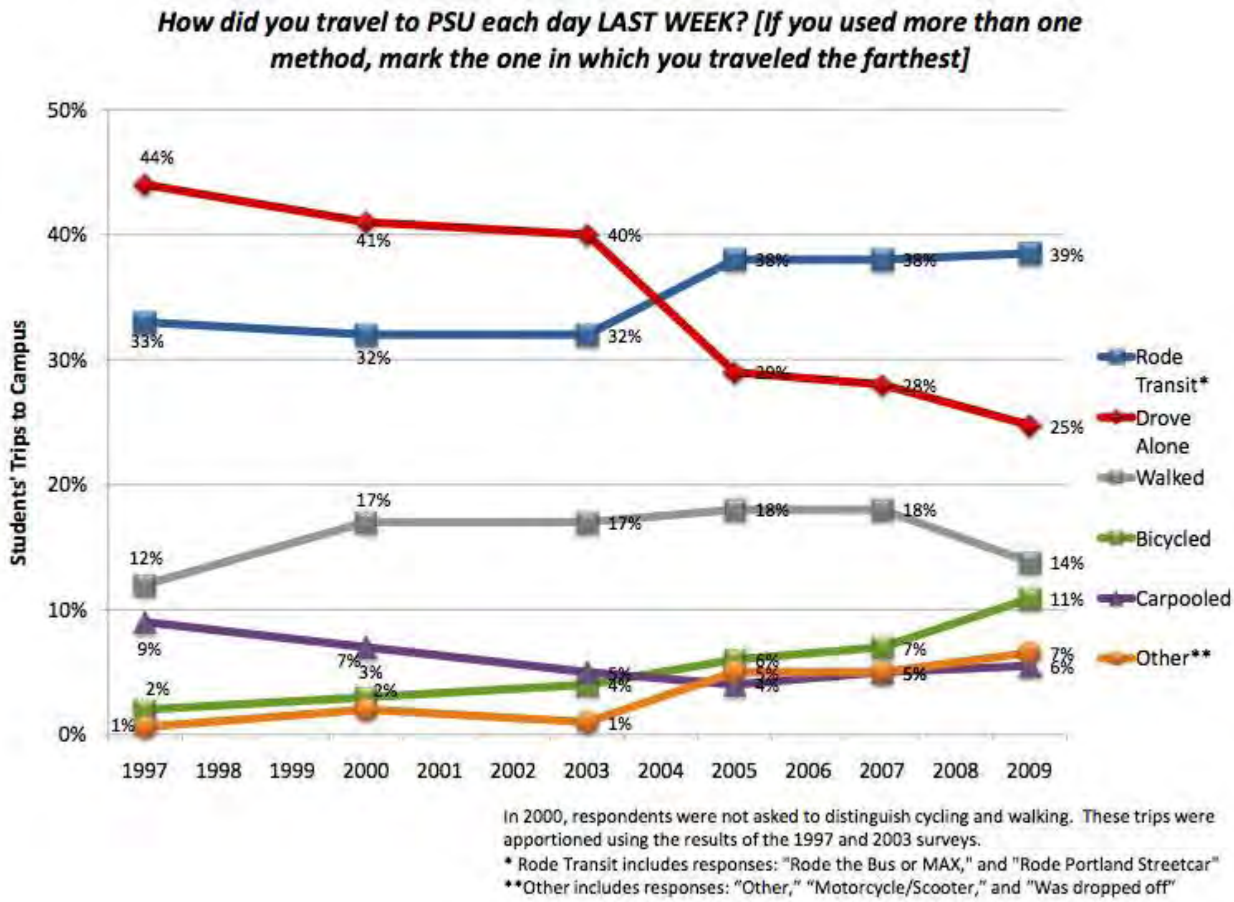


Figure 3-40 Regular surveys can provide invaluable information on commute patterns. *Portland State University*

4 Integration and Conclusion

During Phase II it became obvious that although we were working on the transportation mode choices and land use options, some of our ideas coincided with the energy team's investigation of energy technologies. Our take on the some of the energy team's contributions simply looks at the utilization of technologies to cause a reduction in environmental effects. For example, the energy team looked at utilizing more hybrids in the vehicles, while we looked at how to encourage people to use hybrids or other modes of transportation that could also reduce U-M's impact. For many points made in this report, that relates to some complex solutions that may need for examination or pilot programs to fully implement. If further investigations or pilot programs give encouraging results we hope it will make sense to continue towards more ambitious goals.

Economic Aspects

Capital Costs

- The capital costs of all three parking options are very attractive because increasing parking-rate differentiation and reducing parking subsidies could work inside the systems already in place. Furthermore, reducing parking subsidies could, in fact, raise parking revenue initially. Shifting from monthly or annual parking payment may require installation of card readers at each parking lot but this remains relatively lower than other transportation options covered in this report.

- The development of a campus bicycle master plan, contracts for bicycle services and expansion of parking facilities ranks somewhere fairly favorably in capital costs in comparison to other options. More expensive bicycle facility options such as a bicycle service center or rentals could prove more less favorable to other options at $200,000-$500,000. Development of an intercampus bikeway network and open card-swipe bicycle sharing system could prove to be one of the more expansive options we have covered at $2-10 million.
- Initiating the planning process for diversify land uses, adding sidewalks and ADA compliant curb ramps should remain about equal in capital costs as our bicycling first step but still more expensive than other measures. Continuing the planning process and completing the sidewalk network and improving street crossings may prove slightly more expensive or significantly more expensive than the first pedestrian option depending on the need but still more expensive than other options. Finally, pedestrian extentsions and transit mall development may prove to be the most ambitious in capital costs.
- Transit integration is one of our better options in transportation because there will be savings in paying a flat rate to AATA instead of buying new buses for replacement or expansion.
- Simplifying good movement will require further investigation to determine the amount, if any, of the capital costs.
- Off-campus travel options are not currently projected to require any capital investment since connections to the airport will be handled by systems already in place.
- A transportation habits survey of the will require the least capital investment out of the options we have suggested since it does not require any new equipment and could simply added to programs that are already in place.

Operating Costs

- Similar to the capital costs, all three parking options are very attractive because some increasing parking-rate differentiation will not change operations much, reducing parking subsidies will bring in more revenue and once installed, card readers will not have high operating cost to carry out the shift from month or annual parking payment.
- The operating cost of all our bicycle options will prove more attractive than the capital cost involved because bicycle services will not require significant funding and parking facilities require even less funding. An on campus service center could sustain itself through maintenance fees but bicycle rentals could require some funding but some could come from the service center. A bikeway network would not need more upkeep than is currently spent on pedestrian walkways and an open card swipe bicycle sharing system could prove self-sufficient.
- All pedestrian options could prove very minimal for operating costs therefore most of the cost involved will come from capital investment.
- Transit integration is one of our better options in transportation because there will be savings in paying a flat rate to AATA instead of paying fluctuating fuel prices and maintenance.

- Simplifying good movement will require further investigation to determine the operating costs.
- Establishing any kind of direct campus to airport connection will require some new operating expenses to attract private shuttle companies to make a stop on-campus, therefore, we have ranked operating costs of these options to be lower on the list. However, the more minor marketing of current systems would have a very low operating cost since this would primarily involve updating PTS's website.
- A transportation habits survey would also require very little up keep, cost-wise, since it could be interwoven into other annual information gather such as the Annual Environment Report performed by Occupational Safety & Environmental Health

Payback

- All parking options are meant to reduce automobile traffic coming to campus; therefore, some level of parking reduction is intended with all the mention parking options. Cost savings associated with any parking structures forgone or parking subsidies reduced should counteract this effect or even increase parking revenue for a time.
- Payback for all the bicycle options mentioned will be one of the best options in transportation. In the short term, payback may only come in the form of attracting students to the campus through the ease of bicycle use. However, in both the mid- and long-term plans, there remains room for operations to go beyond attracting students by becoming financial self-sufficient or even contributing to further improvements.
- Payback for all the pedestrian options will come in the form of a more attractive and enjoyable campus, which could attractive more competitive students.
- The payback period for a transportation integration program may not be as good as some of our other options because true difference between a flat rate and the variable cost involved cannot be predicted without further investigation. The pilot program involving one-route integration will give some better idea of the savings and payback period.
- Simplifying good movement will require further investigation to determine the payback.
- Establishing any kind of direct campus to airport connection will require some new operating expenses to attract private shuttle companies to make a stop on-campus, therefore, we have ranked payback period of these options to be lower on the list. However, the more minor marketing of current systems may have a much quicker payback since this would primarily involve updating PTS's website.
- The payback for a transportation habits survey would come through future campus planning officials having more information on the nature of commuting to and around campus. Planning can then react to more comprehensive information allowing for more educated decisions concerning land use and transportation.

Environmental Aspects

Climate

- Since all three parking options are meant to encourage alternative means of commuting to campus, each option should yield some amount of automobile related carbon emissions as well as reduce carbon emissions associated with building the infrastructure (lots and structures). Parking-rate differentiation will offer the least carbon savings while reducing subsidies and shifting monthly or annual payments will offer more savings. These should remain the one of the most effective options for climate.

- All the bicycle mode options suggested in this report enhance an emissions-free commute. Simply by improving the infrastructure for bicyclists, gains in this mode choice could be seen. If any riders shift from driving to biking then that eliminates almost all emissions (save for some in upstream manufacturing), therefore this is one of the best transportation options for climate.
- All the pedestrian options suggested in this report enhance an emissions-free commute. Simply by improving the infrastructure for pedestrians, gains in this mode choice could be seen. If any shift from driving to walking for any of their daily activites then that eliminates almost all emissions (save for some in upstream manufacturing for infrastructure), however, since walking will only replace the shortest of trips, other options may make more significant gains.
- More people in the transit system means buses run more full more of the time, which leads to less CO_2 emissions per passenger mile surpassing even car- and vanpools. Since city transit systems have access to federal transportation funding, the extra expense the positive effect on emissions could be increased further simply through continued funding for hybrid and fuel cell buses
- Unifying goods movement requires more investigation to determine the true impacts on the climate. Logically, if private courier services are primarily using automobiles to move time-sensitive materials around campus then integrating this into a centralized on-campus system using either delivery vehicles already en-route or bicycles will have less carbon emissions than automobile use per package.
- Any of the proposed simplification the U-M campus-airport connection solutions would provide similar benefits to increased bus utilization but remain benefits remains lower than other options because of the shorter mileage involved annually.
- The transportation survey will have only indirect effects, therefore, not rating was given.

Ecosystem Health

- Since all three parking options are meant to encourage alternative means of commuting to campus, each option should yield some amount of automobile related pollutant emissions as well as reduce pollutant associated with building the infrastructure (lots and structures). Parking-rate differentiation will offer the least improvement while reducing subsidies and shifting monthly or annual payments will offer further improvements. These should remain the one of the most effective options for ecosystem health.
- All the bicycle mode options suggested in this report enhance an emissions-free commute. Simply by improving the infrastructure for bicyclists, gains in this mode choice could be seen. If any riders shift from driving to biking then that eliminates almost all emissions (save for some in upstream manufacturing), therefore this is one of the best transportation options for ecosystem health.
- All the pedestrian options suggested in this report enhance an emissions-free commute. Simply by improving the infrastructure for pedestrians, gains in this mode choice could be seen. If any shift from driving to walking for any of their daily activites then that eliminates almost all emissions (save for some in upstream manufacturing for

infrastructure), however, since walking will only replace the shortest of trips, other options may make more significant gains.

- More people in the transit system means buses run more full more of the time, which also means less infrastructure upkeep (and related emissions), other fossil fuel emissions and less tire-wear particulates moving into water ecosystems. This is somewhere in the middle on our priority list because transit still involves all those infrastructure emissions, fossil fuel emissions and tires even though it is lower than automobiles
- Unifying goods movement requires more investigation to determine the true impacts on the climate. Logically, if private courier services are primarily using automobiles to move time-sensitive materials around campus then integrating this into a centralized on-campus system using either delivery vehicles already en-route or bicycles will have fewer pollutants than automobile use per package.
- Any of the proposed simplification the U-M campus-airport connection solutions would provide similar benefits to increased bus utilization but remain benefits remains lower than other options because of the shorter mileage involved annually.
- The transportation survey will have only indirect effects, therefore, not rating was given.

Materials Footprint

- Conversely to the parking options‘ effects of other environmental aspects, these are not expected to have as significant effect on materials footprint. The options may eliminate the need to build new parking lots or structures but will, likely, not significantly reduce the materials footprint of transportation at U-M directly.
- If any shift from driving to biking then that eliminates almost all materials associated with operating and, prolongs or eliminates the need to purchase a vehicle, therefore this is one of the best transportation options for improving materials footprint.
- If any shift from driving to then that eliminates almost all materials associated with operating and, prolongs, the need to purchase a vehicle, however, since walking will only replace the shortest of trips, other options may make more significant gains.
- More people in the transit system means buses run more full more of the time, which also means less infrastructure upkeep (and related materials), less automotive parts and tires per commuter. This is somewhere in the middle on our priority list because transit still involves all those infrastructure materials, parts and tires even though it is lower than automobiles
- Unifying goods movement requires more investigation to determine the true impacts on the climate. Logically, if private courier services are primarily using automobiles to move time-sensitive materials around campus then integrating this into a centralized on-campus system using either delivery vehicles already en-route or bicycles will have less infrastructure materials than automobile use per package.
- Any of the proposed simplification the U-M campus-airport connection solutions would provide similar benefits to increased bus utilization but remain benefits remains lower than other options because of the shorter mileage involved annually.
- The transportation survey will have only indirect effects, therefore, not rating was given.

Social Aspects

Human Health

- The transportation team does not expect significant human health gains from parking policy changes because alternative commuting methods do not necessarily involve more exercise. Furthermore, we expect many drivers will continue driving for most of their commuting needs.
- Bicycling can significantly improve daily activity levels; therefore, any person who begins to bike more will gain all health benefits associated with more exercise. This makes bicycle improvements one of the best options for human health
- Walking can significantly improve daily activity levels; therefore, any person who begins to walk more will gain all health benefits associated with more exercise. This makes pedestrian improvements one of the best options for human health
- Any improvement in transit mode choice could result in more walking since transit often does not arrive directly at a person‘s destination. Unfortunately, this may not improve exercise levels significantly.
- Unifying goods movement will not change activity levels; therefore, no rating was given.
- The campus to airport connection will not change activity levels for travelers; therefore, no rating was given.
- The transportation survey will have only indirect effects; therefore, no rating was given.

Community Awareness/Reputation Benefits

- Parking fee adjustments will need the correct marketing to become a reputation benefit or improve community awareness of environmental sustainability efforts.
- Like other aspects of our solutions, the marketing involved in the program will really be the indicator of the community awareness and reputation benefits of transit integration efforts. However, with appropriate marketing, an improved transit system could give some good benefits but not the best out of our options.
- Any improvements in the enjoyment of getting around on campus and commuting to campus will have reputation benefits simply by making U-M more enjoyable to bikers. Community Awareness depends on the marketing of bicycle improvements but could prove a great opportunity for sustainability awareness.
- Any improvements in the enjoyment of getting around on campus and commuting to campus will have reputation benefits simply by making U-M more enjoyable to walkers. Community Awareness depends on the marketing of pedestrian improvements but could prove a great opportunity for sustainability awareness.
- We do not believe that unifying goods movement will have all that much community awareness/reputation benefits due to the low-profile nature of courier services, unless otherwise specifically targeted by sustainability marketing.
- Simplifying the U-M Campus-Airport Connection could result in significant reputation benefits since ease of transportation to U-M could positively influence visiting prospective students and other guests.
- Having a published survey with results published online like the Annual Environment Report could give the university and various groups or departments a basis on what they could improve on. Future programs would be able to quantify improvements on transportation mode choice. For example, a bike commuter program for students would be able to have competitions for choosing bicycles over cars.

Learning/Research Opportunities

- Parking fee adjustments will give many research opportunities for Urban Planning, transportation engineering and other departments concerned with behavioral changes.
- Bicycle infrastructure improvements of any kind could serve as great learning opportunities both on how to ride and maintain and on sustainability issues in transportation. Learning opportunities exist for urban planning, transportation engineering, etc. to track the changes made versus mode choice switching (dependant on the transportation survey).
- Pedestrian infrastructure improvements of any kind could serve as great learning opportunities on sustainability issues if marketed appropriately. Learning opportunities exist for urban planning, transportation engineering, etc. to track the changes made versus mode choice switching (dependant on the transportation survey).
- Since transit integration has not been done to a large extent, fairly large research and learning opportunities exist with several departments including Urban Planning and transportation engineering.
- We do not believe that unifying goods movement will have all that much learning or research opportunities since such systems are currently already utilized elsewhere.
- A transportation habits survey could provide a lot of information on the current state of U-M but also how decisions affect the habits of U-M community members. Not only is this a learning opportunity for campus planners and members but also a research opportunity for a variety of departments such as Urban Planning, Sociology, Engineering, etc.

Table 4-1 Transportation Team's Prioritization Matrix

Transportation Team Recommendations	Economic Aspects			Environmental Aspects			Social Aspects		
	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
Increase Parking-Rate Differentiation	4	5	5	3	3	2	2	3	4
Reduce Parking Subsidies	4	5	5	4	4	2	2	3	4
Shift from Monthly or Annual Parking Payment	3	5	5	5	5	3	2	4	5
Bicycle master plan, services, facilities	4	3	4	5	3	5	5	5	4
Bicycle service center, rentals	3	4	5	5	3	5	5	5	5
Bikeway network, bicycle sharing system	2	4	5	5	3	5	5	5	5
Diversified land use, sidewalks, ADA	4	5	3	3	3	3	5	4	4
More diversified land use, sidewalks, crossings	3	5	3	3	3	3	5	4	4
Pedestrian extensions, transit mall development	2	5	3	3	3	3	5	5	5
Pilot AATA, U-M transit integration	4	4	2	4	4	3	3	4	3
Fully integrate U-M transit into AATA	3	4	2	5	5	4	3	5	5
Increased promotion of campus-airport transit		5	4	2	2	3		4	
Direct campus or downtown to airport link		3	2	2	2	3		4	
Integrate a U-M to airport link into U-M transit		3	2	2	2	3		4	
Establish the level of current courier-use								3	2
Integrate courier service into campus mail				2	2	3		3	3
Transportation Habits Survey	5	5	5					5	5

*Darkest green means more favorable while lighter green means less favorable, white even more so.

5 Appendix I

Phase 2 Operations Staff Meetings Record:

Oct. 15, 2010

- Sue Gott (Campus Planner)
- Steve Dolen (PTS)

Nov. 19, 2010

- Tom Forest (Mail Services)
- Melaku Mekonnen (Housing)

Dec. 10, 2010

- Tom Forest (Mail Services)
- Steve Dolen (PTS)
- Andy Berki (OCS)
- Katie Lund (GESI)

Appendix II

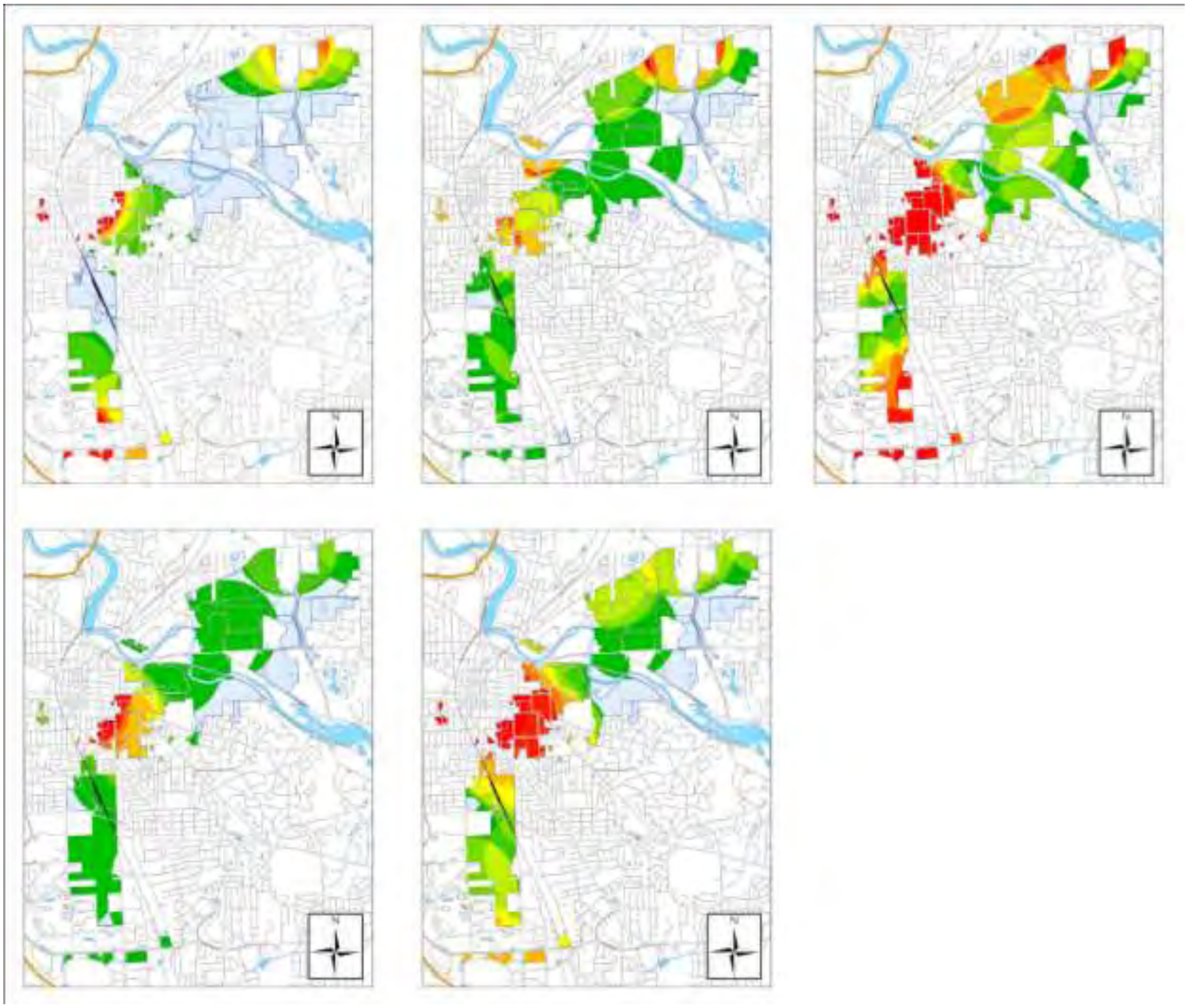


Figure 0-1 Walkability to different category of commercial spots. Categories from left top to right bottom: Bank, Grocery, Service, Retail, Food & Catering service. Red zones represent a higher accessibility than the green zones. Pale blue areas indicate that there are no nearby commercial spots can be accessed within 0.5 miles.

Table 0-1 A comparison of before and after MSU transit integration policies in 1999.[lxix]

Initial Integrated CATA/MSU Bus Service	MSU Bus Service Pre-Integration
• Student cash fare of 25 cents, same fare as the past 4 years, with pledge to keep the student cash fare below the MSU fare, plus inflation, for the duration of our long-term contract with MSU. • Student $40.00 semester and $12.50 monthly passes • Access to entire 110 square mile Greater Lansing area.	• Student fare of 60 cents, must use pre- paid ticket, no cash allowed. • $40.00 semester and $65.00 annual pass – limited to MSU buses only • No monthly pass available
Students who use service designed for people with disabilities will pay the same fare as all other students, currently at 25 cents.	60 cents per ride or pass.
24 hour Parking Shuttle	24 hour Parking Shuttle
Nite Rider will continue and Dial-a-Ride will be replaced with expanded Parking Shuttle service, from 10:00pm to 2:30am, 7 days per week that will provide the same quality service for the MSU customers.	Dial-a-Ride and Nite Rider available from 10:00pm -- 2:30am, 7 days per week.
CATA will add over 10,000 hours of new service from off-campus areas such as East Lansing, Haslett, and Okemos at no cost to MSU, providing greater frequency of buses on-campus.	NA
Qualified MSU bus drivers will be offered jobs with either CATA or MSU.	NA
CATA would invest millions of dollars in buses with bike racks, shelters, and bus stops for MSU using federal and state funds not available to MSU.	NA
CATA will provide all special services, such as shuttles for MSU football and basketball games.	Same

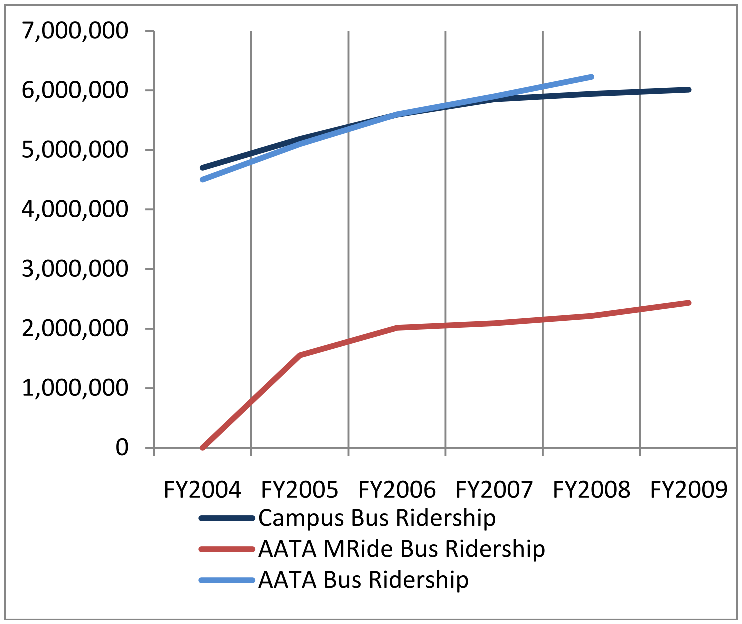


Figure 0-2 Figure 7 Campus[li], AATA[lii] and MRide[liii] Annual Bus Ridership

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Appendix E. IV. : Phase 2 Land & Water Team Report

UNIVERSITY OF MICHIGAN

CAMPUS SUSTAINABILITY INTEGRATED ASSESSMENT

LAND & WATER – PHASE II REPORT

JANUARY 21, 2011

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LAND AND WATER TEAM PHASE 2 FINAL REPORT

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EXECUTIVE SUMMARY

Landscapes, be they urban, rural, or wild, are best understood and cared for when they are considered at multiple scales simultaneously. A plaza, for example, should be thought of in terms of: 1) how the space functions/will function as a place for a gathering of many; 2) how it functions as a place for a single individual (i.e. a human scale, or one scale below the first scale considered); and 3) how the space functions as a part of a larger urban open space system (i.e., one ‗measure' up from the second scale). Similarly, a campus can be best understood if it is thought of: 1) at the individual site/place scale; 2) at the campus scale as these individual spaces come together to form the larger whole; and 3) at the community/regional scale, as a campus interacts with the neighborhoods, towns, and natural systems that surround and/or move through it.

The University of Michigan should strive to be the leader and best in the manner it utilizes and manages its landscape spaces, habitats and ecosystems in terms of their long-term ecological health, ecosystem function, and relevance to the educational mission of the institution. The campus landscape must also function as a social place, so where appropriate, landscape programming and management must also balance the need for human/social well being with the critical need for ecosystem health. The U-M should therefore manage its campus holdings in such a way as to exhibit leadership in its planning and management practices at both the site and campus-wide scales. To accomplish this, the university must identify and establish policies and practices that will serve to link the programming, use and management of its spaces and systems to the larger metropolitan and regional landscape, seeking to provide local leadership in the preservation/restoration of the natural and cultural systems that are a part of southeastern Michigan. The U-M should also seek to enhance the manner in which it educates its students (as well as faculty, staff, and visitors to campus) about its commitment to institutional ecosystem health through on-campus research and teaching associated with the innovative management, planning and design practices being utilized here. The U-M should strive to exhibit both local and global leadership in environmental practice and education through the design, management, and utilization of the campus landscape in new and innovative ways.

SUMMARY OF SUGGESTED ACTIONS:

ACTION 1: Adopt the standards set forth in the Sustainable Sites Initiative as campus standards for landscape planning, design, and management. Ultimately, the U-M should set a minimum Three-Star Rating as a goal for all of its campus landscape holdings and projects. Specific properties, such as both U-M golf courses, should also pursue additional levels of recognition/certification where appropriate; the golf courses, for example, should both strive to be certified by the Audubon Society as a Cooperative Sanctuary under their Golf and the Environment Initiative.

ACTION 2: Preserve, elevate, and/or restore to a high quality and healthy state the soil, water, and hydrologic systems on and around the U-M. Do this by: 1) Continue to decrease, over time, the use of synthetic herbicides, pesticides, fungicides, and snow removal chemicals; and 2) moving beyond 'standard stormwater management' to a higher standard that reflects both a deeper understanding of surface and sub-surface hydrology, and a commitment to doing all that the U-M can to enhance and restore ecosystem health to the larger Huron River watershed.

ACTION 3: Expand current efforts to alter campus landscapes to increase biodiversity, decrease landscape-related water use, and decrease runoff from both water use and stormwater. Elevate the presence of native plant communities on campus, and shift campus landscape management strategies towards the development of a new aesthetic that goes beyond a Jeffersonian campus aesthetic to establish a new, more ecologically aware presence that simultaneously respects the traditions associated with campus design and planning while challenging and altering some aspects of the U-M campus.

ACTION 4: Expand efforts already undertaken to prioritize sustainability and ecological function across campus planning projects. Maximize the use of the campus landscape to address both local environmental issues (such as stream corridor health) as well as global issues such as climate change (through the use of carbon sequestration strategies tied to campus planning and management activities).

ACTION 5: Create opportunities to utilize all parts of the campus landscape as a teaching, learning, and research environment. Utilize/test new technologies in the spirit of experimentation and learning as a way of moving both the campus and its population towards a greater level of understanding and achievement in sustainable design, development, and living.

INTRODUCTION

The Land and Water team has worked upon the assumption that because the campus landscape has a very complex and vast presence, any assessment tools, as well as specific goals and recommendations, will need to take specific landscape contextual issues into account when being developed and applied. To this end, the Land and Water team has identified four landscape ‗types' that could help guide this process; they are:

1. *Traditional Campus* (ex.: Central campus, North Campus)
2. *Forested and/or lower use Non-traditional Campus* (ex.: Arboretum, Botanical Gardens, Saginaw Forest)
3. *Athletic Facilities/Grounds* (ex.: Michigan Stadium, Golf Course, Tennis Center)
4. *Campus Institutional* (ex.: Medical Center, North Campus Research Complex)

Each landscape type should have its own assessment protocol, metrics, policies and recommendations tied to the ‗on-the-ground' realities present within each of those types. The ultimate goals included in the proposals that follow can and should be achieved in each and every one of the landscape types present at the UM. How the policies and practices would be implemented, monitored, and measured might differ depending upon landscape type, but the ultimate outcome of improving ecosystem health and function for all campus landscapes remains as the primary goal.

ACTION PLAN

ACTION 1: Adopt the standards set forth in the Sustainable Sites Initiative as campus standards for landscape planning, design, and management. Ultimately, the U-M should set a minimum Three-Star Rating as a goal for all of its campus landscape holdings and projects. Specific properties, such as both U-M golf courses, should also pursue additional levels of recognition/certification where appropriate; the golf courses, for example, should both strive to be certified by the Audubon Society as a Cooperative Sanctuary under their Golf and the Environment Initiative.

Central to all of the Land and Water Team's proposals, we feel strongly that the University of Michigan should subscribe to the recently published Sustainable Sites Initiative (SSI) goals and standards; this is, effectively, a land and water version of the LEED standard that the U-M currently utilizes in the planning and design of new buildings. A joint effort by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center, and the United States Botanic Garden, the SSI is currently in the early phases of its application and testing; it's eagerly anticipated arrival and subsequent widespread acceptance among the environmental design and planning community is clearly indicative of how well developed and considered these guidelines are, and also seems to insure that like LEED standards, the SSI Benchmarks and Guidelines will have a truly lasting impact upon the built environment for years to come. While some universities such as Purdue University, University of California, Merced, and Virginia Tech have utilized the SSI benchmarking and rating system on selected projects, by subscribing to its guidelines and benchmarks at an ***overall campus scale***, the U-M could become the first university to pursue an SSI rating for its entire campus.

The guidelines should be applied in this case to both new construction and renovation of existing landscapes and grounds. The U-M should set a minimum Three Star rating for all projects; this would be on par with the LEED Silver standard that the UM currently has in place for building construction. Utilizing a phased approach, the U-M should strive to earn at least a three-star (60%) rating from the Sustainable Sites Initiative for North Campus by 2015; earn a three star rating for Central Campus and upgrade North Campus to four stars (80%) by 2020; earn at least three-star ratings for the entirety of the University of Michigan grounds and four stars for academic areas by 2025. As a set of Guiding Principles, the SSI offers the following:

GUIDING PRINCIPLES OF A SUSTAINABLE SITE [i]

1) Do no harm

Make no changes to the site that will degrade the surrounding environment. Promote projects on sites where previous disturbance or development presents an opportunity to regenerate ecosystem services through sustainable design.

2) Precautionary principle

Be cautious in making decisions that could create risk to human and environmental health. Some actions can cause irreversible damage. Examine a full range of alternatives—including no action—and be open to contributions from all affected parties.

3) Design with nature and culture

Create and implement designs that are responsive to economic, environmental, and cultural conditions with respect to the local, regional, and global context.

4) Use a decision-making hierarchy of preservation, conservation, and regeneration

Maximize and mimic the benefits of ecosystem services by preserving existing environmental features, conserving resources in a sustainable manner, and regenerating lost or damaged ecosystem services.

5) Provide regenerative systems as intergenerational equity

Provide future generations with a sustainable environment supported by regenerative systems and endowed with regenerative resources.

6) Support a living process

Continuously re-evaluate assumptions and values and adapt to demographic and environmental change.

7) Use a systems thinking approach

Understand and value the relationships in an ecosystem and use an approach that reflects and sustains ecosystem services; re-establish the integral and essential relationship between natural processes and human activity.

8) Use a collaborative and ethical approach

Encourage direct and open communication among colleagues, clients, manufacturers, and users to link long-term sustainability with ethical responsibility.

9) Maintain integrity in leadership and research

Implement transparent and participatory leadership, develop research with technical rigor, and communicate new findings in a clear, consistent, and timely manner.

10) Foster environmental stewardship

In all aspects of land development and management, foster an ethic of environmental stewardship—an understanding that responsible management of healthy ecosystems improves the quality of life for present and future generations.

These guidelines form the basis for the Benchmarks and Guidelines that follow. They are intended as performance criteria, and are written in a manner that allows for local context (political, social, ecological, economic, institutional/cultural) to determine how best to meet these desired performance benchmarks. As a _chart' it may not flow very well in terms of prose, but it is presented here in its entirety so that it might be understood in the context of the Land and Water Team's overall goals for this Assessment. The issues and benchmarks of the SSI are below:

INDEX OF PREREQUISITES AND CREDITS

1. Site Selection: ***Select locations to preserve existing resources and repair damaged systems***

Prerequisite 1.1: Limit development of soils designated as prime farmland, unique farmland, and farmland of statewide importance

Prerequisite 1.2: Protect floodplain functions

Prerequisite 1.3: Preserve wetlands

Prerequisite 1.4: Preserve threatened or endangered species and their habitats

Credit 1.5: Select brownfields or greyfields for redevelopment (5–10 points)

Credit 1.6: Select sites within existing communities (6 points)

Credit 1.7: Select sites that encourage non-motorized transportation and use of public transit (5 points)

2. Pre-Design Assessment and Planning: ***Plan for sustainability from the onset of the project***

Prerequisite 2.1: Conduct a pre-design site assessment and explore opportunities for site sustainability

Prerequisite 2.2: Use an integrated site development process

Credit 2.3: Engage users and other stakeholders in site design (4 points)

3. Site Design—Water: ***Protect and restore processes and systems associated with a site's hydrology***

Prerequisite3.1: Reduce potable water use for landscape irrigation by 50 percent from established baseline

Credit 3.2: Reduce potable water use for landscape irrigation by 75 percent or more from established baseline (2–5 points)

Credit 3.3: Protect and restore riparian, wetland, and shoreline buffers (3–8 points)

Credit 3.4: Rehabilitate lost streams, wetlands, and shorelines (2–5 points)

Credit 3.5: Manage stormwater on site (5–10 points)

Credit 3.6: Protect and enhance on-site water resources and receiving water quality (3–9 points)

Credit 3.7: Design rainwater/stormwater features to provide a landscape amenity (1–3 points)

Credit 3.8: Maintain water features to conserve water and other resources (1–4 points)

4. Site Design—Soil and Vegetation***: Protect and restore processes and systems associated with a site's soil and vegetation***

Prerequisite 4.1: Control and manage known invasive plants found on site

Prerequisite 4.2: Use appropriate, non-invasive plants

Prerequisite 4.3: Create a soil management plan

Credit 4.4: Minimize soil disturbance in design and construction (6 points)

Credit 4.5: Preserve all vegetation designated as special status (5 points)

Credit 4.6: Preserve or restore appropriate plant biomass on site (3–8 points)

Credit 4.7: Use native plants (1–4 points)

Credit 4.8: Preserve plant communities native to the ecoregion (2–6 points)

Credit 4.9: Restore plant communities native to the ecoregion (1–5 points)

Credit 4.10: Use vegetation to minimize building heating requirements (2–4 points)

Credit 4.11: Use vegetation to minimize building cooling requirements (2–5 points)

Credit 4.12: Reduce urban heat island effects (3–5 points)

Credit 4.13: Reduce the risk of catastrophic wildfire (3 points)

5. Site Design—Materials Selection: Reuse*/recycle existing materials and support sustainable production practices*

Prerequisite 5.1: Eliminate the use of wood from threatened tree species

Credit 5.2: Maintain on-site structures, hardscape, and landscape amenities (1–4 points)

Credit 5.3: Design for deconstruction and disassembly (1–3 points)

Credit 5.4: Reuse salvaged materials and plants (2–4 points)

Credit 5.5: Use recycled content materials (2–4 points)

Credit 5.6: Use certified wood (1–4 points)

Credit 5.7: Use regional materials (2–6 points)

Credit 5.8: Use adhesives, sealants, paints, and coatings with reduced VOC emissions (2 points)

Credit 5.9: Support sustainable practices in plant production (3 points)

Credit 5.10: Support sustainable practices in materials manufacturing (3–6 points)

6. Site Design—Human Health and Well-Being: *Build strong communities and a sense of stewardship*

Credit 6.1: Promote equitable site development (1–3 points)

Credit 6.2: Promote equitable site use (1–4 points)

Credit 6.3: Promote sustainability awareness and education (2–4 points)

Credit 6.4: Protect and maintain unique cultural and historical places (2–4 points)

Credit 6.5: Provide for optimum site accessibility, safety, and wayfinding (3 points)

Credit 6.6: Provide opportunities for outdoor physical activity (4–5 points)

Credit 6.7: Provide views of vegetation and quiet outdoor spaces for mental restoration (3–4 points)

Credit 6.8: Provide outdoor spaces for social interaction (3 points)

Credit 6.9: Reduce light pollution (2 points)

7. Construction*: Minimize effects of construction-related activities*

Prerequisite 7.1: Control and retain construction pollutants

Prerequisite 7.2: Restore soils disturbed during construction

Credit 7.3: Restore soils disturbed by previous development (2–8 points)

Credit 7.4: Divert construction and demolition materials from disposal (3–5 points)

Credit 7.5: Reuse or recycle vegetation, rocks, and soil generated during construction (3–5 points)

Credit 7.6: Minimize generation of greenhouse gas emissions and exposure to localized

air pollutants during construction (1–3 points)

8. Operations and Maintenance*: Maintain the site for long-term sustainability*

Prerequisite 8.1: Plan for sustainable site maintenance

Prerequisite 8.2: Provide for storage and collection of recyclables

Credit 8.3: Recycle organic matter generated during site operations and maintenance (2–6 points)

Credit 8.4: Reduce outdoor energy consumption for all landscape and exterior operations (1–4 points)

Credit 8.5: Use renewable sources for landscape electricity needs (2–3 points)

Credit 8.6: Minimize exposure to environmental tobacco smoke (1–2 points) 204 Credit 8.7: Minimize generation of greenhouse gases and exposure to localized air pollutants

during landscape maintenance activities (1–4 points)

Credit 8.8: Reduce emissions and promote the use of fuel-efficient vehicles (4 points)

9. Monitoring and Innovation*: Reward exceptional performance and improve the body of knowledge on long-term sustainability*

Credit 9.1: Monitor performance of sustainable design practices (10 points)

Credit 9.2: Innovation in site design (8 points)

Of all of this team's goals and actions, this is perhaps the most all-encompassing and potentially most important one, for all of our other recommendations and actions are effectively covered within this program. We can not state strongly enough our support for the U-M choosing to commit to this at a campus-wide scale, not just because of the notoriety we might achieve for doing so, or because of how well-suited it is to helping us as an institution move towards a more sustainable landscape; we should do it because as Leaders, it is the right thing to do. The U-M has already begun to utilize the SSI for selected elements pertaining to landscape construction; expanding these efforts to incorporate the entire SSI program would not only be a logical progression, it would be an important, cutting-edge decision that places U-M in a clear leadership role both nationally and beyond. For more information, please see the following website for the most current, in-depth description of the SSI Performance Benchmarks:

http://www.sustainablesites.org/report/Guidelines%20and%20Performance%20Benchmarks_2009.pdf

ACTION 2: Preserve, elevate, and/or restore to a high quality and healthy state the soil, water, and hydrologic systems on and around the U-M. Do this by: 1) decreasing, over time, the use of synthetic herbicides, pesticides, fungicides, and snow removal chemicals; and 2) moving beyond 'standard stormwater management' to a higher standard that reflects both a deeper understanding of surface and sub-surface hydrology, and a commitment to doing all that the U-M can to enhance and restore ecosystem health to the larger Huron River watershed.

The soils and hydrologic systems present on the U-M campus have been greatly altered and affected by the development of the campus landscape over time. Urbanization, development both on and off campus, and a larger, regional development pattern that has caused density in some areas and sprawl in others has deeply affected the subsurface geology and hydrology of the campus and it environs. That said, there is still infiltration of stormwater and irrigation that occurs, there is still both surface and sub-surface runoff that feeds rivers and streams of the area, and there are still soils that provide the sustenance that trees and other vegetation need to survive in southeast Michigan. The U-M should do all that it can to preserve and elevate the health of all of the soil and water resources on campus, as they provide the foundation upon which a healthy and sustainable campus rests. To do this, the U-M must pay attention to how it manages the landscape, and how it affects the surface and subsurface hydrology of the region through its actions as managers and developers of the campus.

Landscape Management Policies: Reduce the use of chemical herbicides, pesticides, fungicides and fertilizers on all campus grounds, with a goal of 30% reduction in use-by-type by 2015, 75% by 2021, and a chemical-free goal by 2025 (percent reductions should be tied to 2010 use levels). Develop a landscape management strategy that reduces mowing where appropriate, and that calls for less mechanized maintenance and an increase in manual techniques, combining staff efforts with an increase in volunteer management of campus landscapes through programs such as class projects, campus-wide landscape ‗care' events, and more.

Discussion: Landscape Management Policies

Certain zones of campus will be more receptive to low and no-chemical management plans, than others will be. We realize that changing chemical-intensive management practices on campus athletic fields and highly developed areas such as the hospital complex will require a long-view plan. With this in mind, we propose that North Campus lands be transitioned to a zero synthetics management plan within 3 years. A step-wise approach to achieving a chemical free University of Michigan Campus will be the best way to achieve significant but manageable reductions in the use of synthetic soil amendments in the near term. This approach, combined with a proactive educational campaign on the decision to go ‗chemical free[ii]' will also help to drive a cultural shift in the way students, staff and visitors perceive of campus lands management while also giving the U-M an opportunity to learn from its North Campus ‗experiment' and apply those lessons in other landscape contexts on campus. Through the use of less labor intensive and limited or no chemical-based land management strategies, combined with all natural soil amendments such as post-compost products, we can also see both ecological and economic benefits to the campus as a whole over time, serving to reduce the need for landscape-related water use and eliminate the need for synthetic soil amendments and herbicides.

By changing landscape management practices on North Campus first, this plan achieves a 30 % reduction in fertilizer and herbicide use over the first four years, saving an estimated $4000/year, depending upon how aggressively staff moves towards the 30% benchmark. We also believe that implementing a strategic zero-chemical management plan to a large, heavily residential section of campus is the first crucial step towards inspiring the larger Michigan community to visualize and ultimately embrace a 100% chemical-free campus management plan.

Building from the *Chemical Free North Campus*, we propose the elimination of all synthetic landscape management chemicals from all residential, academic and administrative areas of campus, excluding the Law campus and Hospital complex within 10 years. Within 15 years, coupled with proactive educational campaign about the positive benefits of chemical reductions to human and ecosystem health, all non-athletic University of Michigan campus lands will be 100% chemical free.[iii]

Discussion: Snow Removal and De-icing

While not an herbicide, pesticide or fungicide, the U-M does rely on a number of chemicals to address the presence of ice and snow on the campus grounds during the winter months. U-M is already working hard on reducing salt and sand use for de-icing. Currently, a brine solution is used to prevent snow and ice from adhering to walkways, and then sweeper tractors remove it. (The sweepers are multi-use trucks that can be used all year.) Using brine allows facilities to use much less total salt and other chemical deicers. Beet juice and corn juice have been tried as alternatives to brine, but were not adopted because of objectionable smell and staining.

The UM campus community has come to expect efficient snow removal, and facilities often receives calls as soon as snow begins to fall. The two major questions regarding snow removal seem to be:

- *If we reduce chemical use to support ice melting, what, if anything, can we do to encourage <u>coping</u> with snow for those who are able?*

- *Are there areas that could be low priority in terms of accessibility, similar to seasonal roads? Do we need to make every sidewalk equally accessible? Could some sidewalks be removed and replaced with paving alternatives that may not be 'maintainable' during snow and ice events due to their composition, or their high permeability?*

Permeable paving, a stormwater infiltration and treatment solution the U-M is already using in several areas, is supposedly less susceptible to icing than conventional paving because its pore spaces hold and insulate air, keeping the paving surface slightly warmer (SEMCOG). UM is in a position to test this claim as it increases permeable surface area on campus and gains experience in maintaining it.

Heated pavement as an option for ice abatement

U-M already uses areas of heated pavement, such as in loading docks, but these systems use steam heat or heat from the associated building. If the university adopts the use of geothermal heating and cooling for buildings (*see the Energy Team's report*), associated systems could, in theory, be included to heat walkways and plazas. The city of West Union, Iowa, (design by Conservation Design Forum) is an example of a place that utilized a district-wide geothermal system including use of a roadway as a well field, and use of the system itself to heat the road. Further, the inclusion of geothermal coils in a permeable unit paver system has been studied at the University of Edinburgh, and at least under lab conditions it performs well, combining the benefits of stormwater infiltration and snow melting[iv]. While its cost effectiveness may not be discernable at this time, as large paving projects in close proximity to geothermal options arise, the U-M should consider installing and testing paving systems that incorporate geothermal technology for both functional as well as teaching, research, and demonstration purposes.

Discussion: Stormwater Management at the U-M

The U-M has done much to address the issue of stormwater management to-date. Stormwater retention ponds on North Campus, the installation of permeable paving at the new CC Little Bus Stop area, and the permeable concrete and stormwater swales at the Business School are only a few of the examples of how the U-M is addressing the issue of water runoff and infiltration. Still, there are many opportunities to do more to address stormwater runoff quality, quantity, and time of concentration (the time it takes water to hit the ground and move through the catchment area/watershed completely).

The U-M should strive to not only meet the requirements set forth in its current stormwater permit; it should work towards maximizing stormwater runoff quality in all areas of campus, and to also work towards maintaining current levels of both surface and sub-surface hydrologic function, particularly during construction processes as well as during planning and design work at all scales and in all contexts on the U-M campus.

Stormwater Policy:

Create a phased impervious cover replacement policy that will eventually replace half of paved walkways and parking lots, and all game courts, with pervious surfaces. Update stormwater policies to address campus construction and its impacts on runoff -- runoff levels from sites under construction as well as new, completed projects should possess the same runoff pattern, quality, and quantity as the pre-construction conditions generated. Any excess should be collected, retained, and/or infiltrated on site, and water quality of runoff must be monitored and controlled.

<u>Discussion: Impervious surface replacement</u> Impervious surfaces currently make up 46% of U-M ground cover, which is broken into the categories buildings (18%), game courts (0.2%), concrete walks (9%), parking areas (14%), roads (4%) and stairs and ramps (0.4%). Impervious surface replacement has already begun with a number of parking lots, plazas and walks. We recommend continuing replacement, starting with parking lots and experimenting with concrete walk and game court replacement, particularly those that are already in need of replacement (or will be soon). Eventually, the University should aim for replacing all game courts and half of concrete walks and parking lots with pervious surfaces, increasing pervious surfaces by 25%, reducing total impervious surface to 35% of all University land.[v] The University should aim for replacement of 25% of all parking lots with permeable pavement by 2015, and 50% of all lots by 2020. All newly constructed lots should also use permeable paving.

<u>Costs and benefits</u>: Pervious parking lots will cost more to install, but will make up for cost in its benefits in reduced stormwater runoff, reduced deicing requirements and longevity. Porous paving costs 20 to 25% more than traditional parking paving.[vi] The W-16 parking lot, installed in 2002, cost $80,000 for 1,533 square yards, about $6 per foot.[vii] However, pervious pavements may last up to 30 years, as opposed to 12-15 years for impervious pavement in northern climates, making its life cycle cost virtually identical to more traditional methods. In addition, pervious parking lots require less plowing, deicing and sanding, as standing meltwater does not collect on the parking lot surface to potentially refreeze.**Error! Bookmark not defined.**

<u>Barriers to implementation</u>: Short-term cost is the primary barrier to the installation of pervious parking surfaces. Installation of any new pavement requires that an area be closed for an amount of time to its usual pedestrian, vehicle and delivery traffic, causing short-term difficulties.

<u>Concrete walks</u>: While permeable parking lots have an established history of success and the University of Michigan and can be implemented with confidence immediately, permeable walkways have yet to be proven durable and effective in the long term.[viii] Replacement of walks should occur pending the success of the currently installed –experimental" permeable walks on campus, in long-term durability and effectiveness. Given confirmation of effectiveness over time by grounds maintenance, the University should aim to have 25% of all walks on campus to be permeable surfaces by 2018, and 50% by 2023.

Costs and benefits: Pervious walks have similar benefits as permeable parking lots, including reduced use of deicers and sand, increased filtration of water and decreased surface runoff. However, installation of pervious walks is a relatively new technique to the University of Michigan, and the cost-effectiveness of the methods used on campus is still being evaluated by grounds maintenance.

Barriers to implementation: Cost is the primary barrier to the installation of pervious walks. Installation of any new pavement requires that an area be closed for a time to its usual pedestrian traffic, causing short-term difficulties.

Discussion: Maintaining Hydrologic patterns on sites under construction, and those recently completed: The U-M should update its campus stormwater policy regarding construction runoff to conform to Sustainable Sites requirements for construction pollutants. While its current permit already includes many best practices (preventing soil loss through stormwater runoff, preventing sedimentation of stormwater and receiving waters, preventing runoff or infiltration of pollutants from construction sites), the U-M could go further. Policies that explicitly establish soil and vegetation protection zones found in or near the construction site, for example, could help to alleviate compaction and stunted infiltration in during- and post-construction circumstances. Additionally, the U-M should aim for a zero increase in stormwater runoff quantity and quality over normal pre-construction levels in all development and redevelopment projects, and no decrease in runoff quality from before construction. Construction policy should include best management practices to reduce and retain runoff, and protect runoff quality, including: temporary and permanent seeding, mulching, earth dikes, sediment traps, sediment basins, filter socks, compost berms and blankets, secondary containment, spill control equipment, hazardous waste manifests, and overfill alarms.[ix] Construction should also take into account weather conditions during construction activities that could influence runoff quality.

Costs and benefits: Controlling construction runoff quality and quantity will benefit the larger watershed ecosystem in which the University is located. The University already has measures in its Stormwater Management Program Plan addressing stormwater generated on construction sites, so implementation can occur within the established policy framework. However, costs may increase in order to approach a policy of zero runoff increase.

Barriers to implementation: Working with contractors experienced in construction site runoff reduction would be essential. Because of needing to hire companies familiar with the required processes and the work involved in preventing construction runoff, increased costs may be a barrier.

ACTION 3: Alter campus landscapes to increase biodiversity, decrease landscape-related water use, and decrease runoff from both water use and stormwater. Elevate the presence of native plant communities on campus, and shift campus landscape management strategies towards the development of a new aesthetic that goes beyond a Jeffersonian campus aesthetic to establish a new, more ecologically aware presence that simultaneously

respects the traditions associated with campus design and planning while challenging and altering some aspects of the U-M campus.

Biodiversity is harder to model and quantify than runoff, but can be promoted by creating complex and heterogonous plant communities and habitats modeled after native ecosystems. The U-M has a number of very well developed and positively functioning ecosystems extant in places such as North Campus and the Arboretum; still, there are more acres absent a well-functioning ecosystem on U-M‘s Ann Arbor land holdings, particularly on the grounds comprising both the athletic complexes south of campus, the intramural fields near the Huron River, and on Central Campus itself. The U-M has an opportunity to truly make a statement about its commitment to sustainability by taking an increased biodiversity/ecological function approach to all of its campus landscape. Among key tasks to achieve this goal would be to increase the use of native plants and the presence of native plant communities in landscapes currently occupied by a traditional ‗lawn and trees' campus aesthetic. Other key tasks here include a reduction in the amount of mown lawn on campus, an inch for inch tree replacement policy, and an integrated approach to native plant selection and stormwater management.

Native Plant Cover Policy: Create and apply a phased native plant policy to increase species richness and diversity of, and relative cover by, native plants. Prioritize lawn replacement (35%) and vegetated stormwater solutions as starting points, along with planting bed re-design and installation, where possible.. Use native plant policy to disconnect impervious surfaces, reduce impervious surfaces, provide filtration immediately upslope of storm drains and waterways, and prioritize the construction of raingardens, bioswales, and other vegetated retention/detention areas that will help to not only address stormwater concerns, but that also elevate a native plant palette within the Central Campus landscape.

Tree Replacement Policy: Establish a tree planting and replacement policy, including inch-for-inch replacement for all trees removed, and species diversity following from the Sustainable Sites Initiative. For example, if a 10" tree is removed, then 10 – 1`" trees, or 5 – 2" trees would need to be planted in its place. Tree species should be selected to address both species diversity and habitat creation, where appropriate.

Lawn Replacement Policy: Lawn areas that have public access and visibility, but no recreational value should also be replaced with native herbaceous and/or woody vegetation. PIII lawn and former annual beds can be utilized as the first phase of native plant implementation and should be predominantly native vegetation by 2015. Appropriate PII areas should have predominantly native vegetation established by 2020 and appropriate PI areas should have predominantly native vegetation by 2025.

Water Use Reduction Policy: Through the reduction in square footage of lawn campus-wide, a shift in management strategy for large swaths of campus grounds, and through a careful selection of plant species and good soil management practices, the landscape-related use of water will be reduced by 50% by 2020.

Discussion

The following is a more in-depth description and discussion of the policies that we recommend the University adopt to address the goals in sustainability of biodiversity and ecological function outlined above. As a framework for our recommendations in biodiversity and stormwater management, we reference the guidelines and performance benchmarks published by the Sustainable Sites Initiative™,[ix] mentioned previously. In this way, we attempt to ground our recommendations in standards that the University can use to contextualize its biodiversity and stormwater policies, and put credits towards qualifying as a ―Sustainable Site" by the Sustainable Sites Initiative. We also incorporate information from the Southeast Michigan Council of Governments (SEMCOG) ―Low Impact Development Manual for Michigan"[x] which provides best management practices and case studies that are specific to the climatic and cultural challenges found in the region.

Native Plant Cover for Biodiversity and Stormwater Management
Opportunities exist on University grounds to both reduce stormwater runoff and increase both water quality and biodiversity, often on the same site. Based on the results of a stormwater calculation tool recommended by SSI (Center for Neighborhood Technology, 2009), we recommend lawn reduction by 10% by 2015 (from 12,949,304 ft^2 to 8,446,390 ft^2) with 80% of all non-lawn vegetation consisting of native plants (13,701,922 ft^2), performing the double duty of reducing stormwater runoff and increasing native biodiversity. These changes should take the form of plantings and vegetated stormwater management structures, such as bioswales, raingardens and vegetated filter strips. Such features can visually enhance hard surfaced areas such as parking lots and reduce input of water to city storm sewers. Further reduction, possibly up as high as 20%, could be targeted for 2025, should these early efforts prove successful.

Lawn replacement
Identify areas of lawn not essentially associated with Michigan‘s traditional identity or recreation and redevelop to incorporate native plants in an aesthetic way. Traditional ―lawn areas," such as high use areas within the Diag and the Law Quad can be excluded from this recommendation. We recognize that the university has also avoided planting lawn (and in recent years has begun to reduce lawn area) in areas with low public access and visibility to reduce maintenance costs and diversify plant cover. We recommend that lawn areas that have public access and visibility, but no recreational value should also be replaced with native herbaceous and/or woody vegetation. PIII lawn and former annual beds can be utilized as the first phase of native plant implementation and should be predominantly native vegetation by 2015. Appropriate PII areas should have predominantly native vegetation established by 2020 and appropriate PI areas should have predominantly native vegetation by 2025.

<u>Costs and benefits</u>: Regular and effective maintenance is imperative for the sustained ecological success and cultural acceptance of native plantings and vegetated stormwater features. We recommend providing an annual budget of at least $30,000 for invasive removal, prescribed burns and other routine maintenance procedures for native cover and at least $30,000 for the upkeep of stormwater management structures.

<u>Barriers to implementation</u>: The established visual aesthetic of the University of Michigan may slow the acceptance of lawn replacement and native vegetation establishment. It is necessary to demonstrate to University decisionmakers that a shift in planting types need not deter potential University funders, faculty or students, and that instead these new landscapes can be a positive point in the overall image of the University as leading in the field of sustainability.

Tree Replacement Policy

Trees are a valuable ecological as well as aesthetic asset to the University. As a recognized Tree Campus by the Arbor Day Foundation, UM should honor this status and secure the long-term benefits of its campus trees by supporting tree replacement. This would mean providing funds to maintain campus trees in a ―inch for inch" tree replacement policy. In order to maintain biodiversity and create resistance against disease and pests, we recommend the University continue its policy of having no more than 10% of species in one area, and also to expand the scope of this policy to limit trees to 20% of any one genus and 30% of any one family (based on guidelines from the Sustainable Sites Initiative). The university should use the ANSI A300 Best Management Practices for Tree Planting as a guideline, also in order to match the planting standards of the Sustainable Sites Initiative.

<u>Costs and benefits</u>: Forestry services has communicated that an annual budget of $50,000 to $60,000 is sufficient to cover all tree replacement in a typical year. As loss of trees on campus is inevitable due to weather, disease and other natural environmental factors, it would benefit the University's campus aesthetics and ecosystem health to support the replacement of lost trees. This is especially true considering natural processes of tree recruitment are prevented by the regular landscaping practices such as weeding and mowing implemented in the maintained campus environment.

<u>Barriers to implementation</u>: Despite careful management practices, newly planted trees do not have a 100% rate of survival. It is possible that when new plantings fail, a backlog of required new plantings could be created meaning that actual cover-for-cover replacement is not immediate. Where large trees that have shaded buildings for years die, the University must spend money to make up for energy savings formerly provided by the fallen tree and simultaneously to replace the tree. The costs of having to strictly replace every lost tree may cause opposition to increasing total overall tree cover on campus.

Water Reduction Policy

The U-M has already begun to reduce its water consumption on campus, showing in this past year a 3% reduction in water use campus-wide. To move even more aggressively

ACTION 4: Prioritize sustainability and ecological function across campus planning projects. Maximize the use of the campus landscape to address both local environmental issues (such as stream corridor health) as well as global issues such as climate change (through the use of carbon sequestration strategies tied to campus planning and management activities).

Development and Construction Policy: For proposed developments, the university should seek to prioritize sites based on optimal development characteristics that maintain ecological integrity. Favorable site characteristics include slopes ideally less than 10%, have a site construction perimeter/distance greater than 50 feet from a body of water (wetland, stream or river), are situated on areas of previous development that may contain already degraded soils (brownfields), areas adjacent to existing development or infrastructure to promote density, areas with potential for onsite stormwater management or connection to regional stormwater systems and sites that do not contribute to the fragmentation of contiguous natural areas.

Plan Designation of Permanent River and Stream Buffer Zones: Designate U-M property existing within 100‘ of the Huron River, 50‘ from a stream or other body of water as habitat and water quality protection zones, such that vegetation promotes optimal water quality protection and enhancement, floodwater infiltration (if possible), prevents erosion, and that aims to functionally connect with other habitat patches.

Establish permanently preserved conservation zones that protect natural assets: This may include areas in close proximity to rivers and streams, areas of high species diversity and/or contain unique species or habitats, forests with high potential for carbon storage, wetland sites, areas that contribute in the connectivity to the regional natural landscape, existing undeveloped land and sites that important to the management of stormwater.

Landscape policies regarding climate change: Increase the capacity of the University‘s campus to respond to the uncertainties of climate change. This will include maintaining natural areas to promote the increased carbon sequestration, increasing the capacity of the landscape to manage and purify stormwater, increasing the heterogeneity of landscapes to improve their adaptability to changes in temperature and increasing vegetative cover to mitigate the heat effect of a highly urbanized landscape. Because the future land requirements of this research university are uncertain and given the likely changes in climate, it is especially important to preserve existing natural areas.

Landscape policies seeking to increase connectivity at a range of scales: Increasing the connections between the campus and regional landscapes. This may take form in both transportation routes and habitat connectivity. The university should seek to maximize collaboration with non-profits at a local and regional level to ensure that the university and its landscape is more fully integrated into the regional context.

Discussion

Construction Guidelines, Development of Brownfield Sites, and Increasing Density
Maintaining sustainability of the campus and surrounding landscape requires a clear vision of future development to ensure that planning activities align with a common goal. With regards to the overarching goal of the Land and Water section, planning activities of the university should be guided by optimizing ecological function and sustainability of the campus landscape. The plan should address physical development of the campus over the long term in a comprehensive manner that integrates landscape, land use, infrastructure of transportation and utilities, along

with an awareness of the impact and influence campus planning activities have on the surrounding region of Ann Arbor. Sustainable development of the campus should be responsive to the needs of the community as well as the environment in which it resides. For this, it is important to view the campus landscape in more of a regional context rather than a set of greenspaces surrounding university buildings.

Currently, the University recognizes the pressure to develop in a more sustainable fashion but seems to lack a subset of goals and measures to ensure that campus planning and development promotes a desirable outcome. An understanding of the social and ecological benefits of sustainable development may help influence the University to adopt such practices and place them high on the list of priorities.

Though the Sasaki/Andropogon report and the current North Campus Master Plan mention the need to increase density of campus development, the Land and Water team sees it appropriate to highlight this goal once more, this time with special emphasis on ecological benefits to increasing density. Dense development of the campus landscape will help to support the creation of a more socially-vibrant campus landscape, while also serving to help protect water quality in the regional watershed and cost-savings to the university from reduced energy and infrastructure requirements. It also would help to support increased use of mass transit, and could serve as a model for the region in terms of densifying within the urban core.

The EPA report, ―Protecting Water Resources with Higher-Density Development" (2006) addresses the link between stormwater runoff, impervious cover and alternative scenarios of development at multiple scales [xi]. Of particular interest is the study performed at the watershed scale. Before discussing the results, the report states that a healthy, functioning watershed is one that moderates water quality by filtering pollutants and slowing surface runoff to reduce erosion **Error! Bookmark not defined.**. Maintaining these absorbent areas is crucial to regulating the volume and velocity of runoff, frequency and severity of flooding and peak storm events. This has particular relevance in Ann Arbor given its proximity to the Huron River.

Though the study found that percent impervious cover increases with density of development at the site-scale, it is important to note the decrease in impervious cover at the watershed-scale. This leaves more open space intact to filter stormwater, increase air quality, sequester carbon, provide habitat, etc. Interestingly, lawn space and areas surrounding buildings are functionally the same as impervious cover due to the soil compaction from heavy use and construction **Error! Bookmark not defined.**. Therefore, promotion of a dense campus landscape must be considered in light of previous discussions in this report on native plant communities, as well as soil and hydrologic health. Measures to treat stormwater on-site can then be employed to limit the influence of development on natural areas. Table 1 illustrates the effects of varying densities of development on stormwater runoff. Though the study uses houses as a building unit, it could easily be interpreted as any form of structure. Again, development must be considered at the larger regional context.

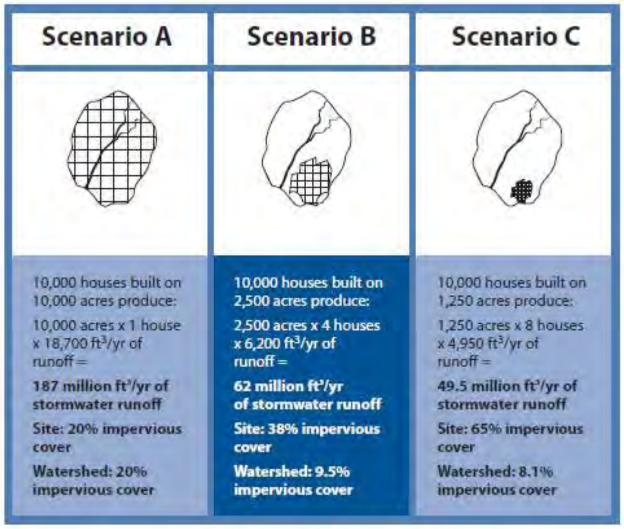

Table 1: Alternative Densities of Development and Stormwater Runoff Generated

This may raise questions among the planning board as to where future development will be occurring if not in the University's undeveloped natural areas. Given that central campus has been developed to its fullest capacity, future development opportunities are mainly limited to North Campus. Though many acres of land are owned by the University in Northeast Ann Arbor, all measures to reduce development in wooded and natural areas should be taken to promote more sustainable forms of a campus landscape.

Many future development opportunities exist on North Campus that lead to a more dense campus through infill and redevelopment of the existing built environment. Doing so will preserve the aforementioned benefits of undisturbed ecological systems while creating a more vibrant campus landscape. The authors of the Working Group's, ―Urban Design for Sustainability" mention a form of devilment referred to as ―decentralized concentration." This refers to development that is beginning to spread away from a core center and out into the periphery. U-M's North Campus seems to be experiencing a similar phenomenon. Decentralized concentration seeks to augment this by creating dense centers, well located within a regional transportation system and environmentally responsible **Error! Bookmark not defined.**.

To create a North Campus which is experienced as something more than a mere extension of Central Campus, development should respond to the natural features of the area. Leaving woodlots intact by promoting dense development will help protect resources but will also provide recreation opportunities for students, faculty and staff. A new identity for North Campus will have been created alongside the protection of the environment.

Besides promoting sustainable and responsible land use, increasing density of campus development is also of economic interest to the University. By situating buildings close to one another, the amount of infrastructure required is reduced and savings to the University will be accrued through time. Fewer and shorter drives will be required as well as sidewalks connecting buildings. Energy savings are also possible from dense development. Energy-saving landscaping and building placement reduces external pressures of heating/cooling load while dense development increases the feasibility and efficiency of district utility systems **Error! Bookmark not defined.**, **Error! Bookmark not defined.**. Fuel costs for transportation are also reduced due to shorter trips taken by buses and other university vehicles [xii].

With these economic benefits, win-win scenarios can be identified that further demonstrate the need to increase the density of development [Error! Bookmark not defined.]. For example, increasing density preserves natural land but also reduces the amount of required infrastructure. Preserving open land around water bodies increases water quality and reduces clean-up costs for municipalities **Error! Bookmark not defined.**. These win-win scenarios can be identified when there are multiple benefits resulting from one action.

For undeveloped sites, the University should refer to a set of criteria that will help guide choices for land-use planning that will protect surrounding ecological systems. Due to the role of riparian areas in maintaining water quality, no development should occur within 50 feet of a waterbody (100' in the case of the Huron River). Similarly, no development should occur on sites with a grade more than 15% since runoff from these areas may overwhelm stormwater management systems or move to quickly for proper treatment before entering waterbodies. The University should seek to site new development on brownfield sites whose soils have already been disturbed. This will reduce the environmental degradation associated with human development. With any new development, the University should use the Sustainable Sites Initiative as a guideline for preferred construction practices.

Barriers to Implementation:

As it stands, few barriers to implementation exist that truly stand in the way of more sustainable land-use planning at the University of Michigan. What may be slowing progress is difficulties with planning and administrative systems, the need for appropriate training and education, slowness in the planning system, the lack of appropriate knowledge sharing systems, the complexity of a holistic vision of land-use and planning, a reluctance of decision makers to accept progressive proposals and the persistence of the status-quo. Though the University has a commitment to remain a leading research institution, ensuring that development activities do not jeopardize the health of the environment and surrounding community should also be understood as a commitment. Though the current planning board may disagree, the two are not mutually exclusive.

Note here that a limit on new development is not being proposed. What is proposed is a more holistic vision of planning activities that place the University in the context of the region and environment at large. Doing so forces decision makers to limit the functional area that development occurs in and generate creative solutions to fulfill both commitments. Growth of the University is possible without increasing its ecological footprint.

In the future, open land will be increasingly scarce. If it is not a leading research University that is taking an initiative to act more consciously in terms of land-use and sustainable development, then who is? As these decisions affect a large group of stakeholders, it is no longer appropriate to be self-centered in the way land is used and developed. It is asked that the University consider its future development projects in the light of this new knowledge and seek to become a model for responsible land-use and development.

River and Stream Buffers

Permanently designating U-M property existing within 100‘ of the Huron River and 50‘ from a stream or other body of water as a vegetation and soil protection zone will ensure that the U-M is able to protect and enhance the quality of the aquatic and riparian resources on its lands in perpetuity. While the U-M currently uses either a 25 or 50‘ buffer in many instances, increasing this distance in the case of the Huron River follows the precedents of many jurisdictions nationwide that are committed to preserving and/ or restoring ecological health to threatened ecosystems such as riparian forests in urban environments. This measure will enhance the surroundings of University infrastructure developed near water in the future, working positively towards a changes aesthetic embracing natural beauty over time.

Vegetation protection zones

Riparian areas should be stabilized (without the use of bulkheads or other hard-surface permanent engineering structures) and planted with native vegetation that is appropriate for the microhabitat. According to the Low Impact Development Manual for Michigan, vegetation and land use in riparian areas should be restricted according to three zones, by distance from the water body:

- Zone 1 (streamside zone): From edge of stream bank to a minimum distance of 25 feet; undisturbed native vegetative cover for the area, such as woody species in forested areas, or grasses or shrubs. This area helps to protect the ecological integrity of the stream ecosystem.

- Zone 2 (middle zone): Extends from end of Zone 1 for a minimum of 55 feet. Consists of undisturbed or managed vegetation. This area should provide distance between upland development and streamside zone (Zone 1), in addition to protecting the stream ecosystem.

- Zone 3 (outer zone): Extends at least 20 feet from Zone 2; native vegetation to prevent encroachment on riparian buffer, but few use restrictions.

<u>Costs and benefits</u>: Initial costs associated with the establishment of a river and stream buffer may be spread over space and time, although the actual cost of establishing these zones is 0 as the university already owns the land; the cost may be instead a ‗sacrificed opportunity cost‘ associated with not being able to build on what might be considered a very aesthetically pleasing site. The benefits of committing to this type of preservation are huge, particularly in terms of ecosystem function, habitat preservation/creation, carbon sequestration, and stormwater runoff filtration.

<u>Barriers to implementation</u>: Historically, the University has resisted permanent land use designations, posing a barrier to the implementation of permanent river and stream buffer designations. Establishing a protocol for addressing existing buildings which violate these buffer

designations may need addressing on a case-by-case basis, increasing the amount of planning and design work associated with the requirement.

Responding to the Uncertainties Surrounding Climate Change
Maintain natural areas to promote increased carbon sequestration, increase the capacity of the landscape to manage and purify stormwater, increase the heterogeneity of landscapes to improve their adaptability to changes in temperature and increase vegetative cover to mitigate the heat effect of a highly urbanized landscape.

Though the University is taking steps to reduce its ecological footprint by adopting LEED for all new buildings, it has not officially established a climate action plan or officially committed to reducing greenhouse gasses. It should.

It is fundamental to incorporate climate action planning into current and future land use management and planning. The ecosystem services provided by natural systems, such as water and air purification, stormwater management, and carbon sequestration, are a significant asset to the University, and are an integral component to mitigating and adapting to climate changes.

As a leading research institute, the University is poised to model and demonstrate a system wide approach to reducing its contribution to global warming. From adopting LEED for buildings and increasing renewable energy to adopting a culture of sustainability and utilizing its landscape as a tool to increase sustainability, UM has the opportunity to exhibit state of the art technology and commitment through a comprehensive approach to addressing campus sustainability. This approach would be incomplete without adequate attention to the ecological function at the site, campus, and regional scale.

As a mediator of temperature, precipitation, infiltration, and wind patterns, the campus landscape plays a direct role in establishing local climate. The uncertainty of exactly how SE Michigan will be impacted increases the pertinence of maintaining the ecological integrity of the University‘s existing natural assets as well as increasing the ability to adapt to environmental change.

This uncertainty demands novel and progressive steps:

New, dynamic planning approaches will be fundamentally different from today's strategies and must be highly adaptive, multidisciplinary, and accommodate a high level of uncertainty. Accommodating climate change will require new development designed for change, transformation of inappropriate existing land uses, and reducing current stressors on ecosystems (e.g., improving ecosystem resilience and resistance to climate change through repairing degraded watersheds, habitat fragmentation, or other degraded natural processes and services, etc.) Sustainable planning approaches must foster regenerative strategies that rapidly transform landscapes to support regional adaptation of both built and natural systems.[xiii]

As a leader of sustainability, the University should seek to increase the campus‘s capacity to mitigate and adapt to climate change. The U-M should also sign onto American College & University Presidents Climate Commitment, which includes analyzing GHG emissions and potential offsets.[xiv] To date, over 650 institutions have already signed onto this effort.

Carbon Sequestration In Campus Trees as a Strategy to Address Climate Change
The value of trees and forest increases as the significance of carbon sequestration is recognized. Sequestration occurs when trees and other vegetation take in atmospheric carbon dioxide during photosynthesis and store it as carbon.[xv] As sequestration reduces atmospheric carbon dioxide, it aids in reducing the rate of climate change.[Error! Bookmark not defined.]

Sustainable forestry can increase forest carbon sequestration as well as support soil and water quality. Carbon sequestration and storage can be increased through planting trees as well as increasing ecological health (USFS). Managing certain forest patches for harvest may increase sequestration and storage as well as provide timber for campus buildings and earn additional LEED credits.

Carbon storage and sequestration by urban trees in the USA is significant. Based on field data from 10 USA cities and national urban tree cover data, it is estimated that urban trees in the coterminous USA currently store 700 million tons of carbon ($14,300 million value) with a gross carbon sequestration rate of 22.8 million tC/yr ($460 million/year).[xvi] In anticipation of future potential carbon accounting and greenhouse gas reporting, or participation in carbon trading markets, woodlands and the urban forest should be maintained for carbon sequestration.

The 2007 Sasaki analysis of North Campus Forests estimated that north campus forest patches (approximately 60 years old) store 5,3252 tons of carbon and sequester 66 tons annually. The monetary value of avoiding externalities is approximately $36,508 dollar value. Although the planted species on campus have previously been identified, without data on the extent of the urban forest, including campus natural areas, it is challenging to estimate potential carbon sequestered on UM properties. There are numerous carbon calculators that may be used to estimate carbon storage.

Increasing Connectivity at a Range of Scales
As previously noted, planning activities of the University of Michigan should respond more to the larger regional context in which it resides and move beyond understanding the university as a functional unit in itself.

Every day, hundreds of people travel to the university from the surrounding region and even more pass through the campus as they go about their business. From an environmental standpoint, more than just people move throughout the campus. As we develop this new way of thinking about the University campus and the way it sits in the regional landscape, it becomes appropriate for campus planning activities to begin responding to the idea of the campus as a conduit for movement of people, animals, plants and water.

Corridors, at a variety of levels, are responsible for facilitating the movement of many organisms. To maintain the functionality of the campus landscape, design interventions that promote and protect regional connectivity may be necessary. Given that connections extend past the boundary of the campus landscape, collaboration between multiple actors under a variety of jurisdictions will be required for the development and protection of corridors [xvii]. To ensure that high quality corridors exist within the region, the University should promote collaboration with organizations such as the Ann Arbor Transit Authority, the Huron River Watershed Council, the

Washtenaw County Conservation District and the Ann Arbor Planning Commission to better meet the needs of its human and nonhuman users.

As ecological components, connective corridors function as habitat and safe areas for movement of animals. These corridors are also of importance to the dispersal of plant species [xviii]. Given that larger patches are able to support a greater number of species, efforts to preserve large contiguous tracts of natural land should be made [xix]. However, small patches are also fundamental for providing ―stepping stones" for movement across a long range [xvii]. The flow of water through ecosystems also demonstrates how landscapes are corridors for movement. Seen in a regional context, effects on water resources in one area are experienced by users downstream. In response, regional design of corridors is needed to create coherence between different areas [xx].

With regards to Ann Arbor and the campus landscape, protection of corridors and open space is important due to the proximity of the Huron River. Many corridors in the region are defined by the movement of water through the Fleming Creek and Huron River Watersheds. The Andropogon/Sasaki assessment reports of a habitat corridor extending from Barton Pond, along the Huron River and northeast along Fleming Creek and Dixboro Road of which woodlots on North Campus contribute to significantly. Woodlots of central campus are less connected to surrounding natural areas but do contribute to overall habitat connectivity by serving as small habitat patches and stepping stones for the larger, more contiguous corridor [xxi]. To facilitate the movement of organisms, campus woodlots should be preserved, if not increased in size and quality. As mentioned previously, for the protection of water quality and the promotion of a continuous riparian buffer, development within 50‘of waterbodies (100‘ in the case of the Huron River) should be prohibited. Collaborating with local groups will ensure that natural areas adjacent to campus woodlots are maintained and habitat fragmentation throughout the region becomes less widespread.

The campus landscape and corridors for the movement of people should also be factored into development activities of the University. Sustainable development will not be achieved if transportation and land-use planning are not understood and treated as integrally linked, since the combination greatly affects the long-term use of land and fuel resources across campus **Error! Bookmark not defined.**[, xxii]. Planning activates should respond to the question of how to bring *people* to the campus rather than cars.

To do so, physical development should align with regional transportation corridors that get used by alternative forms of transportation. Again, the University should collaborate with regional groups, such as the Ann Arbor Transit Authority and the Ann Arbor Planning Commission, to strengthen the connection between the campus and the surrounding region **Error! Bookmark not defined.**[, xxii]. Through this collaboration, alternative forms of transportation should be encouraged and coordinated with the physical planning of the campus and the region. For example, bike routes and complete streets extending through the city can be linked with routes on campus to make a seamless fit between transit systems.

To facilitate the movement of people and increase the feasibility of alternative transportation methods, mainly bike and bus transport, campus development should take place along nodes of transportation. Increasing the density of development along existing major routes will make travelling to the University easier for all commuters **Error! Bookmark not defined.**[, xxii]. The location of the major bus depots on Central and North Campus are effective in encouraging bus transport in the region. By creating a center where both campus and city bus routes overlap, this mode of transit is made more accessible to a wide range of users. Efforts such as this should be encouraged throughout land-use and transportation planning. On North Campus, development should be take place around this center of activity to facilitate the movement between campuses and throughout the region.

Barriers to Implementation:

Barriers to implementation are similar to those previously mentioned for increasing density. Many may be unwilling to invest time and energy incorporating ecological corridors into campus planning activities. It also may be challenging to maintain relationships with regional groups that have different interests. This will be especially difficult for groups such as the Huron River Watershed Council if the focus of the University is too self-centered to include a region in its planning. Though connections between campus and the surrounding region are important for a healthy and functioning watershed and community, the University may feel that time is being misused and more important tasks are being left unattended.

Pressures to ensure that campus density is increased and regional corridors strengthened may need to exist so that campus planning activities do not continue without change. For this, creating conservation zones can restrict the area in which campus development can take place. This will protect areas of ecological value while prompting the University to rethink planning activities to create a vibrant campus community in which energy, resources and community health is conserved.

Costs and Benefits:
Since the U-M already owns the land it would develop, land cost is not an issue. Benefits other than the ones previously mentioned include many economic benefits tied to cost savings related to shared infrastructure, shared paved spaces, and shared parking. Depending upon the type of development and design program, long term cost savings could be considerable.

ACTION 5: Create opportunities to utilize all parts of the campus landscape as a teaching, learning, and research environment. Utilize/test new technologies in the spirit of experimentation and learning as a way of moving both the campus and its population towards a greater level of understanding and achievement in sustainable design, development, and living.

The campus of the University of Michigan holds amazing potential as both a venue for, and an example of, sustainable design, planning and management. Faculty, students and staff should make full use of this invaluable resource in both formal (i.e., course offerings, outdoor walking tours, workshops), informal (self-guided tours, educational signage, informal discussion sections), and revelatory (artistic bioswales, visual interpretations of natural process, solar _gardens') ways. There are many ways to do this, all of which could serve to highlight intentional design decisions and their implications in a manner that not only informs people about what is happening right before their eyes, but also that it shows them, first hand.

Campus As A Classroom Policy: Create a campus landscape/environment that educates members of the community about the sustainability in general, and about the sustainable development practices occurring in the landscape and planning activities occurring on the UM campus. Develop signage that educates students, faculty, staff, and visitors to campus about the ecosystem functions and sustainable design practices in place on the U-M campus. Develop web-based maps as well as print media (flyers, booklets) illustrating sites and activity on campus, focusing upon sustainable design and practice.

Discussion: Campus as a Classroom
To develop a constituency for sustainability at the U-M, thinking about how the place itself conveys the message and illustrates strong, positive methodologies and practices is clearly ‗low-hanging fruit' when it comes to how we might teach our community. While the cost of signage over time might be significant, thinking both about a phased-approach (5 signs per year) as well as a multi-media approach (web, print, guided tour) and how that might build upon the current efforts of PlanetBlue and other groups to ‗get the word out'. In addition to passive learning opportunities, actively soliciting faculty to utilize the campus landscape as exemplars for discussion, for venues for exploration and study, or for more developed research projects about urban sustainability would both encourage engagement with the campus environs while also serving to potentially publicize the efforts of the U-M through publications, podcasts, web pages, and more.

These actions would not only serve to create a more well-educated and aware constituency for sustainability on campus, it would also serve to create a constituency that had an active interest in the care and management of their place. The U-M could take advantage of this through coordinated efforts with student groups and others to take on specific management, maintenance and/or construction projects that would both help keep costs down and more deeply connect people to their physical community. Lastly, these kind of lessons and messages translate very well beyond the boundaries of the U-M; creating a constituency that cares about sustainability, and that has experienced it first-hand, and then having them disperse around the globe truly takes the U-M commitment to sustainability and makes it a global presence over time.

Integration & Conclusion

Integration of these goals and action items with those of other teams is in some cases virtually seamless, while in others, given the unique nature of some goals pertaining to issues/topics specific to landscape issues, the integration will be less overlapping and instead more complementary. Of the five major areas of focus of the Land and Water Team, the incorporation of the **Sustainable Sites Initiative Guidelines and Performance Benchmarks** into both the planning/design and management/maintenance protocols is perhaps the easiest to accomplish, and possesses an extremely high level of overlap with the Buildings group and the LEED system utilized for current work on campus. According to the SSI website, LEED is currently in the process of adopting SSI as a companion-program, which should, in the not-too-distant future, mean that LEED ratings and SSI ratings will be directly linked and supportive of one another. The U-M has an opportunity to get out ahead of the curve by adopting SSI as the landscape equivalent to LEED; doing so for new projects, renovations, and campus planning and management/maintenance protocols would place the U-M alone and at the head of sustainability planning and practice among colleges, universities and other large institutions. In addition to the Buildings team, the SSI is also directly related to other group‘s work as well, including Transportation, Food, Energy, Purchasing/Recycling, and Culture. In each case, the SSI offers both an integrated rationale as to why one practice or strategy might be better than another, and describes potential metrics to utilize in evaluating both their impact individually and in concert with other, related actions/decisions.

A large number of goals/issues that the Land and Water Team addresses has very strong links to the Culture Team‘s work, primarily in terms of how a changed planning/management regime would alter, over time, the campus landscape aesthetic; across all of the Culture Team‘s ‗Aspects' (Economic, Environmental, and Social), this change in aesthetic could impact how people perceive both the landscape and the U-M. Understanding how students, faculty, staff and visitors to campus might react to less lawn, more native plant communities, a few more ‗weeds' or unmown areas, and less ‗lush' landscaping due to lower water use will be key to issues such as student and faculty recruitment and retention, how the U-M community understands and cares for its environment, and how visitors to campus perceive the place.

Other issues that cross team boundaries are the Land and Water Team‘s proposals regarding reduction in impervious surfaces (crosses with Transportation goals relating to parking/land use), linking open space systems with larger regional systems (again, linking to the Transportation Team‘s goals pertaining to Transportation Habits and Bike/Pedestrian options), use of geothermal resources to heat pavement as a snow/ice management strategy (tied to Energy Team‘s Geothermal goal), tree replacement policy, riparian buffer, carbon sequestration, and native plant community policies (Energy Team‘s Biomass goal). The Land and Water Team‘s goals associated with Planning for Sustainability and Increasing Density are directly tied to and supportive of the Transportation Team‘s goals pertaining to Mass Transit, serving to make more economically viable any proposal relating to an expansion of both on campus transit and more regional transit efforts. Finally, the Food Team‘s goal of a University Farm/on-campus food production, while not specifically overlapping of a single goal of the Land and Water Team, is extremely compatible in spirit and in practice with the idea of creating a more sustainable community.

		Phase 2 Prioritization Matrix								
		Economic Aspects			Environmental Aspects			Social Aspects		
	Level of Impact 5 - Very High 4 - High 3 - Medium 2 - Low 1 - Very Low	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Visibility	Learning/Research Opportunities
Land and Water Team Recommendations	Action 1 - Sustainable Site Initiative Standards	2	2	2	4	4	4	3	4	4
	Action 2 - Landscape Management/Stormwater Management	2	3	3	4	4	5	4	3	3
	Action 3 - Increase Biodiversity/Native Plant Use/jWater Use Reduction	3	2	4	3	4	4	Not applicable	4	4
	Action 4 - Planning for Sustainability/Address Loca/Global Issues	3	Not applicable	3	5	4	4	4	4	5
	Action 5 - Use Campus for Teaching, Learning, Research and Outreach	2	2	3	Not applicable	Not applicable	Not applicable	3	5	5

Land and Water Team Prioritization Matrix

Note: This matrix provides some measure of comparison for the five actions suggested within this report across several common _aspects‘ (economic, environmental and social) that all of the other team‘s actions are being similarly measured against. Because the Land and Water Team‘s suggested actions are in some cases very different in nature (following planning guidelines to set permanent buffer zones versus reducing chemical use, or managing the campus forest for carbon sequestration versus utilizing the SSI Performance Benchmarks), drawing comparisons in this type of matrix is not an exact science. In some cases, there is _low hanging fruit‘ that has low capital and operating cost but high potential impact (establishing permanent riparian buffer zones, or shifting towards a predominantly native plant community strategy for campus plantings), while others may have low cost impact but be more difficult to implement (the implementation of the SSI Performance Benchmarks across all campus properties and projects). In the case of the Land and Water Team, most of our suggestions fall in the low- to medium cost range, but have medium- to high-impact in terms of both the environmental and social aspect represented on the matrix. The payback is high for a number of reasons, although the the most easily explained component of this is tied to the fact that the campus landscape is something that we all share, and all experience, every time we come to the university. It is inherently present, highly visible, and very well suited to support and encourage dialog regarding sustainability across contexts and scales. For more detailed information regarding the economic evaluations associated with this matrix, please see the appendix.

Appendix

Level of Impact
5 - Very High
4 - High
3 - Medium
2 - Low
1 - Very Low

Land and Water Team Recommendations

	Economic Aspects			Environmental Aspects			Social Aspects					
	Capital Costs	**Operating Costs**	**Payback**	**Climate**	**Ecosystem Health**	**Materials Footprint**	**Human Health**	**Community Awareness/ Visibility**	**Learning/Research Opportunities**	**Recommendations**	**Assumptions**	**Risks**
Action 1 - Sustainable Site Initiative Standards	**2** - Costs associated with adopting a certain standard	**2** - Costs associated with adopting a certain standard	**2** - Reduce Water usage, native plants, recycling	**4**	**4**	**4** - Use of local materials, recycling, improved watershed	**3**	**4** - An accepted standard	**4** - Standard is an educational tool	1		
Action 2a - Landscape Management	**2** - Replacement Costs only	**3** - Cost would include more workers, mulch from composting	**3** - 30k-55k per year benefit	**4** - No pesticides & herbicides usage	**3** - Natural growth but poor soil conditions exist	**5** - Reduction of Chemicals usage	**3** - No Chemicals but could be problem for Medical grounds	**4** **- Preservation of landscape**	**3** - Chemical free grounds education	1		
Action 2b- Stormwater Management	**3** - Replacement of surfaces and storm drains	**2** - Little maintenance after installation	**3** - Low maintenance. Currently 13% of land are parking lots, creating ample opportunities	**3** - Improved Watershed	**3** - Improved Watershed	**3** - Potential additional concrete use for Storm water storage	Not applicable	**3** - Modification to Parking lots	**3** - Impervious Surface replacement education	1		
Action 2c - Snow Removal	**3** - Installation of heated pavement / Permable Surfaces	**1**	**4** - Reduction of Snow Removal, Maintenance	**3** - Reduction of Salt & Chemical use	**3** - Reduction of Salt & Chemical use	**4** - Reduction of Salt & Chemical use	Not applicable	**1** - Some paths would be uncleared	Not applicable	2		
Action 3a- Increase Biodiversity	2 - Replacement Costs only	**2 - Little maintenance after installation**	**2 - Reduce Water usage, native plants, recycling**	3 - Improved Watershed	4 - Increase of biodiversity + health	4 - Use of local materials, recycling, improved watershed	4	**4 - Preservation of landscape**	5			
Action 3b -Lawn Reduction	**2 - Costs associated with adopting a certain standard**	No operational costs	**1** - Benefits are more from a qualitative perspective	**5**	**4** - Increase in watershed and biodiversity protection	Not applicable	**3**	**4** - Preservation of landscape	**4** - Preservation of landscape	- Protect Land - Canopy Cover - Transportation routes - Construction limits	2	
Action 3c - Water Use Reduction	**3** - Costs for fixing pipes, water saving heads	**1**	**3** - Range between 40k-80k in Savings	**3** - Less reliance on watershed	**4** - Increased watershed protection	Not applicable	Not applicable	**1**	Not applicable	2		
Action 3d - Native Plant Cover	**2**	2 - Native plants require less maintenance	**Water usage, native plants**	**3**	**4** - Increase in native biodiversity	Not applicable	**3** - Potential Allergy / Medical school policy issues	**3** - Landscape alternation to native plants	**2** - Increase in Native plants Education	3		
Action 3e - Tree Replacement Policy	**2 - Cost to plant trees and providing soil** #NAME?	**3 - Cost would include more workers, mulch from composting**	**4** - Return of $1.5-$3 per dollar invested per tree	**3 - Improved Watershed**	**4 - Increase of biodiversity + health**	3 -Improved local climate and watershed health	**climate and urban heat**	**5** - Landscape alternation due to additional tree cover	**4 - Tree diversity and importance of tree cover education**	1		
Action 4a - Planning for Sustainability	3 - Could be some cost increase due to change in practices	**3** - Could be some cost increase due to change in practices	**2** - Long term payback not quantifiable at this time, but could be significant	4 -Positive impact on ecosystem health, transportation benefits, carbon reduction	**4** - Increase of biodiversity + health	aterials, recycling, impr	**climate and urban heat**	**4** - Change in landscape character would be highly visible and communicative of commitment	4 -High potential for research at a range of scales	1		
Action 4b - Ecological Function	3 - Forgiving value of land, Establisment/Adoption of new routes	No operational costs	**1** - Benefits are more from a qualitative perspective	**5**	**4** - Increase in watershed and biodiversity protection	aterials, recycling, impr	**3**	**4** - Preservation of landscape	**4** - Preservation of landscape	- Protect Land - Canopy Cover - Transportation routes - Construction limits		
Action 4c - EstablishingPermanent Riparian Buffers	3 - Forgiving value of land, Establisment/Adoption of new routes	No operational costs	Hi ecological payback, little economic payback	**4 -Positive impact on ecosystem health, transportation benefits, carbon reduction**	**5 Maintains and enhances habitat connectivity**	Not applicable	**4 - Improved water quality in region**	5 Very visible, permanent commitment to ecosystem health	4 -High potential for research at a range of scales			
Action 5 - Campus As Classroom	**2** - Some initial costs, but minimized over time	No operational costs	**1** - Benefits are more from a qualitative perspective	**it re: sustainable urban**	**4** - Increase in watershed and biodiversity protection	Not applicable	**3**	5 - Landscape becomes a focal point for all to see	5 - Local environment becomes classroom/laboratory ; lessons transferrable beyond U-M	- Protect Land - Canopy Cover - Transportation routes - Construction limits	2	

Land and Water Team Annotated Matrix

[i] Sustainable Sites Initiative. 2009. *The Sustainable Sites Initiative: Guidelines and Performance Benchmarks 2009*. Available at http://www.sustainablesites.org/report.
[ii] *Chemical-Free' is meant to mean zero synthetic soil amendments*
[iii] In certain, limited circumstances, some chemicals may need to be used to address highly invasive exotic plants, or pest infestations that are uncontrollable otherwise. Ideally, these would be very infrequent occurrences, but allowable under these guidelines.
[iv] This could be expensive and risky to adopt on a large scale, at least within a short time. However, research and innovation are a major part of UM's mission, so a pilot project testing the use of geothermal heating in permeable paving in a real-world setting would be very appropriate. As a precedent to consider, Oberlin College's Lewis Center for Environmental Studies, finished in 2000, was recently voted the most important green building in the US in a survey in Architect Magazine. This ―zero energy" building uses geothermal heating and cooling.
[v] 35% is the number typically cited by the Center for Watershed Protection as the tipping point for urban stream health. Impervious cover greater than 35% typically guarantees that streams will continue to degrade with little or no chance for a restoration of ecosystem function.
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UNIVERSITY OF MICHIGAN

CAMPUS SUSTAINABILITY INTEGRATED ASSESSMENT

FOOD ANALYSIS – PHASE II REPORT

January 14, 2011

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I. EXECUTIVE SUMMARY

In Phase II, the Food Team focused on providing implementation ideas that could serve as a "playbook" for operations staff who are working to advance food sustainability on the U-M Ann Arbor campuses. The action plan and implementation ideas that follow are not a mandate, rather they are a set of strategies that we feel will be particularly powerful in advancing the cause of campus sustainability. They strike an essential balance between achievable, short-term objectives (i.e. Campus Farm/Garden) and much more difficult stretch goals (i.e. Replace Bottled Water with Municipal (tap) Water). If implemented, these strategies will send a strong and clear message to students, faculty, staff, alumni, and the world, that U-M is taking the challenge of sustainability seriously.

Our first prioritized recommendation is to **Reduce Food-Related Waste by 20% by 2020**. We identified three implementation ideas that provide a comprehensive path to overall waste reduction: *Increased Composting, Replacing Bottled Water with Municipal (tap) Water,* and *Tray-less Dining.* Key benefits associated with these strategies include:

- **Increased Composting:** Responsible reuse of "waste" materials; Passive education of campus diners; 28% or more reduction in material sent to landfill; Reduced greenhouse gas emissions during decomposition process; Production of soil amendment for use in campus landscaping, garden/farm.
- **Replace Bottled Water with Municipal (tap) Water:** Prevent over 600,000 plastic bottles from entering U-M waste stream annually; Leadership will provide significant sustainability learning opportunities and HUGE reputational benefit; Build sustainable habits that last a lifetime; Prevent the emission of over 80 tons of CO_2; Prevent over 40,000 gallons of water from being wasted.
- **Tray-less Dining:** Focus on *preventing* waste rather than *managing* waste; 263,500lbs (34%) or more reduction in annual edible food waste in dining halls; Corresponding reduction in food procurement costs and dishwashing costs; Creates opportunities to educate students about food waste and sustainability.

Our second prioritized recommendation is to **Purchase 20% of Food from Local Sources by 2020**. The three implementation ideas our team identified for this recommendation focus on overcoming the institutional barriers associated with local sourcing: *Create a "Local Food Forager" Position, Adopt a "Local/Sustainable" Food Labeling System,* and *Start a Campus Farm/Garden*. Key benefits associated with these strategies include:

- **Local Food Forager:** Provides a centralized local food expert for U-M; Assists all U-M buyers (and Sysco) with finding cost-competitive local food sources; Assists local farms/processors with navigating U-M contracting, insurance, GAP/GHP requirements; Manages Local/Sustainable food label; Markets local food options to U-M buyers; Tracks progress of 20% local goal.
- **Local/Sustainable Food Label:** Helps campus users/purchasers make sustainable choices; Combines complex components of sustainable food production into one standard.
- **Establish a Campus Farm/Garden:** Passive learning about Michigan's diverse local agricultural product; Is becoming a standard piece of university campus infrastructure

and U-M needs to catch up!; Venue for student groups and faculty to pursue community-based or urban agriculture study. Opportunity for campus users who are passionate about food to "get their hands dirty."

This report contains suggested phased implementation schedules for each strategy. It also contains a discussion of the specific barriers associated with each idea. Most of these ideas are not direct money-savers. Tray-less dining in residence halls will likely provide significant cost savings, and we recommend rolling these savings into financing other sustainability initiatives (such as increased local food sourcing). However, because the food service units on campus do not receive support from the general fund, financing many of these initiatives will be a significant challenge. We strongly encourage the university to provide special funding to establish these programs when necessary, and that units work with the Office of Campus Sustainability to create long-term plans to finance their continued operation beyond this initial period of support.

II. INTRODUCTION

In Phase II, the Food Team focused on developing implementation ideas that will help U-M operations staff put our prioritized recommendations from Phase I into action. Our team consisted of both Phase I veterans and new team members with fresh perspectives, all intensely engaged with the campus sustainability effort (see Appendix 1 for team member bios). Our team sought to involve U-M operations staff in all relevant units, casting a wide net (see Appendix 2 for a list of meetings with U-M staff persons). We found that U-M staff are already working hard to make their units more sustainable, but face obstacles related to limited funding, incomplete information, and limited staff time. These talented individuals are well-positioned to take on the challenge of implementing the stretch goals that the Campus Sustainability Integrated Assessment will suggest, but will require support from university administration and the campus community to meet them.

The goals and implementation ideas in this report are primarily the work of the Food Team. While we found great enthusiasm for our overall goals among U-M operations staff, not everyone agreed with some of our ambitious stretch goals/implementation ideas. We worked hard to address as many barriers and staff concerns as possible in this report, but we recognize that the real work will be done by these passionate U-M operations staff persons. We encourage all U-M staff to set goals high, build on the important work you have already begun, and push yourselves to question and identify established practices that are unsustainable. Only through your continued diligence and superb professionalism can we achieve a sustainable campus!

III. ACTION PLAN

Prioritized Recommendation A: Reduce Food-Related Waste by 20% by 2020

Our research from Phase I of the Campus Sustainability Integrated Assessment (CSIA) revealed that food-related waste is a problem at U-M. Trash sorts conducted in 2007 and in 2010 found that large portions of the waste stream consisted of beverage containers, food packaging, and organic food waste (over 50% for some buildings). We found that many universities struggle with these same problems and through case study research we selected what we feel are the most appropriate and innovative strategies for reducing food-related waste at U-M. The three implementation ideas we selected are: *Increase Composting* (including both pre and post-consumer composting), *Replace Bottled Water with Municipal (tap) Water*, and *Tray-less Dining*. These strategies will not only reduce waste at U-M to a more sustainable rate, they have the potential to create significant sustainability education opportunities, enhance the university's reputation, and send a clear message that U-M is serious about pursuing sustainability.

Implementation Idea #1: Increased Composting

As shown in Table 1 below, a 2007 campus waste audit conducted by U-M Recycling Coordinator, Tracy Artley found that compostable materials accounted for 28%-73% of total weight of the refuse from the buildings audited. These results suggest that expanded composting programs could significantly reduce both the weight and volume of waste sent to landfill on the U-M Ann Arbor campuses.

Table 1. Compostable Material Found in U-M Waste Stream, 2007 Trash Audit

Building Category	Building Name	Compostable Material (Weight)	Compostable Material (Volume)	Percent of Total (Weight)	Percent of Total (Volume)
Administrative	Student Activities Building (SAB)	274	15.95	41.5%	36.1%
Classroom	Angell/Mason/Haven/Tisch Halls	272	24.53	34.0%	42.3%
Research	Life Sciences Institute (LSI)	495	8.45	73.1%	32.9%
Residence Hall	Mary Markley Hall	572	17.28	35.1%	23.1%
Unions	Pierpont Commons	896.5	22.47	54.7%	30.2%
Recreational	Central Campus Recreation Building (CCRB)	45	3.58	28.3%	30.1%

Source: Tracy Artley, U-M Recycling Coordinator

Environmental benefits of composting

Composting is regarded as a sustainable practice because of its significant contribution to the improvement of climate, ecosystem health, and material footprint.

- Composting reduces the amount of organic waste going to landfill and incinerators and decreases the amount of methane emitted during the decomposition process.
- The use of compost as fertilizer and topsoil reduces the need for chemical fertilizer, supplemental water and pesticides. It improves soil health and structure, and increases drought resistance.
- Composting practice also helps reduce materials footprint by diverting food waste from landfill and incineration.

Composting practices in leading universities[i]

- **UC Berkeley:** 100% of Cal dining facilities have pre-consumer composting programs. The university annually composts over 500 tons of post-consumer waste, and initiated a to-go container composting initiative that sources to-go containers and pizza boxes made from bagasse.
- **Harvard University:** 60% of pre- and 65% of post-consumer food waste is composted from almost all dining halls.
- **Stanford University:** 100% of pre- and 98% of post-consumer food waste is composted.
- **University of Pennsylvania:** 90% of pre- and 75% of post-consumer food waste is composted.
- **Dartmouth College:** 100% of both pre- and post-consumer food waste is composted.
- **Ohio State University - Columbus:** compost 100% pre-consumer waste and 70% post-consumer waste at the Ohio Union.

Out of Big Ten universities (including Nebraska), seven currently have pre-consumer composting programs in place, and four of them include post-consumer composting. For a complete list of composting practices at Big Ten universities and other peer institutions, refer to Appendix 3.

We recommend a campus-wide pre and post-consumer composting program. We believe that over time the university will be able to achieve 100% pre-consumer and post-consumer composting throughout the campus. In order to achieve this we suggest a phase-by-phase roadmap and action plan.

Phase 1– Establish regular food waste audit

Food waste audits allows us to understand how much waste in each building is going to landfill now and to evaluate how much it becomes after implementing waste reduction strategies. A trash audit on a regular basis (annually or biannually) enables the university to keep track of the progress of campus waste reduction efforts.

The latest refuse sort of campus buildings happened in the week of March 19, 2007 for a total of 6 buildings representing 6 building categories: administrative, classroom, research, residence hall, unions, and recreational. This waste audit effort presented us a clear picture of the composition of refuse on campus and potential diversion of waste from landfill. Due to the fact that waste audits are very time and labor intensive, we recommend limiting audits to the minimum extent necessary to establish a baseline and track progress towards the goal. Tracy Artley, U-M Recycling Coordinator suggested that this could be accomplished with an annual audit of just a few buildings. We suggest a more ambitious audit that would incorporate at least 10% of campus buildings per year, with multiple building types represented.

Phase2– Expand pre-consumer composting program (100% participation by 2015)

The university has a pre-consumer food waste-composting program in place. However, participation in this program is still sub-optimal. Compostable waste is collected by kitchen workers in plastic bins and later picked up by University Waste Management Services and taken to the City of Ann Arbor's compost site. The cost to participating units is $16.30/pickup/cart. City of Ann Arbor's compost center currently only accepts pre-consumer compostable waste. The food service units participating in the pre-consumer composting program in 2009 included:

Six out of the nine full-service dining halls (Bursley Hall, Oxford and North Quadrangle did not participate), the primary University Catering Kitchen in Pierpont Commons, The Glasshouse Café in Palmer Commons, and MUJO Café in the Duderstadt Center. The ROSS School of Business has a separate composting contract. Table 2 below summarizes the current success and costs of the pre-consumer composting program in 2009.

Table 2. Summary of pre-consumer composting in 2009.

	2009 Waste (tons)	2009 Composting Cost ($)
Betsey Barbour House	4.08	2021
Duderstadt Center	4.40	2209
East Quadrangle	10.35	5200
Mary Markley Hall	6.15	3064
Hill Dining	15.16	7620
Palmer Commons	1.73	880
Pierpont Commons	4.85	2445
South Quadrangle	6.59	3309
West Quadrangle	10.51	5412
Total	**63.82**	**32160**

Source: Tracy Artley, U-M Recycling Coordinator

Our recommendation is to expand pre-consumer composting throughout the campus. 100% implementation would include all Dining Halls, Michigan League, Michigan Union, and other restaurants/eateries on campus that prepare food on site. We estimate that the expansion of pre-consumer composting to include the three dining halls that did not participate in 2009 will result in the diversion of 24.7 tons of waste each year. We also estimate that expansion to the Michigan League and Michigan Union will result in an additional 14.5 tons of annual waste diversion, assuming that the ratio of compostable waste to total waste in these buildings is similar to Pierpont Commons. In total, we estimate that 100% implementation of pre-consumer composting will be able to divert an additional 39 tons of food waste from landfill annually (an over 50% increase in material diverted). For more detailed information about the calculation process of this estimate, please refer to Appendix 4.

Because each building has unique facilities and operating condition, we suggest that staff leaders from Residential Dining Services, University Unions, and OCS conduct building-by building audits before the implementation of composting. The audit will help to identify barriers to implement composting in each building and set up realistic goals. The following are some of the examples of the operational challenges dining hall managers have reported:

1. **Lack of space:** Bursley Hall and North Quadrangle do not have enough space to store and load post-consumer waste as currently configured. We recommend that OCS and dining hall managers work together to find other solutions on a building-by-building basis.

2. **Additional cost:** Currently the annual cost for composting practices in 9 buildings is around $32,000, which adds up to the total operating cost of food services.

The following is a comparison between the cost of refuse disposal and the cost of pre-consumer composting:

- *The average cost for the disposal of refuse is between $160-$220/ton.*
- *The average cost for composting is around $500/ton.*
- Taking into consideration the cost savings from reduced refuse disposal, the incremental aggregate cost of the pre-consumer composting program is about $280-$340/ton and a total of $18,000-$22,000/year.
- This difference is largely attributable to increased labor and equipment costs.

3. **Operational difficulty:** the storage of compostable waste might attract pests and rodents, so higher frequency of pick-up might be necessary. However, more frequent pick-up might incur higher cost. Also, participants are currently required to wash their own bins, but they are not well equipped with the facility to do so. One response to these issues has been to install refrigerated storage space for full compost bins. However, we feel that the energy expended on refrigeration seriously compromises the environmental benefits of composting. We encourage U-M Recycling and OCS to work with composting participants to find other solutions to these challenges, such as daily pickups.

Phase 3 – Start post-consumer composting program

Our Phase 3 recommendation is to start post-consumer composting practice on campus. We recommend starting on a pilot basis in 1-3 buildings and expanding the program as interest and funding develops. We believe the goal should be to eventually include:

- All residence and dining halls

- All buildings with food service or frequent catering, such as: Michigan League, Michigan Union, Pierpont Commons, and Palmer Commons.
- Other buildings, including academic buildings and other auxiliary units who express an interest in participating.

To explore the possibilities of post-consumer composting, University Waste Management Services is working together with outside consultants, conducting studies on implementation details and cost-benefit analysis. We chose not to duplicate the efforts of the consultant team in our work for Phase II. Their report was not available at the completion of Phase II, however it is expected early in 2011.

Besides the cost mentioned above, from the perspective of composting service users there are additional operational and financial challenges associated with post-consumer composting, including:

1. Extra cost to cover composting tipping fee. Here, we assume the tipping fee breaks even with the operating cost to maintain composting site and the hauling cost. (Exclude the depreciation cost of initial capital investment)
2. Extra cost to provide composting receptacles around campus and to use compostable garbage bags.
3. Sourcing of compostable food wear and food packaging.
4. Consumer education and staff training.
5. Introduction of unpleasant smell, pests and rodents.
6. Potential contamination of compostable waste and the necessary sorting of the contaminants.

<u>Potential Solution to Implementation Barriers</u>

Out team conducted some analysis of the implementation barriers mentioned above and did some research about potential solutions. While it is hard to exhaust the financial and operational details at this stage, we hope further feasibility analysis to be conducted with the operational staff before the actual implementation of these recommendations.

1. Building-by-building audit: because of the differences in facility and operating condition in each building, a building by building audit needs to be conducted before the implementation of composting.

2. The university could create an incentive for buildings to "opt-in" to composting practices, such as providing a proportion of capital investment to retrofit existing building facilities etc. Of course, there should be a case-by-case analysis based on the financial investment needed and environmental benefits generated.

3. Hauling costs might be reduced for pre-consumer composting with increased scale of the practice. As identified by Waste Management, the tipping fee for composting and refuse are not that much different ($40/ton and $30/ton respectively). The major difference is the labor and equipment costs. For example, there are 1 or 2 drivers collecting such a small portion of the waste stream, all of their labor costs go into the composting rate.

Additionally, all costs associated with the food waste truck go into that rate as well. We believe with the expansion of existing program, the price difference in composting and refuse disposal will be reduced.

4. Add a term in the contract with licensed eateries to require their implementation of pre-consumer composting. Most of the eateries on campus prepare food on site to some degree. It would significantly expand the scale of pre-consumer composting practice if the University can negotiate new contract with the eateries and encourage them to adopt pre-consumer composting.

5. Pilot projects. To overcome implementation barriers for post-consumer composting practices, food operators can conduct pilot projects before the university making capital investment to build composting facility. The composting site (Tuthill Farm) that Ross is using still has extra capacity to accept food waste. However, Tuthill Farm is farther than the city's composting site, and the farm requires contamination to be controlled below a certain level (~5%), thus the additional cost associated with hauling and potential hand sorting of contaminants need to be considered in the pilot projects.

6. There are some operational experiences from the post-consumer composting practice at Ross School of Business. For example, using an outside firm who specialize in sourcing compostable food ware and food packages to help identify providers. Engaging student groups in the education of student body, and effectively reduce contamination. (See Appendix 5 for a case study of the Ross School of business post-consumer composting program).

7. Zero-waste event. As a start point, MSA can provide grants to cover the cost of composting for certain events, thus encourage student organizations and university branches to increase composting at campus events.

<u>Choices for Waste Management</u>

From a technical stand point of view, there are 6 kinds of composting methods: Backyard or Onsite Composting (including Grass-cycling), Vermicomposting, Aerated (Turned) Windrow Composting, Aerated Static Pile Composting, In-vessel Composting. The pros and cons for each method are summaries in Appendix 6. Due to the fact that on campus waste has a high proportion of food scraps, which contains protein and grease, in vessel composting method will be most technically feasible to deal with the large amount of food waste.

Based our research, there are four potential choices for the university to begin a post-consumer composting program:

1. U-M starts its own on-site in-vessel composting facility to deal with both pre and post-consumer compostable waste generated on campus. However, the total amount of compostable waste is too small to reach the critical mass and achieve economy of scales. As a result, the on-going operating expenses will be comparatively high. There is also challenge with finding suitable site for composting facilities.

2. City of Ann Arbor is outsourcing its composting operation to a New York-based company called WeCare Organics. The company is going to take over the site in February or March 2011. The University can also partner with WeCare Organics and build in-vessel composting facility for the whole city. Thus, with local restaurants and other businesses joining composting practices, per unit operating cost will be greatly reduced.

3. Transport the waste to other composting providers. However, based on research, currently there are not private providers of post-consumer composting within economic distance who can process the large amount of food waste generated on campus.

4. Other alternative choices: Several students from engineering school and business school are experimenting with an aerated digester. If their project is approved feasible for campus wide practice, University of Michigan will become the first university using the composting facility designed by its own students. The ongoing operating cost of the digester needs to be further tested and confirmed. In addition, involving the talents on campus and organizing students to run the facility and improve its performance can contribute an important educational piece of this project too.

Implementation Idea #2: Replace Bottled Water with Municipal (tap) Water on Campus

One of the most visible sources of waste at the University of Michigan are the thousands of disposable plastic water bottles found almost everywhere on the Ann Arbor campuses. In our conversations with faculty, staff and students during Phase One of the integrated assessment, we were consistently told that if U-M really wants to do something about food sustainability, then something must be done about disposable plastic water bottles. The University purchased almost 600,000 bottles of water in FY10. Many of these were sold in campus convenience stores, athletic events, and vending machines. Bottled water is also onstage at virtually every campus lecture or event. It is so common to see bottled water front-and-center at university functions that one might logically assume U-M is being paid by the industry to highlight their product (this is of course true for some athletic events). This implementation idea deals only with university-provided (through sales or otherwise) water. We recognize that individuals may occasionally bring bottled water with them to campus and do not think it is the place of the university to regulate such activity.

Bottled Water is a Growing Sustainability Issue on University Campuses

Recent bans of bottled water on North American university campuses show that this cause is gaining steam and that U-M has an opportunity to show leadership as a relative first-mover. Particularly notable is that students are the constituency leading these efforts. At McGill University in Montreal, ON, students voted to eliminate bottled water from student-controlled facilities and to lobby university administration to eliminate it from the entire campus (see Appendix 7 for a copy of their formal resolution). When Bishops University in Sherbrooke, Quebec put the question of a gradual elimination of bottled water to a student vote, 74% voted in favor of the ban with a 37% voter participation rate[ii]. Washington University in St. Louis received significant press coverage when they banned bottled water from their campus in 2007 (the first U.S. university to do so). Multiple student groups at U-M have staged recent events highlighting the negative effects of bottled water. With this commitment, U-M has an opportunity to be the first major research university in the U.S. to replace bottled water with tap water. Setting this stretch goal will send a clear message that U-M is serious about sustainability.

Negative effects of bottled water

Our research indicates that bottled water is a growing sustainability concern. The rapid growth in the popularity of bottled water has raised concerns not just over waste, but also environmental impact, social justice, and the long-term viability of municipal water systems. If implemented, this campaign will enable all campus users to participate in a living-learning experience where they will receive daily reminders about the importance of water conservation and the impact that their food purchasing habits have on our environment. This implementation idea will also provide opportunities for all campus users to reflect on the importance of municipal water systems to the campus community and the wider society.

The production, distribution, and consumption of bottled water results in significantly higher rates of energy consumption, wasted water, waste sent to landfill, and greenhouse gas emissions, as compared with municipal (tap) water. One study found that tap water results in less than 1% of the total environmental impact of bottled water (Jungbluth, 2006)[iii]. A full life-cycle analysis recently completed by a U-M Masters student in the School of Natural Resource and Environment, Christopher Dettore (2009)[iv] found that even when accounting for the washing of reusable containers, tap water had a significantly lower impact in every category measured (waste, energy, GhG emissions, water). Using environmental impact figures from Dettore's lifecycle assessment, we estimated the annual environmental costs of bottled water consumption at U-M. Table 3 below shows that replacing bottled water with municipal (tap) water could prevent over 8 tons of solid waste per year (some of which is currently recycled), stop over 40,000 gallons of tap water from being wasted annually, prevent over 80 tons of CO_2 from being emitted, and save over 400,000 kWh of energy from being expended.

Table 3: Estimated Annual Environmental Impacts of Bottled Water vs. Municipal (tap) Water, University of Michigan Ann Arbor Campuses

	Bottled water in 500ml disposable bottles	Municipal (tap) water in 500ml reusable stainless steel (includes washing)	Difference (negative impacts prevented)
Solid Waste	18,500 lbs	2,103lbs of waste (recycling rate unknown)	16,397 lbs
(from plastic bottle)	9,500 lbs of waste (2/3 recycled, 1/3 to landfill)	--	--
(from secondary packaging)	9,000 lbs of waste (unknown how much is recycled)	--	--
Water Wasted	79,500 gal	35,775 gal	43,725 gal
GhG emissions (equivalent)	88 tons of $CO2$	6.5 tons of $CO2$	81.5 tons of $CO2$
Energy Consumed	441,700 kWh	26,500 kWh	415,200 kWh

* Impacts estimated using lifecycle analysis techniques derived from Dettore (2009). Based on 600,000 bottles per year.

Potential contribution to waste reduction goal

Plastic bottles represent a significant portion of the campus waste stream. Some of this waste is being recycled, but we are still far from 100%. Even if recycled, disposable water bottles have other environmental costs (see above) and cannot be recycled into another bottle, they can only be “down cycled” to lower-grade forms of plastic used in construction.

A waste audit performed by students in the Fall 2010 ENVIRONMENT 391 class found 40 plastic water bottles in the landfill waste stream of Mason Hall. Although 40 bottles may sound insignificant, this number only represented one sample of waste from one building for one day (and one that has no food service or convenience store). If each of the University’s 377 buildings’ waste streams contain similar volumes, then U-M is responsible for at least 15,000 plastic bottles sent to landfill each day. Comprehensive waste composition figures were not available to confirm this, but a 2007 trash sort (from six U-M buildings representing different uses) showed that 5% to 10% of most building’s trash consisted of recyclable plastics[v].It is unknown how much of this volume was from water bottles as opposed to other plastic containers. However, it is likely that the majority were bottles with no deposit (trash bins are regularly “sorted” for returnables by gracious “volunteers”). In light of these observations, limited as they are, we conservatively estimate that at least 200,000 plastic water bottles go to landfill in U-M waste per year (although this number could be much higher). The environmental impact of this is significant and 100% avoidable. After all, it wasn’t so long ago that bottled water wasn’t available on campus at all, and it is tenuous at best to assert that bottled water is a necessity (except for emergency preparedness).

<u>Why do people choose bottled water over tap water?</u>

We believe that convenience and temperature are the primary reasons why people choose bottled water over tap water. In effect, consumers are paying for a container, and for reliably cold water. There is little evidence that bottled water tastes better than tap water. A taste test conducted in Fall 2010 by a group from ENVIRONMENT 391 with help from Keith Soster at University Unions found that respondents choose filtered water and tap water equally. When asked why they made their choice, the most common response was that they liked the colder one best. These results imply that if campus users have convenient access to a container and reliably cold tap water, it is reasonable to assume that bottled water consumption rates would drop. This is why our phased implementation plan for bottled water reduction focuses first on providing convenient access to refill stations, reusable containers, and container cleaning facilities.

<u>Suggested phased implementation schedule</u>

The specific details of any sustainability initiative will need to be designed and implemented by campus operations staff. What follows should be viewed as one of many possible paths to replacing bottled water with municipal (tap) water on campus. It should not be taken as a prescription, but rather as a guide or set of ideas. We recommend a phased approach to eliminating bottled water, beginning with significant education efforts, expansion of drinking fountains and refill stations, and finally setting a policy of elimination by 2020 (with an exception for emergency preparedness). However, not everyone is enthusiastic about a 100% elimination goal. Keith Soster at University Unions and Sandra Lowry at Residential Dining Services expressed concerns about an outright ban, saying they think it is an unrealistic goal. However, both were supportive of efforts to significantly reduce bottled water. Mr. Soster has even installed a filtered water dispenser in the Michigan Union U-Go’s store as an alternative to bottled water.

2012-2014

- Launch an effort to retrofit drinking fountains on campus to allow for easier filling of reusable water bottles.
  - Ross School and Mason Hall provide examples.
  - Include water temperature testing and maintenance inspections of all fountains.
  - Evaluate all buildings to determine if there are enough drinking fountains installed. Schedule improvements when necessary.
  - Set goal of 2020 for minimum 50% of retrofits complete.
- Incorporate water/food sustainability education into orientation activities.
  - Provide reusable containers to all incoming students.
- Conduct a survey to gauge student and staff interest in the elimination of bottled water as a sustainability tool.

- Investigate providing a bottle sharing and washing service for students living in residence halls. Students would drop off used containers at meals and pick up clean containers on their way out.
    - Students living in residence halls may not currently have access to adequate bottle washing facilities. Could pose a health risk.
    - Containers should be chosen that are compatible with existing RDS dishwashers.
    - We suggest launching a pilot project to assess feasibility.
    - Charge a fee to pay for the washing costs, and lost bottles.
- Renegotiate vending contract to allow for the eventual elimination of bottled water (next contract renewal).
- Announce long-term goal of elimination of bottled water from campus (with exceptions for emergency preparedness).

2015-2019

- Expand bottle share program if pilot project proves successful.
- Request that all university events and lectures stop providing bottled water, replacing it with municipal water and reusable containers wherever possible.
- Install refill stations in all campus convenience stores.
- Consider moving bottled water out of coolers in campus convenience stores. Continue selling at room temperature.

2020

- Require that no university funds be spent on the purchase of bottled water (with exceptions for emergency preparedness).

<u>Barriers</u>

Although widespread consumption of bottled water is somewhat new to our society (popularized in the 1990s), it is clear that it has become remarkably integrated with our campus and our culture. Fully replacing it with municipal (tap) water will in some ways be very simple, but extremely difficult in others. As with many sustainability efforts, the biggest barrier is cost. In our meetings with campus operations staff, replacement of revenue from the sales of bottled water was a consistent concern. However, less-intuitive barriers were also raised such as: how to keep reusable bottles clean for students living in dorms, costs of installing updated/new drinking fountains, potential pushback from the campus community, weakening of impact because of close proximity to independent retailers, and the need to maintain stocks of water for emergency preparedness. Purchasers also expressed concern that current beverage partners would suffer from reduced revenue as a result of a shift from bottled water to municipal water.

Loss of Bottled Water Revenue: Unions, RDS, and most other campus food retailers do not receive subsidies from the general fund. They are responsible for generating all of their needed revenue and bottled water has become a significant portion of their revenue stream. For instance, Unions sold over 50,000 units of bottled water in FY2010 and bottled water constituted 22% of total beverage sales. Beverage sales also drive foot traffic in convenience stores which leads to other sales. A sudden loss of this revenue source would be a significant hardship. That is why we suggest a slow phasing-out of bottled water on campus. It is our hope that over time campus retailers will be able to adjust and find more sustainable replacements. However, not all campus operations staff share our opinions on this subject.

Residence Hall Residents Lack Bottle Washing Facilities: Most residence halls on campus do not have community kitchen facilities for student residents. If students are to become less reliant on disposable containers they will need resources to keep their reusable ones clean and safe. This is likely already a problem as many students have begun to carry their own reusable bottles regularly. In order to address this issue, we suggest establishing a water bottle sharing program operating in the residents halls. It is our hope that RDS will be able to utilize existing dishwashers and staff to operate this program. Ideally, students would pay a fee to participate. They could then exchange their used bottles for clean ones during mealtimes. Bottles are inexpensive (about $3 each when purchased in bulk) and we hope that with minimal cost RDS could provide this service. However, due care should be taken to ensure that the bottles chosen are suitable for use with existing dish room equipment and that the bottles will be attractive to students. Due to time constraints we were unable to fully explore this idea and give detailed cost estimates. Therefore, we suggest that residence hall staff attempt a pilot program in one residence hall to gauge student interest and determine if the project is feasible for expansion.

Poorly Maintained or Inadequate Drinking Fountains: Lack of adequate refilling opportunities is one of the biggest barriers to eliminating bottled water on campus. Before we can advocate for replacement of bottled water it is essential to ensure that campus users have convenient access to drinking fountains. Filling a bottle takes longer than what traditional drinking fountains were designed for. Therefore, it will be necessary to either renovate existing drinking fountains to provide bottle refill stations (see Ross School or Mason Hall for examples) or to install more drinking fountains. Costs of renovations will vary widely and may not be appropriate in all instances. We recommend pursuing a goal of 50% renovation/upgrade by 2010 with an intermediate goal of 10% by 2014. This goal will not pay for itself and will require support either from individual building occupants or possibly as a special sustainability project supported by the general fund or capital campaign.

Pushback from Campus Community: As with many sustainability projects, there will inevitably be some pushback from some members of the campus community. However, at least a dozen North American universities have successfully implemented campus bottled water elimination (although none as large and high-profile as U-M). Education about the environmental impacts of bottled water will be essential to the success of this initiative. We suggest tapping the numerous student groups interested in sustainability to help spread the word. Sustainability education should also be incorporated into new student orientation activities (i.e. “At Michigan, we don’t drink bottled water because it’s bad for the environment. Instead we use reusable bottles that can be refilled at dozens of special water fountains around campus”). Another great opportunity to get students to buy-in to this initiative is the LSA “water” theme semester. We recommend pilot projects in conjunction with the theme semester where stores might place special stickers on water bottles with facts about the environmental impact of purchasing that bottle. In the end, it will be important for everyone that bottled water be eliminated slowly. We think that U-M can be a leader and that the community will accept this change. However, as stated earlier, some operations staff disagree and winning them over may be the most challenging barrier of all. However, it is our experience that all campus food operations staff are committed to the goal of sustainability and we have faith in their ability to overcome these barriers given enough time.

Bottled Water Will Still Be Available Off-Campus: This is true. However, U-M can be a leader and set the example for the campus community. The city of Ann Arbor has already banned the purchase of bottled water with city funds and this is a trend that is spreading across many cities and campuses in North America. U-M can choose to lead now, or potentially be seen merely as a follower once this practice becomes widespread.

Emergency Preparedness: In no way should this recommendation be taken to exclude the university from stocking water to be used in the event of an emergency. If campus convenience store bottled water stocks constitute a significant portion of this emergency water source then alternative arrangements will need to be made before bottled water is eliminated.

Shift to Less-Healthy Beverages: We heard from several people that they were concerned that people would shift to buying unhealthy, sugary, carbonated beverages if bottled water was not available. We understand this concern but do not believe this will be the case. Washington University in St. Louis saw a drop in sales of other beverages after they eliminated bottled water. We also believe that when campus users shift their behavior to carrying reusable containers, they will be more likely to choose free, clean, cold municipal water rather than spend money on something they didn't previously want. However, these trends should be monitored by campus retailers. It will also be essential to ensure that refill station and drinking fountain infrastructure upgrades have been completed before ending bottled water sales at campus retailers.

Campus Visitors: Some U-M operations staff have expressed concerns that campus visitors would be unable to cope with an eventual complete replacement of bottled water with municipal water. This is why we have stressed the importance of repairing and upgrading municipal water dispensing systems on campus before completely replacing bottled water. It is also important to remember that we are not recommending that U-M try to stop individuals from bringing bottled water with them, only that U-M should stop providing it. Recent purchasing bans by major city governments (including Los Angeles, Chicago, and Ann Arbor), and our country's long experience of life before bottled water suggest that we can overcome any visitor discomfort. We believe this could even be true for athletic events if adequate hydration stations and drinking fountains are provided.

Perception of Municipal and Bottled Water Safety: Bottled water manufacturers have advanced the myth that their product is somehow healthier and safer than municipal water. In fact, the majority of bottled water *is* municipal water with minimal additional filtration. Also, as the Bottled Water team from ENVIRONMENT 391 pointed out in their report, the safety of bottled water is largely unregulated and non-transparent. This is in direct contrast with strict regulation of municipal waters systems (tested for a range of contaminants at least once per hour, 365 days per year) and the transparent reporting system (annual audits are mailed to every city residence once per year). U-M OSHA also does regular testing of campus water delivery systems. However, these facts are not widely known.

Implementation Idea #3: Tray-less dining

Tray-less dining is a method to reduce food waste. It limits the amount of food a person can carry so diners only take what they need. Tray-less dining is not a ban of all trays; it simply involves moving trays to a less visible location so students must actively choose to use one. Tray-less requires other structural changes along with tray movement such as modifications to dish return, dining hall setup, and silverware return that facilitate improved customer satisfaction. Our research showed that tray-less dining is a growing trend among leading universities (Appendix 1 shows where Michigan stands among peer institutions) and that it is perhaps the best solution for overall food waste reduction. Tray-less dining actually *reduces* food waste, rather than just managing the waste (as in composting). This implementation idea could easily pay for itself and more in reduced food procurement costs.

<u>Benefits</u>

The dining halls will save water and time in addition to food, because they will not have to spend time washing trays. If tray-less dining is implemented the materials footprint may decrease, because less food and water will be wasted. A 2008 study of 186,000 meals at 25 institutions conducted by ARAMARK found that on average institutions reduced food waste by 25-30 percent per person after implementing tray-less dining.[vi] The same report also found that contrary to dining hall operator expectations 76-82% of dining customers surveyed were supportive of tray-less dining as a waste reduction and environmental sustainability tool. Furthermore, the report found that tray-less dining provides cultural sustainability benefits including increased environmental awareness, increased sustainability participation rates, and healthier eating habits (portion control).

Tray-less dining will likely reduce the volume of food purchased, as well as result in lower water and detergent needs for cleaning resulting in significant cost savings. We suggest that these savings could be used to finance other sustainability goals outlined in this report, such as increased sourcing of local food. Tray-less dining can also increase the student community's awareness of food waste if properly implemented structurally along with an educational component.

<u>Contribution to Waste Reduction Goal</u>

The projected food waste savings are variable from each peer institution and study conducted at University of Michigan. The average food waste savings was 34 percent from 3 University of Michigan studies.

Residential Dining Services (RDS) conducted a study in November 2010 at East Quad Dining Hall.[vii] Trays were available so tray-less was a choice. The study compared the service ware and waste from tray-less diners with people who used trays. The study measured one day of meals at East Quad including breakfast, lunch, and dinner. Diners with trays produced 4.1 ounces of waste per person. Tray-less diners created an average of 2.5 ounces of waste per person, which is 1.6 ounces less than people with trays. This resulted in a 36 percent reduction in food waste. This suggests if each person went tray-less one day a week for 3 meals they would produce 4.8 ounces less of waste. If 800 diners, the number of people who ate lunch that day, saved 1.6 ounces of waste for 10 meals a week for one semester (15 weeks) the dining hall would save 0.6 tons of waste.

A pilot study in March 2009 from a group of students in the course Sustainability and the Campus provided similar results.[viii] The study analyzed food waste and diners attitudes in Mary Markley Dining Hall for 15 meals over 5 days. The study was comprised of two weeks of data. The first week was normal with trays and the second week was tray-less. The diners saved 0.105 pounds (1.68 ounces) per person. If one person reduced their waste by 1.68 ounces for 150 days then they would save 15.75 pounds of food waste. This resulted in approximately 28 percent reduction of food waste. The study found that RDS serves approximately 2.5 million meals per year and suggests RDS would save approximately 263,500 pounds of waste for these meals if it implements tray-less dining.

A pilot study from Sustainability and the Campus in March 2010 at East Quad measured food waste, diner's opinions, and staff reactions.[ix] Each diner wasted 0.147 pounds of food before tray-less. During tray-less week students only wasted 0.091 pounds, which equates to a 38 percent food waste reduction. Both pilots suggest that tray-less dining at East Quad would save on average 37 percent of food waste.

Implementation and Barriers

When implementing tray-less, dining hall set up must be addressed. Each dining hall is a different size and has a different design. We suggest tray-less is phased in based on a building by building basis. Start with dining halls that have food stations in close proximity to seating areas, such as East Quad. Most dining halls have trays and silverware at the entrance adjacent to the card swiping station. Move the trays from the entrance to a less convenient location such as the back of the line or dining hall. At the same time, move silverware to a more centralized location near the seating area. If silverware is near the seating area, the diners will only take the pieces necessary and it will make dining easier.

The dish collection systems on campus may need alterations for tray-less dining. Many dining halls use tray collection carts, which will need alteration in order to collect individual dishes. We suggest using hanging dish tubs on these carts where students can set their dishes easily. Dining Halls such as Mary Markley that have conveyor belts are ideal for tray-less dining and will not need significant alterations. Some structural or design changes may be necessary to implement tray-less in larger cafeterias or cafeterias with tray collection carts. These changes must be considered in the long term to make dining halls less tray-based in the future. The food and dish collection stations must be addressed in each cafeteria to make tray-less as simple and easy for diners as possible. However, in the short-term empty trays or bus tubs could be provided on the tray carts for the purposes of dish collection.

It is critical to phase in tray-less in order to reduce diners feeling as though their trays have been taken away. Begin with East Quad, expand to other small dining halls, and adapt larger dining halls to tray-less in the future. If RDS makes tray-less the standard at East Quad during incoming student orientation then all incoming students will accept tray-less as the default dining set-up and minimize dissatisfaction. If incoming students are introduced to tray-less from the very beginning they will accept it more readily, because they are never exposed to the tray based dining set-up.

For dining halls where returning students chose to eat, starting tray-less at the beginning of the school year, making trays available in a less visible location, and educating the diners will also decrease resistance. Some diners will still be dissatisfied with tray-less dining, but our case study of Ohio State confirmed that initial resistance subsides after a few weeks (see Phase One report for case study). The diners who feel strongly can ask for a tray or pick one up from a less visible location. Where exactly trays should be stored must be a building-by-building decision. We encourage dining hall managers to experiment and find a location that provides adequate access for those who request/need a tray, but still takes advantage of the human-nature tendency to take the path of least resistance.

Education and transparency will help decrease diner pushback. If diners are educated on the benefits and results of tray-less dining they will be more likely to accept it. Some diners at East Quad already go tray-less. The March 2010 study surveyed participants on their experience. The post-survey found 81 percent of people go tray-less at least once a week and half of them are completely tray-less. If RDS changes dining hall setup to make tray-less dining easier these diners will be more satisfied and other diners may choose to go tray-less as well. Implementing structural changes will increase the number of tray-less diners in the future.

Another barrier to tray-less dining is the potential need for more frequent table cleaning. This may require additional labor during busy periods. While we did not collect data on this, we believe it is likely that substantial water and labor savings from reduced numbers of dirty dishes and trays will more than offset the relatively minor increased cost of wiping tables.

<u>Potential Cost Savings Estimate</u>

Auxiliary units such as Residential Dining Services pay for their waste to be picked up. Each unit is charged by loose and compacted cubic yard of waste. As auxiliary units, residence halls must pay the University for disposal of waste. Based on data provided by Tracy Artley, U-M Recycling Coordinator, we calculated that residence halls pay on average $170 dollars per ton of waste (costs vary based on the ratio of compacted/loose waste). This waste value includes all building waste along with cafeteria waste. If each of the 2.5 million diners served by RDS each year wasted 1.6 ounces less per meal (as in the pilot study cited above), it would reduce waste by approximately 125 tons and save approximately $21,250 dollars per year in waste disposal costs.

Tray-less dining can provide additional cost savings in food purchasing. Since Ohio State University implemented tray-less dining, it has reduced its food waste 60 percent and seen significant savings in food purchasing. If the University of Michigan saved 1.6 ounces for each meal (as recorded in the fall 2010 study) it could save over $700,000 dollars per year in food procurement costs (based on the 11.7 million dollar budget,[i] 2.5 million meals served per year, and the USDA estimates of average food consumption per day[x]). For just 800 meals (the amount served in East Quad at lunch on a typical day) RDS could potentially save over $200 dollars. If diners take less food and waste less of what they take then RDS can realize significant savings. These savings could be used to fund other sustainability objectives such as composting or increased local purchasing.

Prioritized Recommendation B: Purchase 20% of Food from Local Sources by 2020

Purchasing more food from local sources will allow U-M to have a positive impact on regional food producers and processors while simultaneously reducing the amount of fuel expended for transportation. We recommend that the University define local food as “grown or processed within the State of Michigan or within 150 miles.” This definition will allow us to take advantage of all our State has to offer, as well as nearby areas of Indiana, Ohio and Ontario that contribute to the local food supply. Michigan has the second most diverse agricultural production of any State. Increasing the percentage of products sourced locally will help educate campus users about the types of food products available locally and about seasonal variations. As an added bonus, locally grown and processed products are often fresher, healthier, and tastier!

In our interactions with major campus food purchasers, we found enthusiastic support for increased local sourcing. However, we discovered several barriers complicating the achievement of this goal including: higher costs, insurance and certification requirements, and decentralized distribution. In order to support the efforts of campus purchasers, we suggest the following three implementation ideas: *Hire a” Local Food Forager”, Establish a “Local/Sustainable” Food Labeling System,* and *Establish a Campus Farm or Garden*.

Implementation Idea #1: “Local Food Forager”

The outstanding and exemplary work that is currently in place to increase local food on campus is accomplished by passionate individuals and creative collaboration between different departments. In order to sustain growth and reach an increased amount of local food purchasing, we envision a new role on campus to increase and manage these unique relationships to local food businesses. We have called this position the local food forager. This position would be the primary liaison between U-M food purchasers and local food providers in providing for the unique needs of the campus, while facilitating a smooth transaction process for local providers. We see this position as a support position to assist all departments with direct purchasing from farms and with finding new local sources, however We see this position as a support position to assist all departments with direct purchasing from farms and with finding new local sources, however operations staff will still use Sysco and other providers directly. We see this position as a support position to assist all departments with direct purchasing from farms and with finding new local sources, however operations staff will still use Sysco and other providers directly.

<u>Benefits</u>

This position would satisfy the cross-cutting themes of the Integrated Assessment by addressing issues of climate, ecosystem health, human health, community awareness and campus reputation. Another important role of the food forager is to prioritize supporting and purchasing goods from the local economy over competitive global options, making U-M a leader in supporting the unique Michigan agricultural economy.

Climate: This position will assist in improving sustainability by reducing food miles traveled by supporting the purchase of more local products. More investigation is needed to analyze the individual farms that U-M purchases from and to compare non-local products to gain a perspective on scale of these benefits.

Ecosystem Health: Another valuable benefit of creating a position to search out local food products would be in the protection of prime agricultural land. Michigan is the second most agriculturally diverse state and has lost over 100,000 acres of farmland from 2002 to 2007.[xi] It is important that U-M supports maintaining agricultural land for agricultural uses, and this can be done by purchasing more produce from our state and within 150 miles. Another important sustainability goal in food purchasing is to buy organic products or produce. Organic agriculture as defined by USDA is "an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity."[xii] While the local food forager will prioritize purchasing local food products and produce over organic products at first, part of the advantage of working directly with local food producers is having more leverage in the type of agricultural practices these producers use. In turn, through purchasing more products and produce locally, it could also increase demand for local producers to use more sustainable growing techniques.

Human Health: By making explicit the importance of where our food comes from, the University will also be elevating people's awareness about what type of food they are eating. This is an important step in changing people's food eating habits towards healthy food choices. Local produce tends to minimize transportation and processing by: traveling less distance, being handled by less people or machinery, and is sold sooner after harvest; these attributes maximize freshness, flavor and nutrient retention.[xiii] Therefore there is a greater chance that in supporting local produce and products we are getting the most nutrition and taste from our products.

Community Awareness and Reputation Benefit: Community awareness includes the community of the student body, faculty and staff as well as the greater Ann Arbor, Washtenaw County, and Michigan community. Both of these communities provide an important metric for gauging the larger campus reputation. In terms of the community of the student body, faculty, and staff, increasing the local purchasing and transparency of food items at U-M food service providers will increase the awareness to the student body of the diversity of products offered in Michigan. Because all students interact with food options on campus in one form or another, it is an important educational component and selling point. A 2009 survey administered by the Princeton Review showed that 23% of respondents reported that information about a college's sustainability would "very much" or "strongly" affect their application decision (see Appendix 3). The fact that there are now ranking services of campuses by sustainability, such as the Green Report Card, also shows that these issues are increasingly pertinent to students' decisions.

Furthermore, local, sustainable food purchasing is becoming more and more popular in current media, and in our local community. In Washtenaw County alone, there is a movement to buy 10% local products, an active Home Grown food festival, and several community groups and businesses, in addition to the active farmer's market community. The University of Michigan would be a leader by not only supporting this grassroots movement, but by going above and beyond.

Local Economy Support: Another important benefit that the local food forager position provides is support for the local producer, and by extension, the local economy. For every $100 spent in local businesses, $68 returns to community, as compared to $43 for a national chain. The local food forager would be able to provide the education and training for local producers regarding the unique qualifications for working with a large university. As mentioned earlier, there are significant barriers for small local producers in doing business with the university, the large scale of needed goods, high insurance requirements, and health and safety certification to name a few.

In our research of the local food system economy in Southeast Michigan, we found 64 innovative businesses, farms, and non-profits that could be a potential resource for the local food forager to expand and streamline the local food purchasing process for the University of Michigan. Supporting these local food initiatives would be a great opportunity for U-M to support the local economy and expand a growing local food system economy in Michigan. These local food businesses would benefit greatly from the support of a large institutional buyer like U-M to grow their ability to source to other small businesses in the area, further expanding the ability for the local food system to grow. Innovative community organizations could help overcome some of the barriers discussed of scale and costs of insurance by working with a local food distribution center. In our research we found two examples of these types of organizations that aggregate local produce and products and function more like a traditional distributor: Local Orbit, and the Southeast Michigan Food Hub. See Appendices 9 and 10 for more information on these innovative organizations.

<u>Operations Efficiencies</u>

Maximize supply and demand: There are several benefits that are provided to the university through the creation of this local food forager position. The first area of benefits is in the ability to foster administrative efficiency. This position allows there to be one contact person for local producers, minimizing administrative work loads for individual departmental food providers. The local food forager would expand the use of current local food providers, maximizing demand of the university and supply of local producers.

Through our discussions with RDS and other food providers, there was concern that expanding local food purchasing to other suppliers, might take away from the current farms that U-M is buying from. Therefore it would be the food forager's role to maximize the supply of produce available from one farm, before looking for more sources of supply, maximizing benefits for the producer and U-M. By sourcing as much as possible from one provider would give the U-M leverage to ask for the most competitive price. When current local food providers have maxed out supply, the local food forager would search out new local products in communication with university food purchasers demand to increase local food options. When the supply of local food products is greater, the local food forager could advertise current local products to all food purchasing departments on campus, providing local products to departments that may not be able to devout time to the search of these items on their own. Finally and most importantly, to reach our goal of 20% percent local by 2020, the local food forager would be responsible for tracking progress of local purchasing amounts, analyzing results and revising purchasing goals, and providing feedback to the university and food purchasing departments.

Cost Competitive Local Products: The food forager would have the unique role of searching out local items that are cost competitive to traditional products. There is no allowance in food purchasing budgets to support the at times extra cost that is associated with local products. Local must be equal or less in price to be bought, so the food forager will find the local products that are competitively priced[1].

The local food forager would help U-M food purchasers by streamlining the unique process of sourcing local products. Important in this process would include identifying local and seasonal sources for high-demand products, expanding the ability to track local purchases and working to further define sustainable products for marketing to consumer. In addition, the local food forager would help local farmers, processors, and distributors navigate the unique process of working with a large public university. Some of these responsibilities would be helping local farmers and food businesses navigate the insurance, paperwork, and health and safety requirements of the university. Another important piece of the local food forager's role would be to work with the Sysco prime vendor to help expand the cost competitive local alternatives to assist in the expansion of local items that Sysco already provides.

Certification/insurance/process constraints for small businesses: An example of how the local food forager would assist operations and the local producer is in the process of attaining GAP (Good Agricultural Practices) and GHP (Good Handling Practices) Certification. The food operations staff has expressed the need for current local produce providers for the university to have their farm be GAP and GHP certified. A work group of operations staff is currently investigating how much a certification process would cost and how to educate and provide resources to help these small farms and businesses through this process. The local food forager would be in a great position to educate farmers about the GAP/GHP auditing process, and help provide assistance in finding third-party certification, as well as helping find resources to pay for this expensive process. This is an important step that is needed to maintain and expand on current direct farm to university purchases, that will need a significant amount of time from a staff person at the university to understand the process and provide resources for the farmers, if the university requires this certification.

Implementation phasing

This important position will need to follow the university hiring procedure and the timeline will be highly influenced by where the position is located. Furthermore, an integrated discussion about the position and roles with current operation staff will greatly influence the success of this role. Ideally the position would be in effect as soon as possible, in order to assist in the other goals of increasing local food purchasing by 2020.

Phase 1: Review job descriptions and define role, full-time/part-time, where position will best be housed (recommend procurement or OCS), whether to partner with Green Purchasing Coordinator

Phase 2: Investigate funding options

Phase 3: Implement hiring process

[1] It may be useful in the future to consider an allowance for some price premium on local products to provide a budgetary incentive to buy more local, sustainable goods.

Phase 4: Inform and integrate operations staff regarding resources of new position

Phase 5: Food forager increases amount of local products and produce purchased and tracks progress

Phase 6: Review of job responsibilities and progress

Costs

The main costs of implementation of the local food forager would be the salary and benefits associated with expanding or adding a position to accommodate these responsibilities. To create this position, it is recommended that operations carefully define the responsibilities of the position and required hours. Once the position has been created, it will be important to inform operations staff of this new role and the resources provided by this position. In our discussions with operations staff it was recommended that this position be housed in Procurement, but a more thorough discussion of the fit of this location would be beneficial.

Barriers

An initial barrier to implementing the local food forager would be the development and creation of the responsibilities and resources of this unique position. This would require additional operational staff demands during the creation of the position, but would lighten staff purchasing loads when the position is in full force. Successful development of the local food forager position would require representation of different types of vendors in the development of the position. A possible concern of implementation would be the decentralized purchasing structure of the food units at U-M. For example, there are over 200 purchasers of food on campus. Because of this decentralized structure, it may be difficult to accurately represent the University's demand to suppliers. Additionally it may be hard to reach all the unique needs of each of these units to encourage expanding local, sustainable purchases.

Another barrier to increasing local food purchasing is the decreased availability of fresh produce during the winter months, when U-M is doing the majority of their purchasing. First, the goal of the food forager would be to find seasonal local produce and products, inevitably the type of produce purchased would change in the winter to include more leafy greens, cold storage vegetables such as potatoes and squash, and other goods that could be grown in hoop houses (passive solar structures) over the winter months. Menus would have to be adjusted to accommodate these different ingredients that are available, but would be an important educational tool to promote seasonal, local goods. In Michigan, hoop houses extend the season to 10-12 months out of the year with no additional heat or light. Furthermore, Michigan State University conducted an on-farm research study of 12 private farms that found when growing in hoop houses production increased such that the gross and net sales make a loan repayable in one to four years.[xiv] Therefore it may be in the best interest of U-M to support local farmers by investing in aid or loans to help farmers extend their season to sell more vegetables year-round.

Uncertainties and concerns in analysis

There are a few areas that require more analysis in the creation of the local food forager position. The development of job tasks are outlined in this report, but these will need to be refined with operations and hiring staff. Further research is needed to investigate the costs of GAP/GHP certification for local farms (see Appendix 11 for more details on GAP/GHP). Finally, there is uncertainty regarding how to measure the benefits gained from managing these local food foraging responsibilities. For example the efficiencies gained by creating a new position to manage this unique purchasing responsibility, rather than being managed in each individual food purchasing unit. This benefit and other benefits listed above are hard to quantify in a traditional cost-benefit analysis with the information available at this point. Another consideration that may aid in the implementation of the food forager position would be to pair this role with the Recycling Team's recommendation to create a green purchasing coordinator. Further investigation is needed into the feasibility of merging the goals and tasks of these two positions. It is important to note that this position is an integral part to the success of reaching and tracking the 20% local purchasing goal, and these uncertainties are minor in relation to the potential benefits from the creation of this position.

Implementation Idea #2: Adopt a Local/Sustainable Food Labeling System

While increasing the University’s capacity to source local foods is the top priority, its importance falls under a larger umbrella of social, economic, and environmental sustainability. Although local is the predominant current trend, a more holistic approach to sustainable food is the logical next step. The University must work on both ends in order to retain its competitive advantages and leadership in sustainable food practices.

Recognizing the substantial burdens imposed by increased local sourcing, we recommend that the University approach sustainable sourcing gradually and with a current emphasis on defining the criteria, standards, and compliance mechanisms necessary to incorporate sustainability into the “Go Blue Eat Local” food label. A comprehensive “Go Blue Eat Local & Sustainable” label would enable the University to benchmark current successes and strategize growth, increase transparency and customer options, reduce confusion, increase awareness, and improve public relations.

<u>Benefits</u>

1. **Defined criteria and standards create measurable benchmarks to evaluate success and set goals –** A defined label streamlines tracking and evaluation. Such measures can serve as both internal and external benchmarks to measure success and set goals for increased sourcing.
2. **Transparency increases customer choices and satisfaction –** Growing concern over the social, ecological, and economic implications of our food choices have spurred a growing demand for transparency in the food system. A certified sustainable option provides conscious consumers with a guilt-free option.
3. **Consolidation reduces confusion over competing labels –** Although consumers are striving to be more conscious with their food choices, the overwhelming number of competing labels creates feelings of helplessness and confusion. A comprehensive labeling system that consolidates the multitude of labels and standards improves communication and alleviates undue stress for both consumers and staff members.

4. **Label creates forum for education and increased awareness –** While the label meets a current demand for sustainable options, it also stimulates a latent demand among students who may not be aware of the issues. Increased transparency of sources and practices provokes a forum for introspection and deeper conversation over consumer choice and consciousness.
5. **A successful model demonstrates leadership and provides valuable lessons for other institutions** – Growing consciousness over food choices suggests that many institutions will soon explore similar issues of food sustainability. The successes of a big institution like the University of Michigan will demonstrate leadership and provide many valuable lessons for aspiring institutions.

Barriers

1. **Defining "sustainable food" –** Complexities in defining criteria, standards, and compliance mechanisms for "sustainable food" deter many institutions from broaching the issue; however, leaders in the field have developed innovative approaches, which will be outlined in the sections below.
2. **Additional labeling imposes additional burdens onto producers –** Producers often associate additional labels with additional costs and requirements. For this reason, we recommend an inclusive "big tent" approach which leverages and amalgamates existing labels. Rather than inflict new costs and requirements, this approach allows producers to showcase and benefit from their existing practices. Greater detail can be found in the sections below.
3. **Labeling adds burden onto staff members –**With vegan, vegetarian, hallal, kosher, MHealthy, and many others food labels; food service staff members are wary of an additional label to manage. However, this process can be streamlined with the appropriate pre-screening and software programming. Food service staff members currently utilize savvy computer software that considers the entered ingredients of each product and yields the appropriate labels. If each supplier is pre-screened and inventoried for its labels and sustainable practices, the software could be programmed to yield a sustainable label as well.

Challenges to Defining "Sustainable Food"

Developing a sustainable food policy is complicated by the wide variety of definitions and standards pertaining to sustainability. In the 1990 Farm Bill, Congress broadly defined sustainable agriculture as an "integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs
- enhance environmental quality and the natural resource base upon which the agricultural economy depends
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- sustain the economic viability of farm operations
- enhance the quality of life for farmers and society as a whole."[xv]

This broad definition has opened the doors to numerous criteria and standards. In *A Guide to Developing a Sustainable Food Purchasing Policy,* Food Alliance authors cite just a partial list of issues pertaining to food sustainability:

- **Labor issues** – Agriculture and food processing are among the most difficult, most dangerous, and lowest paid occupations in the US.
- **Animal welfare** – Improper confinement and handling of animals can cause stress, pain, injuries and chronic disease, all contributing to animal mortality.
- **Hormones and non-therapeutic antibiotics** – Used to promote animal growth and productivity, these treatments can result in antibiotic resistant bacteria and other human health concerns.
- **Genetic modification of crops and livestock** – With limited long-term testing of GMOs, the precautionary principle raises concerns for potential human health and environmental impacts.
- **Toxicity** – Conventional agriculture relies heavily on pesticides, herbicides, and fungicides, which, used improperly, threaten both human and environmental health.
- **Water conservation and quality** – Agriculture represents 84% of freshwater used in the US. Environmental Protection Agency studies also identify agriculture as the leading source of ground and surface water contamination.
- **Soil conservation and health** – Tillage, wind and water erosion, and use of soil fumigants and other chemicals all contribute to depletion of soils.
- **Global warming** – Agriculture is a known source of nitrogen from soil degradation, methane from animal waste, ozone-depleting chemicals, carbon dioxide from farm equipment and transportation, and additional energy is used for food processing, packaging and refrigeration.
- **Protection of wildlife** – Ninety percent of threatened species in the US are known to spend some portion of their life cycle on privately owned agricultural lands.
- **Local economies** – Family-scale agriculture and food processing are under significant economic pressure due to consolidation in industry, and increasingly international trade.
- **Food quality and safety** – Concerns have been raised for food additives used to extend shelf-life or enhance color and flavor, for contaminants, and for food-borne illnesses like e-coli.
- **Diet-related health concerns** – Diet is closely linked with the increasing incidence of obesity, diabetes, high blood pressure, and other preventable causes of sickness and death."[xvi]

Selecting criteria and establishing standards are further complicated by the method of establishing compliance. Are first-party claims by producers or second-party claims by industry associations sufficient, or is only third-party certification via independent inspection acceptable?

<u>Two Innovative Approaches to Defining "Sustainable Food"</u>

Facing these complexities, a number of institutions have worked to simplify the process through the consolidation of criteria and the adoption of a "big tent" inclusive approach. Real Food Challenge and Local Foods Plus adopt two different schemes that aptly represent the spectrum of possibilities.

Real Food Challenge

The Real Food Challenge (RFC), a national campaign sponsored by The Food Project and the California Student Sustainability Coalition, has developed a matrix with four horizontal criteria of sustainability and three vertical standards of compliance. The criteria are Local/Community Based, Fair, Ecologically Sound, and Humane; and the standards of compliance are Green Light (c*lear fit*), Yellow Light (*use caution*), and Red Light (*good start but not enough)*. These standards utilize a variety of first, second, and third party certifications. The results are tiered as Real Food A and Real Food B. Real Food B satisfies Yellow or Green Light standards in just one of the four categories. Real Food A satisfies Yellow or Green Light standards in two or more of the categories (see Appendix 12 for complete matrix.) [xvii]

Local Foods Plus

Local Foods Plus (LFP), a non-profit founded in partnership with the University of Toronto (UT), utilizes a more rigorous point system with the following criteria:

- Employ sustainable production systems that reduce or eliminate synthetic pesticides and fertilizers and conserve soil and water
- Provide healthy and humane care for livestock.
- Provide safe and fair working conditions for on-farm labour
- Protect and enhance wildlife habitat and biodiversity
- Reduce on-farm energy consumption

Approval in each category receives a designated number of points, and a supplier must accumulate 900 of 1200 possible points to earn LFP approval. The results are eligible or ineligible (See Appendix 13 for complete figure). [xviii]

Issues to Consider When Defining "Sustainable Food"

The differences between these two acclaimed approaches represent the variety of approaches the University can take. Key questions that will inform the appropriate scheme include:

- Should the University form its own third-party accreditation agency, similar to LFP and UT, or should the University only leverage existing labels, similar to RFC?
- Should the University adopt a binary standard of compliance, similar to LFP, or should the University adopt a tiered standard with multiple levels of compliance, similar to RFC?
- Which criteria should the University adopt, and with how many consolidated categories?
- How should the University enforce compliance: first/second party claims or strictly third-party certification?

Correct answers will depend on the University's goals, students' preferences, ease of implementation, and a deeper cost-benefit analysis.

Proposed Next Steps

1. **Appoint faculty member or farm forager to develop and supervise a Sustainable Food Team –** This team would work to define criteria, standards, and compliance mechanisms for "sustainable food." Similar to the structure of the Integrated Assessment teams, the Sustainable Food Team would also work to develop a comprehensive matrix of existing labels, monitor new labels and trends in sustainability, define metrics for success, evaluate success, and create action plans for growth.
2. **Assign a deadline to define and develop the label –** Label definition is the first and most important step. Sustainable food practices cannot progress until the University defines its terms and expectations for "sustainable food."
3. **Create database of suppliers' sustainable practices –** In order to apply the new label, the University must inventory each of their suppliers' sustainability practices according to the defined criteria and standards. Depending on whether the University leverages existing labels or adopts its own third-party accreditation, a farm forager, procurement staff member, or Sysco account manager are strong candidates to develop this database.
4. **Program database and label definition into existing food service software –** Armed with defined criteria and a database of sustainable practices, software programmers will be able to incorporate the new label into existing software and streamline the process.
5. **Train staff –** Although the new label will mimic other labels already in use, implementation and proper use of the label present a learning curve.
6. **Benchmark current practices –** The newly programmed food service software should streamline tracking. A one-year evaluation period provides an essential benchmark for strategizing growth. Such evaluation would fall under the responsibilities of the Sustainable Food Team.
7. **Undertake thorough cost-benefit analysis of increased sustainable food sourcing –** Quantifying the costs and benefits of increased sustainable sourcing informs goals for growth. Business students are excellent candidates for the job.
8. **Set goals and develop an action plan –** Armed with benchmarks and cost-benefit analyses, the Sustainable Food Team will have all it requires to set goals and develop an action plan.
9. **Publicize efforts and accomplishments –** University Development, Recruitment, and Alumni Relations can leverage these efforts as proof of the University's status as the "Leaders and the Best." Effective public relations will yield excellent value for accomplishments in an increasingly popular area that is attracting growing concern.

Uncertainty/Concerns:

1. **Limitations of food service labeling software –** Greater investigation is needed to determine the complexities of accommodating a new sustainable label into the current software.
2. **Structure of student-led team –** Commitment, time availability, and continuity are always concerns with student-led teams.
3. **Additional burden on food-service staff members –** Staff members have voiced concern over additional labels to manage. Greater investigation is needed to determine the additional burden imposed by the new label.
4. **Premiums on "sustainable food" –** Are they worthwhile?

Implementation Idea #3: Establish a Campus Farm and Garden

<u>Campus gardens are an iconic representation of commitment to sustainability</u>

From Omnivore's Dilemma to the White House Kitchen Garden, sustainable agriculture currently sits at the forefront of popular conceptions about sustainability. U-M's efforts to project a campus-wide focus on sustainability are not complete without a highly visible University garden or farm. Nearly every one of our peer institutions currently capitalizes on campus garden or farm spaces to publicize their commitment to sustainability. Expanding gardening space on U-M property will increase opportunities for students to learn about the following key food-related themes: the personal health benefits and enhanced flavor of fresh fruits and vegetables; the diversity of foods produced by Michigan farmers; and the local and global environmental impacts of different food production methods. These benefits align with Integrated Assessment cross-cutting themes of human health, climate change mitigation (through reduced food miles) and ecosystem health, respectively.

This report summarizes findings about the benefits and costs of three distinct visions for expanded campus gardening space. While each vision emphasizes a different benefit, the three visions are compatible and should not be understood as competing or redundant options.

<u>Benefits from expanded sustainable agriculture space</u>

Formal educational benefits: Interviews with a number of faculty members[2] identified significant academic benefits from a "living learning laboratory" space: potential coursework including species identification, soil analysis, landscape design and ecology, and pedagogy could utilize a campus garden space to illustrate and apply theory. A summary of faculty-perceived benefits can be found in Appendix 14. Faculty highlighted campus garden spaces' unique ability to foster interdisciplinary partnerships among the many disciplinary perspectives that bear on food production, access, and consumption. Additionally, the process of developing and executing garden plans would engage students of design, engineering, and environmental science in valuable practicums.

Informal, Direct Educational Benefits: Students can derive a number of non-credit educational benefits from additional garden space. The University's Cultivating Community currently engages students in hundreds of hours of recreational and educational activities every semester, and demand is growing: requests for a campus farm or garden represented the most common submission to Graham Institute's Integrated Assessment feedback form. When gardening, students can master a number of inter-related skills, from composting to planting, weeding and harvesting, while working in a team setting toward shared goals. Complimentary, healthy recreational activities follow naturally: Cultivating Community has evolved to include cooking demonstrations, food preserving classes, and volunteer days at area gardens.

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[2] CSIA team member Greg Chojnacki collaborated with Jes Skillman and Renee Henry, members of the Sustainable Agriculture Working Group, to conduct interviews with Robyn Burnham, Raymond DeYoung, Bob Grese, MaryCarol Hunter, Rachel Kaplan, Ivette Perfecto, Mike Shriberg, and John Vandermeer to solicit feedback on educational benefits arising from increased campus space. Key insights from these interviews and contact information are included in Appendix 14.

Involvement in food production delivers far-reaching health benefits, increasing students' awareness of the processes that create foods' nutritional value. This awareness promotes a nutrition-based perspective on food that encourages a healthy lifestyle. As one faculty member pointed out, non-credit courses on agricultural skills like organic cultivation could serve a role similar to non-credit skiing, snowshoeing and hiking courses.

Informal, Passive (Indirect) Educational Benefits: Increased campus garden space can break down misconceptions about food production among the general public. For example, the "edible estates" concept of landscape design aesthetically pleasing arrangements of edible plants, moving beyond the dichotomy between "productive" and "beautiful" spaces. Seeing food as connected with an everyday landscape raises consciousness about the environmental impact of a broad range of decisions. Professor Bob Grese cited just one of many examples: "[garden spaces on campus] make us more aware about water systems, how we deal with drainage off our roofs, how we use that water to irrigate crops that we're growing… what we put on the sidewalks, which runs into the soil."

Potential Sites

The benefits described above all flow from distinct elements of gardening spaces: the public awareness objectives and reputational benefits to U-M will only flow from a highly visible space. Other spaces would focus more on accommodating a range of approaches to agriculture, from intercropping to hydroponic cultivation to season extension technologies, and they would not need to emphasize aesthetic appeal if they were less visible. Table 4 below identifies site requirements for each type of proposed garden space.

Table 4: Necessary Attributes of Appropriate Farm/Garden Sites

Type of Farm/Garden	Key Purpose	Water access	safe soil	tools storage space	on-site compost	sufficient sunlight	room for a hoop house (20'X40')	effective barriers to deter pests
Demonstration / symbolic	raise awareness about local food production, especially in the urban context	Yes	Yes	Yes	No	Yes	No	Yes
Individual student plots	expanded space for recreational gardening	Yes	Yes	Yes	Yes	Yes	No	Yes
Research / Experimentation	formal practice of sustainable methods on a larger scale (though still less than 1 acre)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

East University Pedestrian Mall (Demonstration / Awareness-building): A central location seen by thousands of students each day, the East University mall presents a uniquely attractive area in which to establish a demonstration garden. By creating a vegetable garden in one or more of the grass plots punctuating the mall from its south end to North University, the University could make a highly visible statement of support for increased awareness about sustainable food systems. Rather than focusing on student access to gardening space or high levels of productivity, this space would seek to maximize the aesthetic potential of well-planned, carefully managed vegetable cultivation. The space would also incorporate plant labels and placards educating the general public about its purpose and the varieties of plants growing within it. Finally, it would serve as a way to publicize other available gardening spaces that are less obvious to the average student.

Nichols Arboretum (Recreational / Individually run student plots): Cultivating Community has identified land within the Nichols Arboretum well-suited for individual student plots or a community garden. Located near the Peony Garden, the site would accommodate three rows of raised beds ranging from 10 to 20 feet long and 5 feet wide. It is near campus, could support a substantial number of independent student plots, receives sufficient sunlight, and appears to have good soil composition for gardening. The space's most important current deficiency is its lack of a water source. One possible remedy to this would be a collaboration with engineering students, possibly led by Steven Wright, a professor of civil and environmental engineering who has worked with the city of Chelsea to bring water to its community garden, among other Chelsea water management projects. This space would need significant initial labor to clear and allow cultivation. While its location close to campus would support convenient access by a number of students, it would not be as visible to the average passerby as something located directly on campus where thousands of students would pass it each day. Also, the terraced layout of the area might preclude more standardized, experimental setups for formal, for-credit classes on sustainable agriculture methods.

Matthaei Botanical Gardens (Rigorous experimental / innovative practice): Cultivating Community has also identified space within the Botanical Gardens that could support formalized experimentation area or larger-scale intensive agriculture demonstration. The 1-to-2 acre area lies to the north of the main entrance, near the private residence south of Matteson barns. This area is flat and relatively uniform, with access to water. Its more uniform, open space, could accommodate construction of a hoop house to demonstrate cutting-edge season extension technology, cultivation of heirloom and hybrid plant varieties, or controlled soil experiments to test effects of soil nutrient management. Finally, this is the only space that could possibly incorporate any farm animals (chickens, goats) in symbiosis with vegetable production. The private residence could be used as a residence for a summer intern / student farm manager position responsible for maintaining the area at standards agreed to by University and the Botanical Gardens.

This space could also be parceled out as student garden plots, but its more remote location relative to campus makes it less desirable than the Arboretum space for this purpose. Similarly, this space would not exhibit the key passive educational benefits to the student body, although it would clearly foster education of the public who visit the Botanical Gardens.

Costs

Start-up Costs: Both Cultivating Community's experience and that of peer institutions shows that gardens can be established at very low cost (the Ginsburg garden estimated its start-up cost at approximately $700, almost half of which was for a high-quality manufactured sign explaining the space to passersby). However, start-up costs would vary for each site, and each site could be envisioned in a number of different ways, with consequences for costs. It is outside the scope of this report to fully determine those designs and costs.

One of the most salient educational opportunities from each of these proposed garden spaces would lie in the planning for opportunities for education in this process would be a class or independent study. One way to engage the student body in planning garden space – and controlling costs – would be an interdisciplinary design contest, conducted in partnership with University Planning and Grounds Services, to devise the most environmentally sound, innovative, attractive and cost-effective demonstration gardens for the East University Mall space.

Maintenance Costs: These costs can be kept relatively low for all three sites, by engaging volunteers to perform all weeding, site clean-up, necessary pruning, and other physical maintenance. Since both larger spaces would likely feature on-site composting, soil amendments would not need to be bought in large quantities. There are a number of sources of free seeds, particularly for student organizations.

The most significant maintenance cost would be a small number of interns responsible for directing volunteer activity to ensure that volunteers receive a worthwhile, engaging experience in exchange for their labor.[3] By investing in paid interns, the University can leverage a significant amount of free maintenance labor. For example, from July through the first quarter of the Fall semester, Cultivating Community's two interns leveraged over 220 hours of volunteer labor. Especially for a central campus demonstration garden, we would encourage garden managers to meet with the Landscape Architect's office and Grounds Services to coordinate design and identify maintenance standards that will lead to an attractive space that everyone can take pride in.

Reconversion Costs: It is important to more detailed proposals to work with the Landscape Architect and Grounds Services to plan for costs of reconverting any space back to its prior use in case the garden is implemented and is not successful.

Seasonal mismatch as a potential barrier

There is concern that the mismatch between the peak gardening season and the academic year would diminish the benefit that students and the community at large enjoy from gardening spaces. Thoughtful management practices would mitigate the effects of this phenomenon, however. Consider the following responses to problems related to seasonal mismatch.

[3] The Landscape Architect's office employs a formula that estimates the amount of maintenance hours required to keep a highly visible, aesthetically oriented space in good condition, based on square footage. Proposals for a demonstration garden should utilize this resource to estimate total labor needs.

1. Season extension technologies such as cold framing and passive solar hoop houses would allow student use of gardening spaces earlier and later than conventional cultivation practices, allowing year-round activity in many cases. These options are already being explored and, in some cases, utilized by Cultivating Community.

2. The question of available labor for maintenance during summer months is an important one. This proposal relies on some paid interns to manage gardening spaces. As mentioned above, a highly visible demonstration space would utilize a management plan developed in coordination with the Landscape Architect. This plan would include required labor adjusted to reflect seasonal maintenance demands.

3. Another question related to seasonal mismatch relates to what the space would look like during winter months. Importantly, any space could demonstrate soil management best practices by exhibiting attractive ground covers such as native grasses and legumes that maintain soil nutrients and structure while preventing erosion.

Examples of Successful Gardens/Farms

There are abundant examples of the variety of spaces proposed in this report. As mentioned above, nearly all of U-M's peer institutions – as well as St. Joseph's hospital - currently operate gardens or farms and have confronted the key issues that U-M would face. Reference Appendix 3 to see which peer institutions currently maintain campus farms or gardens. The University should continue to engage actively interested students to fill in gaps in knowledge and developed detailed garden proposals. This type of collaboration will maximize the educational benefits of the garden while also encouraging robust student ownership of the space from its inception.

IV. INTEGRATION & CONCLUSION

Throughout our work on the Campus Sustainability Integrated Assessment, the Food Team sought to choose recommendations and strategies that will promote multiple sustainability goals. We kept our goals broad so that many implementation ideas and techniques could be used to achieve them. We also took care to select implementation ideas with a range of difficulty and diverse benefits that would sometimes fill unique sustainability niches or sometimes compliment other sustainability efforts.

Combine Food Team and Purchasing & Recycling Waste Goals

During Phase II, it became obvious to us that the Food Team's recommendation to reduce food-related waste by 20% by 2020 is synergistic with the Purchasing & Recycling Team's goal to reduce overall U-M waste by 40% by 2020. Because food waste is such a large component of campus waste, we recommend combining these two goals. The implementation ideas outlined in this report represent potent strategies for achieving and surpassing the 20% food waste reduction goal. Combined with the strategies of the Purchasing & Recycling Team, we believe it is possible to meet the 40% goal before the 2020 target date. If this happens, we suggest setting a new, more ambitious goal. To be truly sustainable, the University will need to reduce waste dramatically and approach zero net waste operations. However, because this is the beginning of U-M's sustainability journey, we still believe 20% by 2020 is a good goal exactly because it is highly achievable. Once the momentum of food waste reduction in moving, we hope it will be hard to stop and the engaged operations staff who tackled the 20% goal will want to continue to towards more ambitious goals.

Food Team Implementation Idea's Contribution to Higher Sustainability Goals

Climate

- Expanded composting will prevent Methane emissions that occur in landfill decomposition.
- Replacing bottled water with municipal (tap) water on campus will have significant positive environmental effects by reducing CO2 emissions, energy consumption, landfill waste, and water waste (see Table 3)
- Tray-less dining will reduce the amount of food shipped to campus resulting in fewer greenhouse gas emissions from transportation and food production. It will also significantly reduce the amount of organic waste sent to landfill from U-M.
- Expanding local food purchases to 20% by 2020 will significantly reduce the amount of greenhouse gases emitted to transport food to campus

Human Health

- Bottled water is not subject to the strict testing requirements that municipal (tap) water is. Replacing bottled water with tap water will ensure that the water consumed on campus is clean and healthy. Unlike bottled water, municipal water also contains fluoride, an element that promotes dental health.
- Tray-less dining incentivizes diners to take only the amount of food they really want to eat. Our research shows that diners take less food in tray-less dining situations. This may

transfer to less calorie consumption, promoting healthier eating habits. However, this topic requires further study.

- Local food is almost always fresher than imported food. Expanding local food purchasing to 20% will likely result in fresher, more nutrient-rich foods served in campus dining facilities. The adoption of a local-sustainable food labeling system would also ensure lower levels of residual toxic pesticides and herbicides on ingredients used to prepare meals on campus.
- A campus farm will provide some expanded access to fresh, healthy, local food for campus users (very limited).

Ecosystem Health

- Expanded composting will provide nutrient rich soil amendment for use in campus landscaping and/or the campus farm/gardens. This will reduce the need to use traditional fertilizers which commonly run-off into streams and rivers, degrading water quality.
- The plastic used to make disposable water bottles persists in the environment for at least 450 years. Shifting from bottled water to municipal water will prevent the production of 600,000 plastic bottles per year. Petroleum production and exploration has caused massive damage to ecosystems (i.e. BP gulf oil spill). Plastic bottles are made from petroleum.
- Establishing a local/sustainable food label will support sustainable farm practices. Many of today's large-scale agricultural operations cause significant damage to ecosystems through the use of pesticides, herbicides, and genetically-modified organisms (GMOs). Purchasing more sustainably-produced food products will reduce these damaging farm practices in Michigan.
- Establishing a campus farm will provide opportunities for campus users to learn about sustainable agriculture, a lesson they can take with them and use to improve their communities throughout their lives.

Materials Footprint

- Expanded composting will reduce the amount of material sent to landfill by as much as 50% for some U-M buildings.
- Shifting from bottled water to municipal (tap) water will prevent hundreds of thousands of plastic bottles from going to landfill each year.
- Tray-less dining will actually *reduce* the amount of food needed to provide the 70,000 meals that RDS serves annually, not just *manage* the waste.
- Locally produced food products can often be shipped in reusable containers as opposed to disposable ones.

Community Awareness

- Post-consumer composting will provide daily reminders to campus users about the amount of food they waste.
- Shifting from bottled water to municipal water on campus will send a message that will be heard globally about the negative effects of bottled water. U-M has the opportunity to take a leadership role on this issue of emerging importance.

- Tray-less dining will provide an educational opportunity to remind campus diners about how much food they have been wasting.
- Increasing local food sourcing may necessitate more seasonal and creative menu planning. This will expose campus diners to the amazing diversity of agricultural product our region has to offer. It will also raise awareness about what products are available at what times of year causing students to question the sustainability of asparagus in February.
- Establishing a local/sustainable food label will send a clear message to all campus buyers and diners about the sustainability of their individual choices.
- A campus farm and/or high-visibility garden will provide daily passive learning experiences for campus users. Walking past the campus garden will provide students the opportunity to see first-hand what food looks like before it hits their plate. The campus garden and farm will also provide opportunities for students who are engaged in food sustainability activities more opportunities to get their hands dirty.

<u>Prioritization Matrix and Interpretation</u>

		Economic Aspects			Environmental Aspects			Social Aspects		
		Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Visibility	Learning/Research Opportunities
Food Team Implementation Ideas	Composting	5	5	N/A	4	5	5	N/A	4	3
	Bottled Water	4	3	N/A	4	4	4	2	5	2
	Tray-less Dining	2	1	N/A	1	N/A	4	2	5	2
	"Local Farm Forager"	0	3	N/A	3	5	2	3	3	1
	Local/Sustainable Food Labeling System	0	2	N/A	1	3	N/A	5	5	N/A
	Campus Farm and Garden	2	2	N/A	N/A	N/A	N/A	1	5	5

While the six implementation ideas are all related to sustainable food practices, the diverse features of these ideas makes it hard to compare and prioritize them. The following matrix is used as a “big picture” to summarize these ideas and make them comparable with each other. We assigned rankings to each implementation idea based on three aspects of attributes: economic aspects, environmental aspects and social aspects. Additional interpretation of these rankings can be found in Appendix 15.

Based on their relative ease of implementation, we present these implementation ideas in the following order. However, it is important to remember that often the more difficult to implement ideas have the greatest potential impacts.

1. **Tray-less Dining:** the only one of our implementation ideas that will likely yield significant economic benefits. This strategy has the potential to reduce food procurement costs and decrease material food print. In addition, with a proper education piece, it allows students to realize how much food they have been wasting and encourages healthy eating habits.

2. **Establish a Campus Farm/Garden:** this idea allows the University to generate a high level of social benefits with relatively little cost. It is the most popular sustainable practice idea among the student community as indicated by the online feedback responses. A campus farm/garden is a highly visible symbol of commitment to food sustainability ideals, is easy to incorporate with education and learning components, and it has been widely adopted in other peer institutes.

3. **Local/Sustainable Food Label:** this practice can be built upon the existing food labeling system, but will require increased staff time. It has high ranking in social benefits, but has less impact on the environmental aspects. This recommendation is highly linked with the Local Food Forager idea.

4. **Local Food Forager:** the creation of this position is a key component of the local food sourcing recommendation. A local food forager makes the execution of other local food souring recommendations possible, which leads to significant environmental and social benefits. However, the operating cost is relatively high. This idea is highly linked with the Local/Sustainable Food Label idea.

5. **Increased Composting:** the capital cost for composting is high, including potential renovation of kitchen facilities and the construction of an in-vessel composting facility. On-going operating cost is high as well. However, this practice will significantly contribute to climate, ecosystem health and reduce materials footprint. Post-consumer composting also has the additional benefit of encouraging daily sustainability thinking and learning among campus users.

6. **Replace Bottled Water with Municipal (tap) Water:** The economic cost of this recommendation is relatively high with lost revenue and capital costs for improved drinking fountain facilities. However, this idea will allow U-M to yield huge reputation benefits and set ourselves apart as true leaders in campus sustainability. It will contribute significantly to environmental and materials footprints goals. Also, it will enhance people’s awareness of the negative environmental impacts that bottled water has while reinforcing the importance of supporting municipal water systems (arguably the most important public health achievement of all time)

V. LITERATURE CITED (see endnotes)

VI. APPENDICES (in separate document)

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FOOD TEAM PHASE TWO REPORT APPENDICES

Appendix 1: Food Team Bios

During Phase II of the Campus Integrated Assessment, the Food Team was comprised of faculty lead Professor Larissa Larsen, and seven students representing a range of disciplines including urban planning, environmental studies, public policy, and business. The diversity of our team provided us with skills in long-range planning, research, communication, entrepreneurship, and analysis. Many of our team members have long been concerned with sustainable food practices and contributed rich personal experiences to our effort.

Greg Chojnacki graduated from Macalester College in 2005 with a BA in Political Science. In fall 2010 he began his studies in pursuit of the Master of Public Policy degree at the Gerald R. Ford School of Public Policy, with a focus on quantitative methods of public policy analysis applied to food systems policy. While working at the nonprofit Supportive Housing Network of New York prior to joining the Ford School, he founded and co-directed a Community Supported Agriculture (CSA) group in Astoria Queens, New York. Harvest Astoria CSA continues to connect over 300 community members with local, organic and sustainable farmers. While preparing to work on federal policy related to food production and the environment, he is excited to have a chance to promote sustainable agriculture on a local level.

Kathleen Elmquist is an undergraduate student pursuing a B.S in the Program in the Environment in the School of Literature, Science, and the Arts. She plans to specialize in sustainable food systems. She is currently enrolled in the course ―Sustainability and the Campus," where she is working on a zero waste project for University Unions. Kathleen has spent time volunteering at Food Gatherers Community Kitchen making dinner for the homeless. She is currently an active member of a student group named Cultivating Community that sustains a garden on Hill Street in Ann Arbor and volunteers at other gardens around Southeast Michigan.

Peter Grella is a first-year graduate student in the School of Natural Resources and Environment. He is working towards a Masters in Environmental Policy and Planning, in furtherance of an eclectic academic career that includes a B.A. in music and a minor in Chinese studies, for which he studied in Beijing. As an undergraduate at Allegheny College in Meadville, PA, Peter engaged in environmental planning and advocacy through the campus group Students for Environmental Action (briefly serving as secretary) and as an intern at the Meadville Redevelopment Authority. His interests include landscape ecology and planning, coupled human-natural systems, and the question of art and culture's place in the human experience of and interaction with the environment.

Jing Huang graduated from Tongji University in Shanghai, China with a B.S. in Urban Planning. She is now pursuing dual Masters Degrees in Business Administration (MBA) and Urban Planning (MUP). Concentrating in strategy and finance, she hopes to brought expertise in cost-benefit analysis to the Team's analysis. She has been actively involved in student organizations and university initiatives. As an Urban Planner, she has a particular interest in sustainable studies and practices.

Noam Kimelman graduated from the University of Michigan with a B.S. in Biological Anthropology in 2009 and is now pursuing dual Masters Degrees in Health Policy (MPH) and Urban Planning (MUP). During six consecutive years at the University, Noam has benefited from a wealth of resources and passionate peers, enabling him to launch and direct two fresh foods access initiatives: The Ypsilanti Health Initiative, and Get Fresh Detroit LLC. Although the organizations utilize different programming, channels, and organizational structures, the both align incentives to make fresh and healthy foods more affordable and more accessible for lower-income populations. Expecting to graduate in May 2012, Noam hopes to continue bridging disciplines of public health, public policy, urban planning, smart design, and entrepreneurship to advance the healthy, vibrant, and equitable communities of the future.

Kevin McCoy graduated from the University of Michigan, School of Music in 2001 with a B.M. in Instrumental Music Education. He spent time working as both a marching band instructor and as the production supervisor of an electronics manufacturing firm before returning to the University of Michigan to pursue the Master of Urban Planning degree. He is in his second year of graduate study, concentrating in transportation, environmental, and land use planning and expects to graduate in May 2011. Kevin is a resident of the city of Detroit, where he is an active participant in his community's urban garden. On the food team, he serves as the student leader.

Breanna Shell graduated from Denison University with a bachelor‘s degree in Psychology in 2006. She volunteered with Safe Routes to School programs, neighborhood associations, and community gardens before discovering Planning as a career. She is in her second year of study, pursuing a Master of Urban Planning in the Taubman College of Architecture and Urban Planning (TCAUP), expected to graduate in 2011. At TCAUP she focuses on community development, sustainable land use planning, and the practice of creating local food systems. As a Food Team member during both Phase One and Phase Two, she has played a critical role, focusing on local food sourcing.

Appendix 2: List of Food Team Meetings with U-M Operations Staff and Community Outreach

Throughout Phase II, the Food Team held both weekly team meetings and occasional smaller group meetings. Barbara Hagan and Megan Loll from U-M Office of Campus Sustainability also attended many of these meetings, providing invaluable assistance to the team. Below are some of the key meeting involving outside stakeholders. In addition to these meetings there were many additional email and phone call interactions that are too numerous to list here.

9/21/2010, 9/23/2010

- Team members attended Earth Fest on Central and North Campus Diag.
- Casual conversations with campus users and U-M operations staff also in attendance

10/8/2010

- Faculty Lead and Student Lead attended Integration Team meeting focused on U-M budget, hosted by Vice Provost Martha Pollack

10/12/2010

- Meeting with Tracy Artley, U-M Recycling Coordinator
    - Discussed pre and post-consumer composting details, benefits and barriers
    - Discussed methods of tracking progress towards 20% waste reduction goal

10/14/2010

- Student Lead and one other team member attended the third Campus Sustainability IA Town Hall

10/25/2010

- Large meeting to discuss certification of small farmers. Organized by U-M OSEH. Attended by representatives from RDS, Procurement, U-M Hospitals, and OSEH
- Attended by Team Member Bre Shell.

10/26/2010

- Large meeting with many key stakeholders including:
    - Sandra Lowry - Associate Director, U-M Residential Dining Services
    - Keith Soster - Director of Food Service, U-M Unions
    - Randy Burns – Senior Buyer, U-M Hospitals
    - Jennifer Nord – U-M OSEH
    - Jennifer Randall – Sysco Detroit
    - Tracy Artley – U-M Recycling Coordinator
- Discussed all team goals and implementation recommendations
    - Focus was on barriers to implementation

11/5/2010

- Meeting with members of Purchasing/Recycling Campus Sustainability IA Team
- Concluded that P&R Team‘s goal of 20% overall waste reduction was in-line with Food Team‘s 20% food-related waste reduction goal.

11/10/2010

- Several group members assisted in a tray-less dining experiment at East Quad run by Sandra Lowry, Associate Director of U-M Residential Dining Services

11/16/2010

- Met with Sue Gott, University Planner
  - Discussed Campus Garden implementation idea, including potential site requirements

11/17/2010

- Sustainability Fair on U-M Central Campus Diag.
- Talked with students and passersby about the CSIA and food team work

11/22/2010

- Meeting to respond to stakeholder reactions to Food Team Final Report Outline as provided the previous week. Participants expressed concern that their opinions were not adequately represented in the outline that had been presented. We discussed their concerns and ways that the outline could be changed to better reflect their opinions of and the barriers associated with implementation ideas. Participants included:
  - Michael Lee – Director, U-M Residential Dining Services
  - Sandra Lowry - Associate Director, U-M Residential Dining Services
  - Keith Soster – Director of Food Service, U-M Unions

12/6/2010

- Meeting of all student groups engaged in sustainable gardening on campus
  - Discussed forming a coalition to lobby university administration for increase on-campus garden/farm space for students and coursework
  - Team Member Greg Chojnacki attended this meeting

12/8/2010

- Phone call with Ken Rapp, U-M Landscape Architect
  - Discussed attributes of a highly-visible on-campus garden
  - Team member Greg Chojnacki attended this phone meeting

Appendix 3: Food Practices at other Universities

Correlations between dining sustainably and perception of quality

However slightly, it seems that recognition of environmentally conscious practices in college dining, among other environmentally minded initiatives, might affect a school‘s image and admissions. A 2009 survey administered by the Princeton Review showed 23% of respondents reporting that information about a college‘s sustainability would very much or strongly affect their admissions decision[1]. A USA Today article also featured a student whose decision to select a college came down to a preference for sustainable dining[2]. Across many campuses that do not contract out their food services, students continue to push for sustainable food options, and contracted providers such as Aramark[3], Sodexo[4], and Parkhurst[5] are also responding to increased demand for local, organic, and humanely produced food. The recent popularity of sustainability ranking systems, such as those offered by the Sustainable Endowment Institute‘s College Sustainability Report Card and the Association for the Advancement of Sustainability in High Education‘s new STARS[6] program, makes identifying ―green" colleges easier to do.

In light of the possibility of sustainability‘s influence on image and desirability for applicants, four lists of colleges were created and the colleges compared to see how their sustainable practices might compare with that of the University of Michigan and if a correlation exists between sustainability and their generally perceived quality, as ranked by U.S. News & World Report[7]. The lists were of the Report‘s top 10 universities, the Report‘s top 15 liberal arts colleges, the Report Card‘s rank of Big Ten schools (in which the University of Michigan is included), and other colleges the University of Michigan considers peer institutions.

The information gathered below is adapted from survey responses volunteered for the 2011 College Sustainability Report Card[8], which reflects the 2009-2010 academic year[9]. A generally

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1 The Princeton Review, Inc. [Internet]; 2009. 2010 College Hopes & Worries Survey Report. [cited 2010 Dec 5]; [6 pages]. Available from: http://www.princetonreview.com/uploadedFiles/Test_Preparation/Hopes_and_Worries/HopeAndWorries_Full%20Report.pdf

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7 U.S. News & World Report [Internet]. Best Colleges 2011; c2010 [cited 2010 Dec 5]. Available from: http://colleges.usnews.rankingsandreviews.com/best-colleges

8 Sustainable Endowments Institute [Internet]: The College Sustainability Report Card; c2007-2010 [cited 2010 Dec 5]. Available from: http://greenreportcard.org .

9 A summary of the Report Card‘s methodology can be found on their website.

useful reference for assessing the environmental consciousness of a college, the Report Card solicits information about sustainable practices from schools, including dining and waste practices, which is then weighed and turned into a rank and letter grade. Here, information considered most relevant to us is selected for four categories, representing the share of local food available, the production methods applied to food on campus, whether an on-campus garden or farm exists, and waste-reducing activities.

This small amount of evidence suggests that sustainability in the dining hall among top universities and University of Michigan peer institutions does not strongly correlate to the overall quality of a college as ranked by U.S. News & World Report. However, among liberal arts colleges, those that rank more highly with U.S. News & World Report also score highly on the College Sustainability Report Card. Many of these schools surprisingly had campus gardens that provide some nominal addition to dining hall fare. Nearly every college was able to claim their waste cooking oil as recycled for biodiesel production. Tray-less programs were popular, though few schools practiced tray-less dining exclusively. Otherwise, while the portion of local food purchased seems to have no correlation to U.S. News & World Report rank, it weighs heavily in the college's Green Report Card score, up to 30%, and so correlates strongly with a high grade. The University of Michigan did not rank highly among the Big Ten, coming in 8th.

Unfortunately, despite the Report Card's popularity as a reference tool for students – hence the focus on it for this appendix – its survey responses are often inconsistent between colleges and often factually inaccurate. For instance, it incorrectly reports that U-M composts 100% of pre-consumer food scraps, and while correctly reporting that one dining hall is tray-less, in its summary ―many" are. Information for the Green Report Card is gathered from self-reported surveys or, if the surveys are not returned or additional information is desired, gathered from publicly available sources. Due to the nature of the survey, which aims to evaluate a standardized set of indicators, the information does not necessarily accurately depict the full range and variety of sustainability efforts on individual campuses, since such efforts may not be reported on the survey or discovered by researchers[9]. Therefore, we must presume that the grade and survey is helpful mostly for very cursory judgments and as a starting point for further investigation, so the generalizations made here are not at all conclusive.

Sustainable Endowments Institute [Internet]: Report Card 2011, Methodology; c2007-2010 [cited 2010 Dec 5]. Available from: http://greenreportcard.org/report-card-2011/methodology#datacollection

The Big Ten

UNIVERSITY OF MINNESOTA (Minneapolis, MN)	Local Food*	Sustainable Production**	Campus Farm or Garden***	Waste, Composting, and Dining Practices****
Sustainable Report Card Rank: 1st of 11 **U.S. News & World Report Rank:** 64th **Overall Score:** A **Food & Recycling Score:** A **Innovations:**	A variety of local foods are purchased.	Some organic food is purchased. The school purchases hormone free dairy, cage-free eggs, and fair-trade products, and is the only Big Ten to purchase grass-fed beef.	N/A	The University composts about 30 tons of pre- and post-consumer waste per month.
UNIVERSITY OF WISCONSIN (Madison, WI)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 2nd of 11 **U.S. News & World Report Rank:** 45th **Overall Score:** A **Food & Recycling Score:** B **Innovations:** Some of the waste grease converted to bio-diesel is used as water-heating fuel in one of the residence halls.	Of an $8,000,000 budget, $890,046 (11%) was spent on an extensive variety of locally produced food, directly purchased from 10 sources and from 50 others through distributors. A further $275k (3.4%) was spent on locally processed food.	1.7% of the school's food budget, $139,965, was spent on organics over all categories of food except milk and seafood. The school does not exclusively purchase any fair-trade products. Over 90% shell eggs are cage-free.	The University of Wisconsin sources some produce and herbs from an on-campus garden.	The school composts over 90% pre-consumer food waste, but composts less then 5% post-consumer food waste. It has no trayless program.
MICHIGAN STATE UNIVERSITY (East Lansing, MI)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 3rd of 11 **U.S. News & World Report Rank:** 79th **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:**	Of $23,834,000, 13% was spent on locally producuced food purchased from 68 producers and close to 50 vendors and represents every category of food. The school also purchases locally processed food directly from 30 processors.	Only $8,000 was spent on organics in 2009-2010, on vegetables, eggs, and poultry. Only fair-trade coffee is provided on campus. The school does not invest in any hormone/antibiotic free or cage free products. Between 10-20% of some select seafood items meet sustainable harvest standards.	The school sources some greens and herbs from a large student-run organic farm that also houses hens, sugar maples, and an apiary.	Michigan State composts a proportion of pre-consumer waste but does not post-consumer waste. One of 14 dining halls is trayless. Some waste oil is collected for biodiesel production.
OHIO STATE UNIVERSITY (Columbus, OH)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 4th of 11 **U.S. News & World Report Rank:** 56th **Overall Score:** B+ **Food & Recycling Score:** B **Innovations:**	Ohio State purchases a conservative portion of locally produced and processed veggetables, fruit, processed dairy, meat, and baked goods.	No portion of Ohio State's dining budget is dedicated to purchasing organic produce. Some fair-trade coffee is provided on campus. The school does not intentionally purchase free-range, hormone- or antibiotic-free products.	A small portion of salad greens are sourced from an on-campus garden.	Ohio State composts 100% pre-consumer waste and 70% post-consumer waste. 90% of meals are tray-less service. The school has extraordinary dedication to using biodegradable serviceware, utensils excepted.
PENNSYLVANIA STATE UNIVERSITY (University Park, PA)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 5th of 11 **U.S. News & World Report Rank:** 47th **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:** A large agriculture research college, Penn State is unusual in its ability to source huge amounts of dairy from campus, though a large portion of it is only processed on site. The horticulture school also supplies some produce and flowers for sale during summer and	Penn State purchases a portion of its vegetables, fruit, fresh and processed dairy, eggs, and milk directly from 20 local sources. The school also purchases locally processed food from 48 sources.	A portion of Penn State's vegetables and fruits, grains, dairy, meat, and processed products are organic. Some fair-trade coffee is provided on campus. The school does not intentionally purchase free-range, hormone- or antibiotic-free products.	Penn State gets almost all of its dairy from the on-campus creamery, part of its Dairy Production Research Center, which has its own herd of cows. Additionally, some mushrooms are also sourced from campus.	100% of pre-consumer food waste is composted, much of it on campus at the Organic and Materials Processing and Education Center. There is no post-consumer waste. The college is planning a test-pilot trayless program.
UNIVERSITY OF ILLINOIS (Champaign, IL)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 6th of 11 **U.S. News & World Report Rank:** 47th **Overall Score:** B **Food & Recycling Score:** A **Innovations:**	Of a $13,239,000 budget, the University spent $2,173,000 (16%) on local food in all categories save seafood. $3,283,000 (25%) was spent on locally processed food.	Only $11,300 went towards the purchase of organic produce, red meat and pork, grains, processed dairy, and some other processed food items. Only fair-trade coffee is served on campus, as is some chocolate. 100% of tilapia, scallops, mussels, and clams, 40% salmon, and a number of other seafood items are harvested according to sustainable standards. The school does not purchase hormone-free, free-range, or antibiotic-free products.	The University Student Farm provides a portion of produce and herbs, at a cost of $43,445 in 2009-2010.	Take-out containers are only from post-consumer recycled or biodegradable. All residential dining hall meals are trayless. The school has just begun a composting program, and currently composts 1% pre-consumer food waste.
INDIANA UNIVERSITY (Bloomingfield, IN)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 7th of 11 **U.S. News & World Report Rank:** 75th **Overall Score:** B **Food & Recycling Score:** B **Innovations:** The school has a 50% discount for beverages filled in reusable mugs, one of the most generous deals seen. It is also the only Big Ten to have done away with bottled water. Its composting program operates in conjunction with the school's botanical	The University spent only 0.1% of food spending on an extensive variety of local food, including much of its apple purchase. 4.6% of its food purchases were from local processors.	In 2009-2010, the University of Indiana devoted $10,000 to the purchase of organic vegetables. 50% of shell eggs are cage-free. The school serves some fair trade coffee and tea. A variety of seafood served is also harvested to sustainable standards.	The school does not have an on-campus farm or garden.	Bottled water has been eliminated from dining halls. Waste oil is recycled as biodiesel. 80% pre-consumer waste is composted. There is no post-consumer compost waste program.
UNIVERSITY OF MICHIGAN (Ann Arbor, MI)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 8th of 11 **U.S. News & World Report Rank:** 29th **Overall Score:** B **Food & Recycling Score:** B **Innovations:**	Of the $11.7million spent on food in 2009, $1,053,744 (9%) was spent on locally produced vegetables, fruit, dairy, meat, cereal, sweeteners, and beverages. $588,188 (5%) was spent on locally processed food.	University of Michigan spent $12,000 in 2009 on organic fruits and vegetables, representing 0.79% of total produce purchases. The school does not purposefully buy organic food other than produce. In addition to some tea and chocolate, all coffee on campus is fair-trade. The school does not deliberately purchase cage-free or free-range products, with the exception of 1% of eggs (served exclusively in one dining hall). 100% liquid dairy products are hormone-free.	The college does not have an on-campus farm or garden.	The school composts 100% of pre-consumer waste, but has no post-consumer composting program. As of 2011, only one of eight dining halls will practice trayless dining.
PURDUE UNIVERSITY (West Lafayette, IN)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 9th of 11 **U.S. News & World Report Rank:** 56th **Overall Score:** B- **Food & Recycling Score:** B **Innovations:**	A small portion of Purdue's budget, $75,143 (0.7%) of $11.3million, is dedicated to purchasing local fruits, vegetables, and milk. $2million (17.7%) is spent on locally processed foods, through 1 distributor and 2 direct providers.	$13,000 organic processed dairy and some other processed foods were purchased in 2009-2010. The University purchases no free-range, cage-free, fair trade, hormone or antibiotic-free products. 100% cooked shrimp is produced in a sustainable fashion.	The college does not have an on-campus farm or garden.	There is no pre-consumer composting or trayless program. Waste grease is turned into biofuel, and post-consumer waste is used in an aerobic digester to produce methane for campus electricity production.
NORTHWESTERN UNIVERSITY (Evanston, IL)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 10th of 11 **U.S. News & World Report Rank:** 12th **Overall Score:** C+ **Food & Recycling Score:** B **Innovations:**	Northwestern purchases food directly from 38 producers.	Only fair-trade coffee is served in the dining halls. All dairy and poultry is hormone free. All seafood is produced in a sustainable fashion.	N/A	All but one dining hall is trayless.
UNIVERSITY OF IOWA (Iowa City, IA)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: 11th of 11 **U.S. News & World Report Rank:** 72nd **Overall Score:** C- **Food & Recycling Score:** C **Innovations:**	Some local food is purchased.	Some organic food is purchased.	N/A	Trayless dining is encouraged. Free refills are offered to students who use reusable mugs.
UNIVERSITY OF NEBRASKA (Lincoln, NE)	**Local Food**	**Sustainable Production**	**Campus Farm or Garden**	**Waste, Composting, and Dining Practices**
Sustainable Report Card Rank: N/A **U.S. News & World Report Rank:** 104th **Overall Score:** C **Food & Recycling Score:** A **Innovations:**	Some local food is purchased directly from 34 farms.	Some organic food is purchased. Some hormone-free, antibiotic-free, and cage-free food is provided.	N/A	Trayless dining is practiced in most facilities. Waste cooking oil is recycled for biodiesel.

Other University of Michigan Peer Institutions

JOHNS HOPKINS UNIVERSITY (Baltimore, MD)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
US News & World Report Rank: 13th **Overall Score:** C+ **Food & Recycling Score:** C **Innovations:**	N/A	Only cage-free eggs and hormone- and antibiotic free milk is provided.	N/A	Some meals are trayless.

CORNELL UNIVERSITY (Ithica, NY)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
US News & World Report Rank: 15th **Overall Score:** A- **Food & Recycling Score:** B **Innovations:**	Cornell spent 11% of its food budget on locally produced or processed produce, dairy, meat, and prepared foods.	$86,500 was dedicated to purchasing organic produce, dairy, grains and beans, meat, beverages and prepared foods. Some fair-trade coffee is available, along with some tea and banans. Most dairy and 20% of beef is hormone- and antibiotic-free.	Cornell's experimental farm is a source of some herbs and greens.	100% of pre- and 60% of post-consumer food waste is composted. Biodegradable disposable serviceware is available. 60% of meals are trayless. Waste cooking oil is recycled for biodiesel.

UNIVERSITY OF CALIFORNIA-BERKELEY (Berkeley, CA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
US News & World Report Rank: 22nd **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:**	UC Berkeley spent $1,244,924 on locally produced food and $1,056,736 on locally processed food, totalling 15% of the food budget.	$1,464,965 worth of organic produce, grains, milk, eggs, and some processed food was purchased in the 2009-2010 year. Some fair-trade coffee is provided, along with some tea and chocolate. All eggs, about a third of beef and poultry, and two thirds of milk were produced in confinement-free conditions. All ground beef, most milk and some poultry is certified hormone- and antibiotic-free.	The college does not have an on-campus farm or garden.	All pre- and post-consumer food waste is composted. All meals are trayless. Biodegradable disposable serviceware is available. Bottled-water use has declined by 28% after three years promoting tap water. Waste cooking oil is recycled for biodiesel.

UNIVERSITY OF CALIFORNIA-LOS ANGELES (Los Angeles, CA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
US News & World Report Rank: 25th **Overall Score:** B **Food & Recycling Score:** A **Innovations:**	A portion of vegetables and fruit is locally produced.	UCLA spent $187,234 on organic food. Some fair-trade coffee is served, in addition to some chocolate. All eggs are produced in cage-free conditions. All milk is hormone- and antibiotic-free. 77% of seafood is sustainably harvested.	UCLA sources some herbs and vegetables from two campus gardens.	Biodegradable dinnerware is provided. Most dining facilities compost pre- or post-consumer food waste. Up to a half of meals served are trayless. Waste cooking oil is recycled for biodiesel.

UNIVERSITY OF VIRGINIA (Charlottesville, VA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
US News & World Report Rank: 25th **Overall Score:** B **Food & Recycling Score:** A **Innovations:**	University of Virginia spent $616,500 on locally grown and $567,900 on locally processed produce, dairy, meat, eggs, and prepared food.	$103,600 was spent on organic produce, dairy, poultry, and beverages. Some fair-trade coffee is provided, in addition to some tea, chocolate, bananas, and ice cream. All beef is hormone- and antibiotic-free, confinement-free, and vegetarian fed. A quarter of eggs are produced in cage-free conditions. 90% of seafood is sustainably harvested.	The college does not have an on-campus farm or garden.	80% of pre- and post-consumer food waste is composted. Compostable dinnerware is provided. 97% of meals are trayless. Waste cooking oil is recycled for biodiesel.

UNIVERSITY OF TEXAS-AUSTIN (Austin, TX)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
US News & World Report Rank: 45th **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:**	Of an approximately $7,000,000 food budget, $166,104 (2.4%) was spent on locally grown and $477,670 (6.8%) on locally processed produce, dairy, grains and beans, meats, eggs, sweeteners and some prepared foods.	$44,132 was dedicated to a variety of organic food. Some fair-trade coffee is provided. All chicken is vegetarian-fed, and 45% is hormone- and antibiotic-free. A small portion of eggs and beef is produced in confinement-free conditions. Nearly all seafood is sustainably harvested.	The college does not have an on-campus farm or garden.	Biodegradable disposable dinnerware is provided. A composting program has only just begun. 100% of meals are trayless. Waste cooking oil is recycled for biodiesel.

UNIVERSITY OF MARYLAND (College Park, MD)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
US News & World Report Rank: 56th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Of a $13,623,713 food budget, UMD spent $279,463 (2.1%) on locally grown food, and $1,452,740 (10.7%) on locally processed food.	$8,000 was dedicated to organic vegetables. Some fair-trade coffee is provided. 75% of eggs are cage-free, and 50% of milk is hormone- and antibiotic-free.	The college does not have an on-campus farm or garden.	85% of pre- and 70% of post-consumer food waste is composted. Biodegradable dinnerware is provided. There is no trayless program. Waste cooking oil is recycled for biodiesel.

U.S. News & World Report Top 10 Universities

HARVARD UNIVERSITY (Cambridge, MA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 1st **Overall Score:** A- **Food & Recycling Score:** A **Innovations:** Two farmers markets operate on campus grounds from June through October.	Of a budget in excess of $7,100,000, $832,100 (11.7%) was spent on locally grown and $2,534,050 (35.7%) on locally processed food of an extensive variety.	$240,730 was spent on organic produce, milk, grains, eggs, and some prepared foods. Some fair-trade coffee and tea is served on campus, in addition to some fair-trade chocolate. 100% of milk is antibiotic and hormone free. Nearly 20% of eggs are cage-free. A potion of seafood is certified sustainably harvested.	Harvard has a recenty established community garden, from which it sourced some greens, onions, tomatoes, and herbs.	60% of pre- and 65% of post-consumer food waste is composted from almost all dining halls. Trayless dining is available during some events and on selected days.

PRINCETON UNIVERSITY (Princeton, NJ)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 2nd **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Princeton purchases some locally grown or produced vegetables, fruit, milk, meat, eggs, sweeteners, and baked goods.	The school purchases some organic processed dairy and cereals. Some fair-trade coffee is served on campus. 100% of eggs, chicken, and pork are produced in confinement-free conditions. All chicken and 55% beef are vegetarian-fed. 100% of milk is antibiotic and hormone free. All seafood is sustainable produced.	A small garden provides some herbs and produce.	1% of pre-consumer waste is composted at the campus garden. 100% post-consumer waste is given to a local farmer. 70% of meals are trayless. Used cooking oil is recycled for biofuel.

YALE UNIVERSITY (New Haven, CT)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 3rd **Overall Score:** A **Food & Recycling Score:** A **Innovations:**	Yale purchased $1,599,812 worth of locally grown and an equal value produced food of an extensive variety.	The school purchased $720,000 of organic food in all categories of products. Some fair-trade coffee, tea, chocolate, and bananas are available. 90% of eggs are confinement free. Most meat products are both vegetarian-fed and hormone-free. Much fish provided is sustainable harvested.	The college does not have an on-campus farm or garden.	A portion of waste food scraps are composted. 20% of meals are trayless, in a single dining hall. Bottled water is unavailable at large functions.

COLUMBIA UNIVERSITY (New York, NY)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 4th **Overall Score:** B+ **Food & Recycling Score:** B **Innovations:**	36% of dining service's budget is spent on locally grown or processed food.	Some seafood is sustainably harvested.	The college does not have an on-campus farm or garden.	One dining hall is trayless.

STANFORD UNIVERSITY (Stanford, CA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 5th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Stanford purchases a wide variety of local food from over 30 producers and over 100 distributors.	The school purchases an extensive variety of organic food. Close to a quarter of egg, meat, and poultry purchased is produced in confinement-free conditions. 100% milk and poultry is hormone free. A portion of meat products are vegetarian-fed. Most seafood is sustainable harvested.	Stanford sources a variety of herbs, vegetables, and melons from its community and dining hall gardens.	100% of pre- and 98% of post-consumer food waste is composted. Trayless dining is encouraged. When possible, disposable diningware is biodegradable or otherwise made from recycled materials.

UNIVERSITY OF PENNSYLVANIA (Philadelphia, PA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 5th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:** A number of vending machines introduced on campus are energy efficient and stock products that meet a sustainable critera, which information is available on a display.	The school spent $1,137,283 on locally produced and $200,697 on locally processed food in every category of product.	$602,091 was spent on organic food in every category but eggs. Only fair-trade coffee is available on campus, in addition to some fair-trade tea, chocolate, and bananas. 100% eggs are cage-free. A portion of beef, pork, and chicken are also confinement free. 29% of beef is both hormone-free and vegetarian fed. 100% of milk and poultry is hormone free. All seafood is sustainably harvested.	A hyproponic garden on campus provides some produce and herbs.	90% of pre- and 75% of post-consumer food waste is composted. Dining services exercizes a bottled water ban. 100% of meals are trayless. Disposable diningware is either biodegradable or of post-consumer recycled content. Cooking oil is recycled for

CALIFORNIA INSTITUTE OF TECHNOLOGY (Pasadena, CA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 7th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Of a $2,250,000 budget, $60,000 (2.7%) was spent on locally produced and $135,000 (6%) on locally processed dairy, produce, and baked goods.	$87,000 of produce, processed dairy, meat, seafood and baked goods was organic. Only fair-trade coffee is available on campus. The school does not actively purchase confinement free animal products. Most beef products are hormone and antibiotic free. 60% of seafood is certified sustainably harvested.	The school gets some citrus and olives from its campus's trees, and there are several campus gardens.	No pre-consumer food scraps are recycled. Some post-consumer waste and coffee grounds are used in the gardens. All meals are trayless. Cooking oil is recycled for biodiesel.

MASSACHUSETTES INSTITUTE OF TECHNOLOGY (Cambridge, MA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 7th of 11 **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:**	Of a $3,150,000 budget, MIT spent $500,000 (15.9%) on locally produced food, and also provided locally processed food, of an extensive variety.	The school provides an extensive variety of organic food. Some fair-trade coffee is served on campus.50% of provided eggs were produced in cage-free conditions. 50% of milk, poultry, and beef is hormone-free. All seafood is sustainably harvested.	The college does not have an on-campus farm or garden.	100% pre-consumer food waste is composted. Post-consumer composting is newly implemented. Much provided disposable servingware is compostable. Trayless dining is practiced in some locations.

DARTMOUTH COLLEGE (Hanover, NH)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 9th of 11 **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Of a $6,923,047 budget, Dartmouth spent $355,000 (5%) on food produced locally, and $485,000 (7%) on food processed locally, of an extensive variety of products.	$34,900 was spent on organic vegetables, processed dairy, eggs, grains and beans, and other prepared items. Only fair-trade coffee is served on campus, in addition to fair-trade tea and bananas. All shell eggs are both cage-free and vegetarian fed. 30% beef is free-range. Most processed dairy is hormone free. 60% of seafood is certified sustainably harvested.	A self-described organic farm provides some produce.	100% of both pre- and post-consumer food waste is composted. One facility representing 20% of meals practices trayless dining. Used cooking oil is recycled for biodiesel.

DUKE UNIVERSITY (Durham, NC)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 9th of 11 **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:**	25% of Duke's food budget is spent on locally produced or processed food.	Some hormone- and antibiotic-free products are provided.	N/A	Pre- and post-consumer food waste is composted in some locations.

UNIVERSITY OF CHICAGO (Chicago, IL)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank 9th of 11 **Overall Score:** C+ **Food & Recycling Score:** B **Innovations:**	N/A	Exclusively fair-trade coffee is served on campus. All milk is hormone-free.	N/A	Pre- and post-consumer food waste is composted in all residence dining halls.

U.S. News & World Report Top 15 Liberal Arts Colleges

WILLIAMS COLLEGE (Williamstown, MA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 1st **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	For 2009-2010, Williams College spent $251,241 on local produce, dairy, meat, eggs, and value-added goods, bought directly from 13 producers and through 5 distributors.	$31,578 was spent on organic produce, dairy, meat, eggs, grains, and some processed products. Only fair trade coffee is served on campus, as well as some tea. A portion of the dairy, meat, and eggs are free-range and hormone and antibiotic-free.	The college gets 500 lbs of produce from an on-campus sustainable garden.	Disposable dishware is made from post-consumer recycled content or is otherwise biodegradable. 90% of both pre- and post-consumer food waste is composted. A trayless program was started last year. A bottle water ban is in effect in dining service halls.

AMHERST COLLEGE (Amherst, MA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 2nd **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Of a $2,320,000 budget, $113,300 (4.9%) was spent on an extensive variety of locally produced food directly from 6 producers, and $348,000 (15%) on locally processed food .	$59,212 was spent on organic vegetables and fruits, dairy, and sweeteners. Only fair-trade coffee is served on campus. The college does not purchase any cage free eggs. It provides 100% hormone-free milk, and a small proportion of seafood is certified sustainably produced.	The college does not have an on-campus farm or garden.	Trayless dining is encouraged. 100% of both pre- and post-consumer waste is composted in cooperation with a nearby farm. Cooking oil is recycled for biodiesel. The college has a bottled-water ban. Disposable dishware provided is biodegradable.

SWARTHMORE COLLEGE (Swarthmore, PA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 3rd **Overall Score:** B+ **Food & Recycling Score:** B **Innovations:**	Swarthmore sources some locally grown and processed vegetables, fruit, dairy, poultry, eggs, and processed goods.	The college serves some fair-trade coffee, chocolate, tea, and bananas.	Some $300 was invested in a garden that provides herbs for the dining halls.	100% pre- and 50% post-consumer food waste is composted.

MIDDLEBURY COLLEGE (Middlebury, VT)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 4th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Of a $3,382,724 budget, $531,488 (15.7%) was spent on locally grown and $127,972 on locally processed products of an extensive variety, purchased directly from many producers and distributors.	$37,047 was spent on organic produce, processed dairy, grains and beans, and prepared foods. Some fair-trade coffee is served on campus. 100% poultry and eggs are cage-free, 100% beef is grass-fed, and all meat is hormone and antibiotic free.	$2,441 was invested in an organic campus garden which supplies some vegetables to dining halls.	100% of meals are trayless. 100% of pre-and post-consumer food waste is composted. UVM tries hard not to overpurchase food. Biodiesel is made from waste cooking oil.

WELLESLEY COLLEGE (Wellesley, MA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 5th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	Of a $3,200,000 budget, Wellesley spent $300,000 (9%) on locally produced and $1,000,000 (31%) on locally processed produce, seafood, dairy, and some other prepared food.	$100,000 (3%) was spent on organic vegetables, milk, grains, cerals, and sweeteners. Some fair-trade coffee is served on campus, as well as chocolate and tea. The school does not purchase cage-free or grass-fed products. 100% milk is hormone free, as well as a small portion of poultry and beef. Some fish are sustainably harvested.	A campus garden provides some herbs, tomatoes, and eggplant.	100% meals are trayless. 15% pre-consumer food waste is composted, while there is no post-consumer compost program. Disposable dishware is biodegradable. Biodiesel is made from waste cooking oil.

BOWDOIN COLLEGE (Brunswick, ME)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 6th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:**	41% of its food budget is spent on locally produced and processed food.	30% eggs are cage free, and 10% of beef is vegetarian fed.	N/A	80% of pre- and post-consumer food waste is composted.

POMONA COLLEGE (Claremont, CA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 7th **Overall Score:** A **Food & Recycling Score:** A **Innovations and Exceptions:**	$232,231 of Pomona College's $2,172,423 food budget was spent on locally produced food, and $600,325 on locally processed food, including produce, milk, seafood, and some spreads and sauces.	Some organic produce and beverages are provided. Only fair-trade coffee is served on campus. 100% seafood is sustainably produced. 100% milk is hormone and antibiotic free.	The school does not have an on-campus garden or farm.	An average 400 meals worth of excess food is prepared per week for homeless shelters. 100% meals are trayless. 100% pre-consumer food waste is composted. Disposable dishware is biodegradable.

CARLETON COLLEGE (Northfield, MN)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 8th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:** Food waste reduction efforts extend to voluntary composting in the residence halls and library.	Of $1,965,967, $305,883 (15.5%) was used to purchase a variety of locally produced food and $166,540 (8.5%) spent on locally processed food of a wide variety.	A total of $7,800 (0.4%) of the food budget bought organic produce, cerals, and beverages. Only fair-trade coffee and tea is offered. 100% eggs are cage-free, 100% beef is vegetarian fed, 100% beef, poultry, and milk is hormone free, and 100% seafood is sustainably harvested.	The school invests $1,700 in a campus garden, from which is gets some produce.	All pre- and post-consumer food waste is composted. Disposable containers are post-consumer recycled content or otherwise biodegradable. There is no trayless program.

DAVIDSON COLLEGE (Davidson, NC)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 9th **Overall Score:** B+ **Food & Recycling Score:** B **Innovations:**	Some locally produced and processed produce, milk, and meat is provided.	Only fair trade coffee is served on campus. Cage-free eggs are available in one café.	The school sources some herbs from an on-campus garden.	90% of pre- and post-consumer food waste is composted. Disposable containers are post-consuer recycled content or otherwise biodegradable. The dining facilities exercise a bottled water ban. Waste cooking oil is recycled for biodiesel.

HAVERFORD COLLEGE (Haverford, PA)	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
U.S. News & World Report Rank: 10th **Overall Score:** B+ **Food & Recycling Score:** B **Innovations:**	For 2009-2010, Haverford spent $350,00 for each locally produced and processed food of a wide variety, accounting for 32% of its budget.	The school does not actively pursue purchasing organic products.Only fair-trade coffee is served on campus. 50% of eggs are cage-free.	The school does not have an on-campus garden or farm.	Disposable containers are post-consumer recycled content or otherwise biodegradable. 100% meals are trayless. All pre-consumer food waste is composted. The dining facilities exercise a bottled water ban. Waste cooking oil is recycled for biodiesel.

U.S. News & World Report Top 15 Liberal Arts Colleges (cont.)

College	Local Food	Sustainable Production	Campus Farm or Garden	Waste, Composting, and Dining Practices
CLAREMONT MCKENNA COLLEGE (Claremont, CA) **U.S. News & World Report Rank:** 11th **Overall Score:** B **Food & Recycling Score:** A **Innovations:**	Of a $957,796 food budget, $78,000 (8%) purchased locally produced and $150,000 (15.6%) purchased locally processed produce, dairy, poultry, eggs, and prepared food.	$35,000 (3.7%) purchased organic products. Some fair trade coffee is served on campus. All animal products are hormone-free. 40% of eggs are cage-free.	The school does not have an on-campus garden or farm.	100% of meals are trayless. Biodegradable disposable dishware is available. Waste cooking oil is recycled for biodiesel.
VASSAR COLLEGE (Poughkeepsie, NY) **U.S. News & World Report Rank:** 12th **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:**	20% of the college's food budget is spent on locally produced or processed produce, dairy, grains, baked goods and beverages.	100% eggs are cage-free, and most dairy products are hormone and antibiotic free.	Vassar has a farm for experimental ecology and biology, on which several acres are leased for a CSA and community garden. The school does not itself farm to provide food.	Vassar composts 100% pre- and post-consumer food waste. 90% of meals are trayless. Waste oil is recycled for biodiesel.
WESLEYAN UNIVERSITY (Middletown, CT) **U.S. News & World Report Rank:** 13th **Overall Score:** B+ **Food & Recycling Score:** A **Innovations:**	Wesleyan dedicates 20% of its food budget towards an extensive variety of locally produced and processed food purchased from a number of distributors and producers.	Some organic produce, dairy, grains, sweeteners, beverages, and tofu are organic. Only fair-trade coffee is served on campus, in addition to some chocolate. All eggs are cage-free. All poultry, dairy, and beef products are hormone and antibiotic free. 100% beef is vegetarian fed. All seafood is certified sustainably harvested.	The school does not have an on-campus garden or farm.	100% of meals are trayless. 80% pre-consumer food waste is composted. There is no post-consumer compost program. Disposable dishware is post-consumer recycled content or otherwise biodegradable. Waste cooking oil is recycled for biodiesel.
SMITH COLLEGE (Northampton, MA) **U.S. News & World Report Rank:** 14th **Overall Score:** A- **Food & Recycling Score:** A **Innovations:** While other featured colleges have had trayless programs only since after 2007, Smith College claims that it has never abandoned trayless methods.	Of a $2,841,700 food budget, Smith spent $313,795 (11%) on locally produced and $211,760 (7.5%) on locally processed produce, dairy, meat, sweeteners, and beverages from a number of producers and distributors.	$74,500 (2.6%) worth of produce, processed dairy, meat, and coffee was organic. Only fair-trade coffee is served on campus. A small portion of poultry and eggs are cage free, small portion of beef is vegetarian fed, and 100% milk and yogurt is hormone free. Some fish is sustainably harvested.	A student-run community garden sources some greens for the college.	Biodegradable disposable dishware is available. 100% of meals are trayless. Dining facilities exercise a bottled water ban. Waste cooking oil is recycled for biodiesel.
WASHINGTON AND LEE UNIVERSITY (Lexington, VA) **U.S. News & World Report Rank:** 15th **Overall Score:** B **Food & Recycling Score:** A **Innovations:**	Of a $1,868,000 budget, W&L spent $326,896 (17.5%) on locally produced and $49,034 (2.6%) on locally processed food of a wide variety.	Some $322,740 (17.2%) of food purchased was organic produce, grains, dairy, meat, poultry, and eggs. Some fair-trade coffee and chocolate are served on campus. 90% of eggs are local and cage-free. 100% of meat and dairy products are free from hormones and antibiotics. Around 90% of animal products are also vegetarian fed.	The college gets some herbs and peppers from a campus garden.	Biodegradable disposable disware is available. 70% of pre-consumer food waste is composted. All meals are trayless. Waste cooking oil is recycled for biodiesel.

* "Local food" is food produced or processed within 150 miles of the campus.

** "Sustainable Production" includes organic food and other production methods or trade conditions not necessarily reflecting the chemical or nutritive composition of the food. "Organic" refers to food certified organic by the USDA or Quality Assurance International standards. "Sustainably harvested seafood" indicates meeting Monterey Bay Aquarium Seafood Watch guidelines or Marine Stewardship Council Blue Ecolabel standards.

*** "Campus Farm or Garden" includes any site on campus that produces or processes foods used in dining services, bought or sold on campus, or used for education purposes.

**** "Waste, Composting, and Dining Practices" refers to the creation or treatment of food waste, packaging reduction efforts, exceptional recycling, composting, or reclamation efforts, etc.

Appendix 4: Estimation of Potential Waste Reduction of Pre-Consumer Composting Expansion (100% participation)

Table 1: Estimate of additional waste diversion potential from expansion of pre-consumer composting program to all dining halls

2009 Pre-consumer composting participants	2009 compost collected (lbs)	2009 # of meals eaten	Compost collected /meal eaten (lbs)		
Betsey Barbour (finish Kitchen)	8151.91	39,190	0.21		
East Quadrangle	20697.31	248,454	0.08		
Mary Markley Hall	12308.31	170,285	0.07		
Hill Dining Center	30313.14	765,827	0.04		
South Quadrangle	13189.41	543,848	0.02		
West Quadrangle	21021.83	236,647	0.09		
Did not participate in 2009		**2009 # of meals eaten**	**Compostable waste estimate/ meal eaten (lbs)**	**Compostable waste estimate (lbs)**	**Compostable waste estimate (tons)**
Bursley		526,240	0.06	32,443	16.2
Oxford (finish Kitchen)		12,111	0.21	2,519	1.3
North Quadrangle				14,488	7.2
Total					**24.7**

*North Quadrangle estimate based on meals eaten from Aug-Nov 2010, assuming waste characteristics are similar to other dining halls.

Table 2: Estimate of additional waste diversion potential from expansion of pre-consumer composting program to all Michigan Unions

2009 Pre-consumer composting participants	**2009 Annual Waste (Tons)**	**2009 Pre-Consumer Composting (Tons)**
Pierpont Commons	105.9	4.9
Did not participate in 2009	**2009 Annual Waste (including compostable) (Tons)**	**2009 Pre-Consumer Composting Estimate (Tons) (if total pre-consumer compostable material is the same as Pierpont Commons)**
Michigan League	117.4	5.1
Michigan Union	213.7	9.4
Total		**14.5**

Appendix 5: Ross School of Business Post-Consumer Composting Program Case Study

We mentioned in phase I report that Stephan M. Ross school of Business is the only place on campus that is practicing both pre-consumer and post-consumer composting program. Taking a closer look at the experience in Ross will be beneficial for other operating units in implementing their own composting program. Through interviews with various stakeholders, including the Ross Catering management team and Ross Facilities Office staff, we are able to depict a basic picture of their actions and results.

Siegle Café is the dinning services in Ross. It is managed by Aramark, a professional food service firm practicing in over 600 educational institutions. Their operating unit in Ross school is called Ross Catering. Due to the fact that there was no place for dishwasher in Ross building, Ross Catering had to use disposable food wares. Ross Net Impact (RNI), a network of University of Michigan graduate students, alumni and professionals, knowing this fact, initiated a proposal to encourage composting the compostable waste generated in Ross building. They mobilized Ross Catering to purchase compostable food wares, and persuaded Ross Facilities, the administrative branch overseeing Ross building, to finance for composting practice. They also organized workshops and events in Ross building to educate students and the whole Ross community to identify and sort for the different waste-streams.

There are several components in Ross composting practice that contributes to the success of this program:

1. Availability of sites: the composting site is Tuthill Farms and Composting in South Lyon, MI. It is only half an hour away from the campus, and they use aerated static pile composting, to compost yard waste and food waste together.
2. Support from the Ross community: the leadership team in Ross and the student body are all for the sustainability initiative. RNI played a very important role in educating the community and arouse people‘s awareness.
3. Flexible schedule of the hauling services: the haling services is paid on a per truck basis, so that cost becomes variable depending on the amount of waste need to be transported.

<u>Cost</u>

*Ross facilities pay about 30-35K for composting per year

1. Compostable food ware, garbage bags: these are the only incremental costs paid out of the pocket of the vendor. Ross Catering works with Michigan Green Safe Products, a company specializing in sourcing sustainable products, to get its compostable food ware, food package and even water bottles. Ross Catering told us the price for compostable food ware would be a little higher than normal disposable ones, but not that much. Compostable garbage bags are thinner and more expensive to purchase, and also they do not have long shelf life (<30 days), which does not allow huge inventorying.

2. Trash bins: Ross facilities purchased around 30 60-gallon trash bins to store the waste outside the building. Once they are all filled up, the truck driver will come and pick it up.

3. Hauling: during school terms, Ross sends 100 cubic yards per week on average to Tuthill Farms. There is a truck picking up the waste from Ross on a flexible schedule. The truck can load 9-12 cubic yards and charges $125 per truck. The frequency of pick up is determined by the amount of waste generated.

4. Sorting: if the contamination in the sorted waste exceeds 5%, the truck driver would have to hand sort the waste, and he is going to charge extra fees for that. However, Ross has not incurred this cost yet as a result of the good education efforts.

5. Training and education: it is not only about providing education to consumers, but also provides training to the staff. Standard practice needs to be established to separate pre-consumer food waste and use different garbage bag for compostable and non-compostable waste. But after a period of time, this cost is gradually going down and even eliminated.

6. Tipping fee: Tuthill Farm does charge a drop off fee for food waste. However, the amount is incorporated in the hauling fee and Ross does not pay extra fee for that.

Benefits

1. Save in waste tipping fees: less waste goes to the landfill.
2. Reputation and Community Support: Ross is regarded as the vanguard in sustainable practice.

Appendix 6: Comparable Composting Methods

Appendix 6 Comparison of Composting Methods

	Suitable for	Not Suitable	Pros	Cons
Backyard or Onsite Composting	Yard trimmings and food scraps	Animal products or large quantities of food scraps	Requires very little time or equipment	Odors, insects and animals
Vermicomposting	Best method for apartment dwellers or small offices		Worm bins are easy to construct (they are also commercially available) and can be adapted to accommodate the volume of food scraps generated	Worms are sensitive to variations in climate, more complicated maintenance procedures
Aerated (Turned) Windrow Composting	Can accommodate large volumes of diverse wastes, including yard trimmings, grease, liquids, and animal byproducts (such as fish and poultry wastes)		Can compost large quantities, such as that generated by entire communities and collected by local governments, and high volume food-processing businesses	Potential for pests and bad odors. Windrow composting often requires large tracts of land, sturdy equipment, a continual supply of labor to maintain and operate the facility, and patience to experiment with various materials mixtures and turning frequencies.
Aerated Static Pile Composting	Relatively homogenous mix of organic waste. Works well for larger quantity generators of yard trimmings and compostable municipal solid waste	Animal byproducts or grease from food processing industries	Requires less land than the windrow method, produces compost relatively quickly—within 3 to 6 months	Requires careful monitoring to ensure that the outside of the pile heats up as much as the core, might involve significant costs and technical assistance
In-vessel Composting	Any type of organic waste(e.g., meat, animal manure, biosolids, food scraps)		Can be used year-round in virtually any climate; produces very little odor and minimal leachate; uses much less land and manual labor than windrow composting.	In-vessel composters are expensive and might require technical assistance to operate properly.

Appendix 7: Student Society of McGill University General Assembly, Resolution to End Bottled Water Sales

Motion Re: Bottled water use on campus

Whereas the SSMU constitution states: "The Students' Society commits to demonstrating leadership in matters of human rights, social justice and environmental protection. The Society shall be mindful of the direct and indirect effects corporations, businesses and organizations have on their social, political, economic, and environmental surroundings"; and

Whereas beverage exclusivity contracts between companies and schools and municipalities are typically negotiated without public consultation with little meaningful debate and limit the opportunity for conscious consumer choices to support local businesses and public water supplies; and

Whereas bottled water is 240 - 10,000 times more expensive than water from the tap, despite the fact that both Dasani and Aquafina, the two principal brands of bottled water sold on campus, source their water from municipal tap systems; and

Whereas manufacture and disposal of plastic bottles releases dangerous toxic chemicals and contaminants into the air, contributing to environmental degradation; and

Whereas bottled water requires fossil-fuel based transportation and contributes to global warming while tap water is energy efficient in its delivery; and

Whereas independent, peer-reviewed scientific studies have found toxic contaminants such as arsenic, mercury and bromides in bottled water; and

Whereas bottling plants receive government inspection on average every 2-3 years, compared to the daily government inspection of tap water facilities; and

Whereas public tap water is safe and healthy and significantly more accessible, and more environmentally sustainable than bottled water,

Therefore be it resolved that SSMU move towards the elimination of the sale and distribution of bottled water within the Student Union building; and

Be it further resolved that SSMU lobby McGill administration to follow suit and eliminate the sale and distribution of bottled water on the McGill campus; and

Be it yet further resolved that SSMU distribute information to all clubs and services, and to the student body on issues pertaining to bottled water; and

Be it yet further resolved that SSMU promote the sustainable alternative of already readily available tap water, and other sustainable methods of water distribution such as water coolers, re-usable glasses, etc.

Appendix 9: Summary of Correspondence with Local Orbit, a Local Food Aggregator in SE Michigan

Contact Information:

Erika Block
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www.localorb.it

1. From your experiences, do you think the supply can meet the demand by 2020? Think $3 million/year and 200,000-300,000 cases of produce.

Yes - but it will take some capacity building and initial flexibility on the part of institutional buyers.

Many farmers have unused acreage that could be put into production if they had increased distribution channels. Consistent near-term purchasing will generate steady income, build trust, provide incentives for local producers to expand production and add infrastructure for continued growth, such as hoop houses to extend the growing season. Increasingly, growers are developing experience with extended season production.

Local sourcing can include a diversity of products - not just produce. You can certainly source more than 20% with meat, dairy, baked goods, beverages, and numerous value-added products.

Additionally, in the same way Whole Foods has provided low interest loans to some of its local growers, institutional support for expanded production, whether through grants, loans, or advanced purchasing with an initial deposit, may help expedite a growth supply.

2. What do you expect will be the premium on local sourcing?

It is difficult to identify a percentage or dollar amount. Local/regional products can be price competitive if producers keep a higher percentage of the final dollar and there is sufficient volume - which is precisely what institutional demand can provide for producers.

There is a misconception that fresh and local necessarily costs more. If products are in season and travel a shorter distance, the cost is frequently lower than non-local products.

> *The "local" attribute does not command price premiums, perhaps because New York is a national player in the apple market. In fact, apples at the farmers market, all of which are local, usually exhibit the lowest retail prices in Syracuse. Instead, it is differentiation by apple variety that commands premiums.* (USDA Economic Research Report Number 99, June 2010)

Investment in physical infrastructure to increase production capacity - through the loan/grant options mentioned above - will also help keep prices reasonable in the long run. Minimizing the middle of the supply chain through direct sales and better business processes have further impact.

Here are some interesting considerations from a recent conversation with a colleague who oversees contracted campus and corporate dining services for clients in 8 states and has built robust local sourcing networks:

1. If food is a functional service for the client, provide a commodity price and solution.
2. If food is an amenity and service for the university community, focus on products that are better for your guests and students. The conversation is about improved heath, reduction in diabetes, supporting local economies.

The question of what an institution can or can't afford is not purely about cost per pound:

- What would students want the administration to support?
- How can it reduce other costs or provide additional benefits to the institution?

3. How can your software (or others you know of) simplify the sourcing process for the UofM?

Streamlining

Local Orbit provides streamlined purchasing and a multi-seller marketplace. This includes ordering from multiple vendors in a single shopping cart and one payment per month (or bi-weekly).

Vendors list their products, prices and available inventories, including the provenance, ingredients, growing methods and any certifications. This is not limited to fresh produce - it includes proteins, value-added, specialty items, baked goods, beverages, etc.

Purchasers go online and order from multiple vendors through a streamlined process, with a single invoice. The ordering system provides direct sales opportunities and honors the individual branding/identities of local food producers - but has the efficiency of Sysco-like ordering systems.

Access to Producers

We are currently working with farmers and food producers through our existing Michigan sites. We are also launching and two new sites with Michigan MarketMaker and Eastern Market. Together, these partnerships will provide broader access to Michigan producers than any other distribution channel.

Customization

Each marketplace is local and customized for the specific needs of a community. We can create an ordering portal within 48 hours, with business rules determined by UofM, such as vendor approval, delivery days, pricing tiers, payment terms, or invite-only access.

Local Orbit can create a single ordering portal for all purchasers at the university and give them separate buyer accounts (umich.localorb.it). We could also create separate portals for different divisions, such as:

- umhs.localorb.it
- um-residence.localorb.it
- um-athletics.localorb.it
- um-catering.localorb.it
- umich-dearborn.localorb.it

We could also create accounts for UofM purchasers in an existing marketplace, such as Eastern Market.

Transparency and Storytelling

- Sellers provide information about their farm or business, how they produce their products and where they are located.
- As a direct marketplace, buyers know exactly where their food comes from and who handled it.
- Local Orbit can provide downloadable PDFs with farm and product stories that can be shared on menus or posted in cafeterias.
- UofM can customize its "storefront" in any way - highlighting campus food initiatives, local products/farmers, education materials or important news for purchasers.

Tools to help local food producers

- We provide marketing and business management tools that help producers work more efficiently and let them focus on expanding production.
- 10% of Local Orbit's profits will be used for a micro-loan fund. This will enable increased capacity by providing capital for such needs as hoop houses and equipment.

4. Are you aware of existing local/sustainable product labels? How are they defined?

This is a complex topic and one we should discuss in person!

Local Orbit standards were developed after a good deal of research, with a "Big Tent" approach that is inclusive and ultimately gives producers income-based incentives to become increasingly sustainable: http://www.localorb.it/lo2/misc/standards

We are exploring partnerships with certifiers and considering building online tools to help producers maintain the audit information for various certifications through their Local Orbit accounts.

You might want to check out these resources:

Labeling/Certification

- http://foodalliance.org/
- http://www.naturallygrown.org/

- http://www.cooperativegrocer.coop/articles/2010-06-04/emerging-eco-labels
- http://localfoodplus.ca/
- http://www.maeap.org/maeap
- http://www.nongmoproject.org/consumers/understanding-our-seal/
- http://demeter-usa.org/get-certified/
- http://www.ics-intl.com/programs.html
- http://www.fairtradefederation.org/
- http://www.animalwelfareapproved.org/
- http://www.wholesome-food.org.uk/whatis.html

GAP Certification

- http://www.ams.usda.gov/AMSv1.0/gapghp
- http://www.gaps.cornell.edu/
- http://www.globalgap.org/cms/front_content.php?idcat=3
- http://www.mlui.org/farms/fullarticle.asp?fileid=17344

Food service: http://greenseal.org/certification/standards/gs46_restaurantfoodsvcs.cfm
Hospitals: http://www.noharm.org/us_canada/issues/food/guide.php

Appendix 10: Summary of Correspondence with the Southeasten Michigan Food Hub, a Local Food Aggregator in SE Michigan

Contact Information:

Susan Fancy (susanfancy@yahoo.com)
Sustainable Agriculture and Operations Director
Michigan Center for Sustainability at Grass Lake Sanctuary

The southeastern Michigan food hub is planned as a facility that will support metro Detroit institutions, restaurants and other venues, and the Detroit corner store market. Fresh chopped & processed capability will be available at launch, and down the road we may also include fresh frozen, canned and/or dried foods. The food hub will support crop coordination for consistent supply of long season Michigan crops such as lettuces or blueberries, and winter greens and other crops that can be grown using season extension. We will have onsite cold storage as well for root crops that can be sold into spring.

1. From your experiences, do you think the supply can meet the demand by 2020? Think $3 million/year and 200,000-300,000 cases of produce.
Yes - we should be at $5M sales within the first 5 years (2016-2017), and double that by 2019-2020.

2. What do you expect will be the premium on local sourcing?
Price - in general our intent is to be close to or at the going wholesale price. Of course quality is a consideration...if it's really nice produce, maybe a 5% upcharge, or 10% depending on what it is...but it also depends on other market conditions including weather impacts, supply gluts/ droughts, etc.

3. How might the hub simplify the sourcing process for the UofM?
The food hub offers convenience - access to a full complement of fresh, local, and sustainably grown foods. It takes a lot of time for any one organization to attempt to source a wide variety of local ingredients, much less sustainably grown local ingredients. Very quickly one is attempting to manage 35 or 45 grower relationships! And those won't cover everything that is in season in sufficient quantities. It is more cost effective for everyone if a food hub performs the role of local crop planning, aggregation, and coordination of distribution.

4. Are you planning any degradations of local and sustainable within the hub, or will everything be sourced locally, period?
depends on what customers are asking for - within reason. In general the food hub will supply local, sustainable, and seasonal produce. However, we need to understand more about our potential customers to understand what their needs are. So far we have mostly talked to to customers with a deep buy-local commitment, and they are not looking for non-local/ seasonal items. Next on the agenda is to talk to customers where buying local is pretty challenging becuase of their scale, and understand what their other needs may be. In general we would like for the food hub to honor the rhythm of supplying what is in season, which in Michigan is a *tremendous* variety of foods...but maybe bananas would be critical for one customer, and and we

would look into that. However, we would not carry California raspberries in January, but instead have some fresh frozen Michigan raspberries available for a winter treat.

5. How might you define sustainable? Are you aware of an existing labeling system?
GAP certification to ensure food safety is of course needed.

For sustainability, the only nationally recognized label accepted for produce right now is *USDA Organic*. There are other standards such as *Certified Naturally Grown*, *Certified Biodynamic*, and *Food Alliance*. I resonate with the Food Alliance standard as it is the most comprehensive, but realistically any of these standards are not the first thing that is needed to build the local food system (unless customers start clamoring for them and are willing to absorb the extra costs that they currently bring!). In lieu of these, the food hub would evaluate and include new possible growers on a case by case basis. This approach has been working well for two other aggregators operating in other areas of the country. Compared with USDA organic or no consideration of sustainability at all (which often means chemically laden produce), it seems to offer a good middle ground at least for the near term.

6. Will you include locally processed within the hub's scope?
Yes, fresh chopped is planned to be available at inception, and other processed foods such as individually quick frozen, canned or dried possible down the road. Fresh frozen seems to be the greatest need from what I have seen informally so far.

I hope this helps, I am here if you have other questions or want to go over it on the phone. It would be terrific to understand U-M's buying habits for produce in the next few months, to ground me in to what kinds of things they buy, in what quantities, and when (no commitments, just to understand what happens now in absence of a food hub). I am formulating the needs of possible customers, and this will help me with talking to and starting to recruit farmers in the months ahead.

Appendix 11: GAP and GHP Certification Costs

Summary of communication with Jennifer Nord, U-M OSEH.
RE: UM Local food purchasers food safety issues, GAP/GHP certification process and costs

Group Members
Members of the university community from departments such as Residential Dining Services, University Unions, Procurement, Patient Food and Nutrition Services at UMHS, and Occupational Safety and Environmental Health have been meeting to discuss food safety issues related to purchasing food from local fresh fruit and vegetable producers. Fresh produce that is minimally processed is not subject to regulatory oversight and therefore is not inspected for food safety. In the past it was generally believed that fresh produce was not frequently a vehicle for pathogens and was rarely related to food borne illness outbreaks. This resulted in the belief that regulation of this industry was not necessary. More recently multiple food borne illness outbreaks related to fresh produce have been identified. As a result of the recent produce related outbreaks food safety laws have been evolving. In January of 2011 the Food Safety Modernization Act will be become law. The new legislation will require some regulatory oversight for fresh produce growers. However, it does exempt growers with annual sales less than $500,000 and that sell their product locally. The University of Michigan does purchase fresh produce from local growers that will fall into the exempt category.

Rationale, definition and timeframe
The University of Michigan would like to be sure the food it purchases is as safe as possible. Therefore the above mentioned group has decided to require local producers to become USDA GAP Certified or equivalent. The United States Department of Agriculture (USDA) Good Agricultural Practices (GAP) and Good Handling Practices Audit (GHP) Verification Program is designed to have a third party to examine the food safety practices of fresh produce growers and handlers. It is currently a voluntary program, although some requirements will be established with the passing of the Food Safety Modernization Act. The program consists five sections. The first section which examines worker health and hygiene is the only required section, all others are voluntary. So if a producer decides to become GAP certified the worker health and hygiene section must be completed. The other sections investigate the potential for contamination during the growing, harvesting, packing storage and transportation processes. At U-M sections one and two of the USDA GAP Audit checklist must be completed and certified by harvest time of 2012. At that point we will begin requiring GAP Certification or equivalent of all of the fresh fruit and vegetable suppliers.

GAP/GHP Process and Costs
The first step for a producer is the development of a food safety plan. That plan must be thoroughly documented and should include an entire section on worker training. This plan is used by the auditor during the audit to determine the effectiveness of the safety program. Many local producers are not familiar with the stringent documentation requirements and regulatory oversight so the creation of a comprehensive food safety plan can be very daunting. According to many auditors this first step is so large it can prevent producers from completing the GAP program. Once the plan is created the producer must be sure to document or record all worker

training, water quality tests, composted manure tests…. At harvest time the producer must arrange for an audit by a certified USDA GAP auditor.

GAP audits or inspections cost $92/hour through the Michigan Department of Agriculture. That should include drive time. The current average time for inspections is 4 hours (per MDA). The amount of time an inspection will take depends upon the size of the farm, the type of crop harvest that is to be inspected and the level of preparation by the producer. Pre-harvest audits or practice audits can be completed by the MSU Extension Service for a total cost of $100. The Extension Service personnel will walk through the entire process with the producer in an effort to help them pass their audit. Please note that GAP certification is only good for crops that have similar harvesting techniques. For example, all leafy greens with the same or a similar harvest technique will need one harvest inspection or audit to receive GAP certification. If a producer grows two or more crops with different harvesting techniques each crop must have a separate GAP audit. Also, if a harvest lasts longer than 30 days a second inspection will be conducted at the rate of $92/hour.

Concerns

Please note there are resources available to help producers create food safety document. The current fear on the part of the UM local producer food safety group is that the fresh fruit and vegetable growers will not want to pay for the certification. We feel they may discontinue selling to the University. I am not suggesting that help with this process from a local forager would not be welcome. All help is welcome.

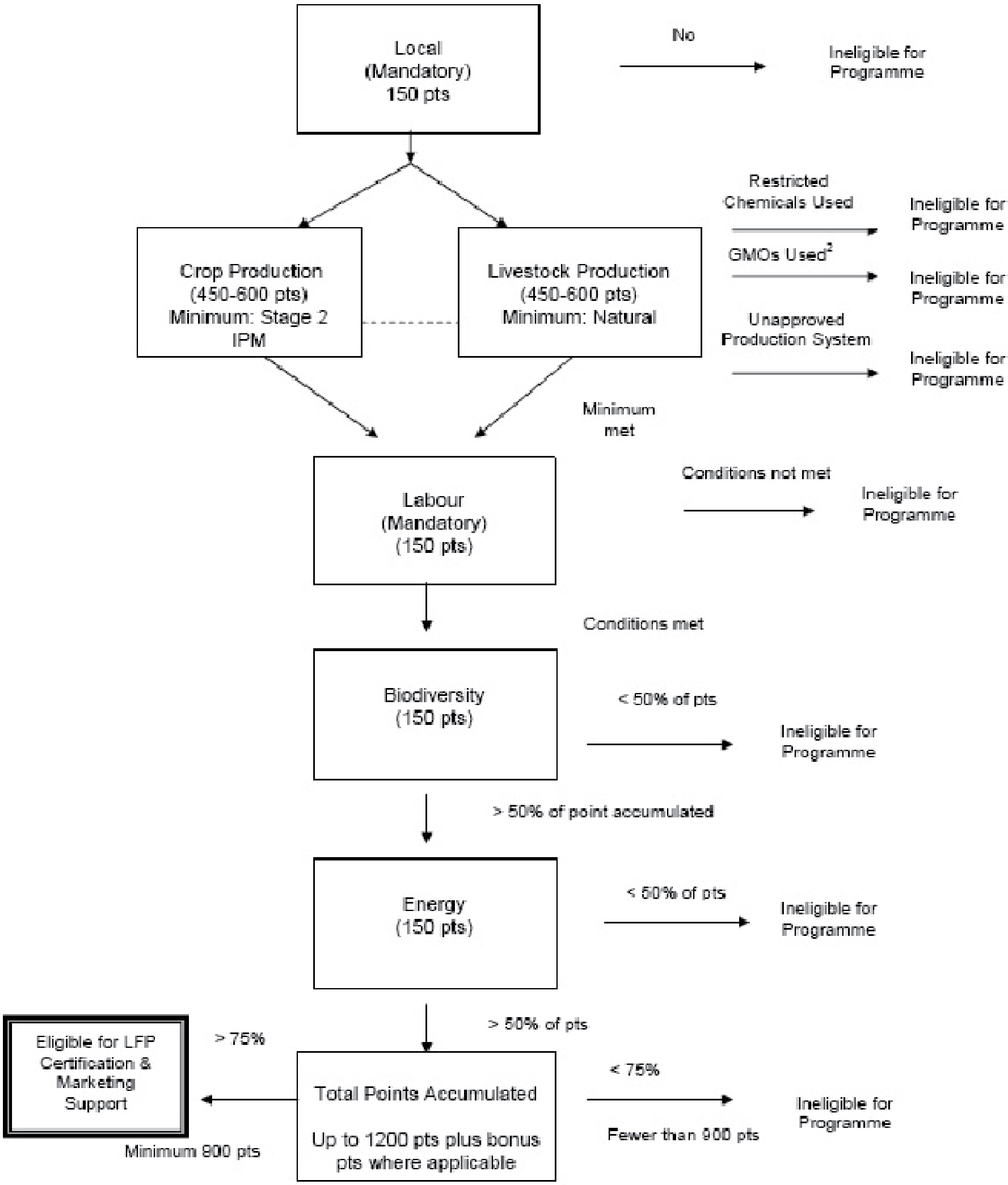
Appendix 12: Real Food Challenge Matrix

	Local	Fair	Ecologically Sound	Humane
Green Light ***A clear fit*** **YES**	Unprocessed Foods -Grown/Raised within your food shed or 150 miles ***and*** *at least one of the following:* a) You have a direct purchasing relationship with the farmer or your distributor provides you with transparent and verifiable information about farm practices and location b) ***or***, Farm is independently or cooperatively owned and operated within the region c) ***or***, Small-medium scale farm	-*Fair Trade Certification.* * -*Domestic Fair Trade Certification* (Agriculture Justice Project) -Direct Fair Trade** -Business/farm has a social responsibility policy that includes: --Living wage + paid sick/vacation --Right to organize or bargain collectively --Right to grievance process --Health care benefits --Job protection	-*USDA Organic* -*Protected Harvest Cert.* -*Marine Stewardship Council Cert.* -*Biodynamic certification* -*Rainforest Alliance Cert.* -*Food Alliance Cert.* -Seafood Watch Guide "Best Choices" *	*Certified Humane Raised & Handled* -*Food Alliance Cert.* * -Seafood Watch Guide "Best Choices" *
Yellow Light ***Use caution*** **YES**	Unprocessed Foods -Grown within 250 miles ***and*** at least one of the following: -(a), (b) or (c) in the Green Light category (see above)	-*Food Alliance Cert** -Workers belong to a *union* -Business/farm operates as a cooperative and/or has a profit sharing policy for all employees -*Rainforest Alliance Cert.*	-Transitional Organic -*Fair Trade Cert** -Seafood Watch "Good Alternatives" -*Salmon Safe* -Coffee: Shade-Grown, *Bird Friendly* -*Transitional Organic*	- AGA Grassfed -Pasture Raised -Grass-finished/100% Grassfed -*USDA Organic* -Cage-free (eggs)
Red Light **Good start, but not enough....** **"No"** --------------------- **Claim does not have substance** **"NO"** ------------------ ***"No way"***	--------------------------------------- --------------------------------------- -Grown more than 250 miles away -Traveled more than 250 miles away during distribution	--------------------------------------- --------------------------------------- -Child labor -Indentured servitude -Slave labor	Raised without antibiotics --------------------------------------- Natural, GM Free/GMO Free --------------------------------- - -Seafood Watch "Avoid" -Confinement/Battery Cages	-USDA Grassfed -Raised Without Antibiotics -Natural/ Fresh -Grassfed/Grain-finished -Vegetarian Diet --------------------------------------- Natural, Fresh No anitbiotics/hormone free (eggs) --------------------------------------- -Confinement/ Battery cages
Health Concerns **If these ingredients are present, the food item does not count**	high fructose corn syrup, hydrogenated vegetable oils, MSG, rGBH/rBST, sodium nitrate, sodium nitrite, trans-fats			

In order for a food item to be counted as local, fair, ecologically sound, or humane, it must meet one or more of the criteria in the "Green Light" or "Yellow Light" sections for that category.

Source: http://www.realfoodchallange.org/calculator

Appendix 13: Local Foods Plus' Criteria & Method of Certification



Source: http://localfoodplus.ca/wp-content/uploads/2010/03/LFP-GENERAL-STANDARDS-FOR-FARMERS-AND-RANCHERS-August-2009.pdf

Appendix 14: U-M Faculty Feedback on the Educational Benefits of Additional Farm/Garden Space

Name (uniqname)	Position/Dept.	Formal Academic Benefits	Informal Educational Benefits	Broader Social/Community Benefits	Other
Robyn Burnham (rburnham)	Associate Professor, Ecology & Evolutionary Biology, Geological Services, etc.	Would use for BIO 225, Plant Diversity, such as for plant identification assignments.	Students actively involved would learn about the yields possible from relatively small gardening spaces when carefully managed.	Engaging signage could be used to educate the public about crop varietals, timing of planting and harvesting in local climate, and other elements of food production	A well-publicized harvest event would be a great social event toward the beginning of the school year.
Raymond DeYoung (rdeyoung)	Associate Professor, SNRE	Social science investigations exploring psychological benefits of contact with gardening; student-led soil management courses	Gardening programs akin to non-credit skiing, hiking, courses would benefit many students	The University should consider a Food Theme Semester with core courses around food issues, which could certainly use garden spaces to teach about practical local eating	Programming for community youth could be another important benefit
Bob Grese (bgrese)	Professor, SNRE, and Director of Nichols Arboretum and Matthaei Botanical Gardens		Very valuable resource for students who know little about food production and/or are interested in working in international development, eg Peace Corps	There are important benefits to people realizing that food production can be an integral, aesthetically pleasing part of the urban landscape. Seeing food growing nearby creates a powerful rationale for urban environmental stewardship.	Gardens can play a uniquely effective role in bringing people together, because people's innate fascination with food provides a strong basis for interaction
MaryCarol Hunter (mchunter)	Assistant Professor, SNRE	Courses like her urban ag course or ecological plant design course would benefit.	Working in a garden can relieve psychological stress and increase the capacity for directed attention, which is required to learn.	A garden space could be an important opportunity for the University to connect with the wider Ann Arbor community.	The space will help students learn about the relationship between theory and practice, an important distinction for them to understand.

Rachel Kaplan (rkaplan)	Professor, SNRE	Applying a "service learning" model to for-credit courses could be appropriate in this space.	Food production could be linked to daycare on campus, and should be used for a purpose	Her book, *The Experience of Nature*, discusses psychological benefits of gardening.	Seasonality is a concern for her in trying to coordinate with courses.
Ivette Perfecto (perfecto)	Professor, SNRE	Many courses would benefit: landscape architecture, soil composition, herpetology, Food, Land and Society	The space could offer learning opportunities for students interested in organic cultivation as well as K-12 programs	The University's food-related curriculum is very theoretical, but there is nothing like getting your hands dirty to understand how food is really produced.	When you grow your own food it raises many other issues like health, sustainability, environmental safety, etc.
Mike Shriberg (mshriber)	Education Director, Graham Institute	Student for-credit independent projects could really benefit, as student interest in food issues is skyrocketing right now. Addressing the water access issue in the Arb could be a practicum for engineers.	The garden could be a space where many disciplines are brought to bear, fostering interdisciplinary learning and connections. It is invaluable as a trans-disciplinary learning site.	The problems of the 21st century tend to require solutions that combine insights from a number of disciplines, and having a space where students and experts from many fields can be involved will bring a broad benefit in encouraging students to cross disciplinary boundaries.	Agrarian Adventure coordinates youth gardening programming, and they might have insights into how to utilize this space over the summer months (and as a community resource). Contact: Monica Patel, President
John Vandermeer (jvander)	Professor, Ecology and Evolutionary Biology	Would use garden space in BOT 101, would love to see organoponic demonstration; experimental spaces in Bot. Gardens and Arb would be a strong addition.	Stressed importance of interdisciplinary collaboration that a garden could achieve	Emphasized benefits that come from opening spaces such as a garden to community participation	

Appendix 15: Detailed Prioritization Matrix

		Economic Aspects			Environmental Aspects			Social Aspects		
		Capital Costs	Operat ng Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Visibility	Learning/Research Opportunit es
Food Team Recommendat ons	Compost ng	a range of $.5-$3 million for in-vessel compost ng facilit es	$70-$300/ton, depending on the scale of operat on	savings from reduced refuse disposal is lower than cost of compost ng	decreases the emission of greenhouse gas	reduces the need for chemical fert lizer	can divert more than 600 tons of compostable waste per year from landf ll and incinerat on	N/A	students would be involved in the waste sort ng	might be able to have engineering students to work on it
	Bot led Water	revovat on of drinking fountain	lose prof t from bot led water sell	no economic benef t for the University	reduce over 80 tons of CO2 emission	stop over 40,000 gallons of water from being wasted annually	prevent over 8 tons of waste per year. reduce the consumpt on of energy by 400,000 kWh per year.	municiple water has strict quality control, luoride in municiple water is benef cial to dental health	let the community know about the negat ve impact of bot led water, make U-M a world leader	passive learning through passive absence of bot led water
	Tray-less Dining	small amount, only need a alterat on of dish collect on system in some dining halls	may need more frequent table cleaning service	save over $700,000 per year on food budget and ... on waste desposal fee	reduce energy, water and detergent used to wash trays	N/A	reduce about 125 tons of food waste per year	might leads to less calorie consumpt on, promot ng healthier eat ng habits	remind campus diners about how much food they have been wast ng	passive learning at every meal
	"Local Farm Forager"	0	salary and benef ts associated with expanding or adding a posit on to accommodate these responsibilit es	might not be able to save money through increased local sourcing	reducing food miles traveled leads to reduced amount of greenhouse gas emission	protect on of prime agricultural land	Locally produce food products can of en be shipped in reusable containers as opposed to disposable ones.	fresher, more nutrient-rich foods	support local economy: for every $100 spent in local businesses, $68 returns to community, as compared to $43 for a nat onal chain	passive learning about seasonal produce and Michigan agricultural diversity
	Sustainable Food Labeling System	can leverage the exist ng labeling system	may need some staf t me to monitor and improve the labeling system	no obvious economic benef ts	will encourage less energy-consumpt ve agricultural methods	support sustainable farm pract ces	N/A	lower levels of residual toxic pest cides and herbicides on food ingredients	send a clear message to campus buyers and diners about food sustainability	N/A
	Campus Farm and Garden	start-up cost is low, but varies based on sites	need paid interns to direct volunteer act vity	no obvious economic benef ts	N/A	N/A	N/A	provide expanded access to fresh, healthy, local food for campus users	arouse people's awareness of sustainable food pract ce, the university might distribute the	provide learning experience to students through volunteer work

Appendix E. VI. : Phase 2 Purchasing & Recycling Team Report

UNIVERSITY OF MICHIGAN

CAMPUS SUSTAINABILITY INTEGRATED ASSESSMENT

PURCHASING & RECYCLING – PHASE II REPORT

JANUARY 22, 2011

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EXECUTIVE SUMMARY

The Purchasing and Recycling team primarily examined Property Disposition and the various ways in which recycling is managed on campus. Secondarily, given our charge, we examined purchasing and the use of Life Cycle Assessment (LCA) as a tool to measure environmental impacts of various material flows on campus. In order to accomplish our tasks we developed preliminary material flow diagrams for the campus.

Property Disposition

Property Disposition (PD) is charged with receiving and disposing of virtually all used property on campus at the end of its useful life at the U-M. On average, five truck loads per day of used items from university units are dropped off at PD. These are sorted, priced, inventoried, sold, recycled, or treated as hazardous or regular waste depending on their nature. Items are sold on commission with 90% of the sale price returning to the unit property owner. Annual sales average about $2 million. The 10% PD commission is supplemented by General Funds to cover capital and operating costs. Items are sold through the retail store, EBay, closed bids and auction. The PD website (http://propertydisposition.umich.edu/index.html) provides basic information such as facility location, hours of operation, FAQ's, contact information for staff and recent bid results. It does not contain item specific information and it does not permit on-line sales. PD uses a commercial retail hardware and software system called CounterPoint to facilitate pricing and sales. Marketing is fairly limited, for example, to the use of periodic ads in university or local newspapers and through the use of PD-developed email distribution lists.

Due to lack of time and lack of data, we were not able to complete a thorough cost and LCA analyses of PD. However, our limited analysis identified several potentially important operational and strategic level areas to explore further. The PD building was built as a bus maintenance facility and is not well suited for PD. For example, the lack of a proper loading dock and the existence of high bays results in substantial heat losses and inefficient use of trucking, labor and space. The current software, or at least as it is implemented, does not provide timely reliable data for item tracking, inventory management or marketing and sales. In addition, it requires manual intervention to communicate with university accounting systems. We also feel that more innovative marketing to target audiences has the potential to significantly increase sales revenues. More importantly, especially after visiting Michigan State University's Surplus Store and Recycling Center, we feel that U-M should undertake a more strategic study of PD within the entire property supply chain and sustainability effort on campus. Ideally this would be done before expending serious effort or money on capital or operational improvements. For example, instead of investing in a proper dock or improved software, it would make sense to first determine through a strategic study if PD should be completely reorganized and possibly combined with other units in a purpose-built facility.

Although not formally part of PD, there is an initiative lead by Kathleen Thompson in ISR to develop a website for facility managers that will list surplus furniture that units are willing to give for free to other units, in effect eliminating transportation to and from PD. This approach can't deal with the volume and variability of items dealt with by PD, but for this class of items it presents potentially significant cost and environmental benefits for the university. From our perspective this type of initiative logically should fall within the purview of PD. However, given PD's current goals and resources, it doesn't. Perhaps it can be successfully implemented by an informal committee of facility managers. We believe it would be more effective if someone was formally given responsibility for it and given resources to implement it properly.

Recycling & Waste Minimization

Incommensurate with general growth of the U-M campus and community, waste output has been increasing rapidly over the past few years. In 2004 the university paid for the disposal of 13,833 tons of waste. Fiscal year 2009 reported an additional 4,000 tons bringing the total for that year to 17,355 tons. With tipping fees expected to rise, increasing recycling rates will be a key factor in maintaining an efficient waste management plan for the U-M. While recycling rates have increased in recent years, that increase is disproportionate to the increase in total waste, rising only 4% since 2004.

The IA recycling team conducted site visits to the City of Ann Arbor Recycling Center which sorts and manages recyclables and the Michigan State University Surplus Store & Recycling Center. They also met with key staff and participated in the Michigan Union Waste Sort and first-ever Zero-Waste Sporting Event, a Men's Basketball Game versus Harvard. The team examined opportunities for streamlining waste management, identifying room for gains in efficiency and improving overall tracking and data collection.

Increasing recycling is a major means to reduce waste but it must be part of a portfolio of strategies to minimize waste. Other methods to be considered are described in this section via changes to the Property Disposition program, better Purchasing practices and more efficient management of the office supply program, but also includes new innovative solutions such as composting (described in the Food section), collection of non-recyclable materials via programs such as TerraCycle, and heightened education initiatives to promote reduced rates of waste generation. Recycling provides the great potential for waste reduction at reduced cost to the alternative of dumping at landfills. Recycling provides raw materials for a number of commodities in daily use at the U-M. Programs like TerraCycle also offer other potential benefits--high visibility and recognition as a pioneering university to find solutions to waste that have no current solution beyond landfill. Finally, increasing waste reduction strategies at sporting events offers great reputational benefits and an opportunity for the university to act as a leader and role model for what can be achieved with collective action.

Purchasing

The U-M procures over two billion dollars worth of goods and services annually. There are 4,000 registered users on M-Marketsite, the U-M's preferred procurement portal. Purchases are also made with purchase cards (p-cards) for goods and services as well as short codes with preferred vendors. This year spending through M-Marketsite rose from $46.5 million in fiscal year 2009 to $51.5 million in fiscal year 2010.[i] We were unable to obtain sufficient data to compare with changes in overall spending or further break down spending into specific commodity categories. In addition, M-Pathways non-Marketsite ePro requisition is the most used and highest dollar value procurement method.

The IA purchasing team met with key stakeholders in university procurement including staff from Procurement Services, the Office of Campus Sustainability, Planet Blue, Student Affairs, the Provosts Office, students and faculty. The team also met with administrative assistants who place a bulk of the orders to vendors, and felt strongly that their input was incredibly valuable yet often left unheard. Based on key insights provided by these stakeholders, a number of opportunities for cost savings were identified. We examined not only the possibility of establishing sustainable procurement guidelines at the U-M but also the institutional structures necessary to facilitate this cultural and procedural shift. Economizing scarce financial resources and procuring more environmentally preferable goods were common themes of concern. The primary criteria in evaluating ideas was cost savings- either long or short term- directly benefiting the U-M, as well as those measures that begin to alleviate the environmental, social and economic burden to society of the unnecessary extraction, manufacturing, transportation, use and disposal of commodities.

The daily operations at the university rely heavily on commodities and services, all of which have far reaching economic, social and environmental impacts within and beyond the borders of the U-M campus. As a large and prestigious state funded institution, the university recognizes the unique impact of its purchasing decisions on local and global economies, within Ann Arbor and the state of Michigan, as well as the suppliers and markets worldwide that university procurement practices support. Fostering sustainable growth is not only fiscally responsible but, decidedly critical to ensure the long term sustainability of this and many academic institutions.

LCA

Life Cycle Assessment (LCA) is a useful tool for estimating the overall environmental impact of goods and services for a sector of the economy, an institution, or for a particular process or product. In the evaluation of a good's impacts, which is our focus, production, use, and disposal can be considered. It is a critical methodological companion to standard cost analyses to insure that changes made are not only cost effective, but that they actually enhance university "greenness." LCA has been widely used in assessing environmental impacts of industrial products but it is rarely used in analyzing the environmental impacts of large institutions such as universities. One major reason is that the complexity of large institutions' activities makes it extremely difficult to collect sufficient data for a Life Cycle Inventory (LCI, i.e. the total resources consumed and total emissions generated) to conduct a LCA based on the material flows of individual processes. In our report we present LCA results using an alternative database called the USA Input/Output (I/O) Database which provides estimates of environmental impacts of categories of materials based on national economic flows and impacts. This I/O LCA was done in Phase 1 for fiscal year 2009. We repeated the analysis for fiscal year 2010. By themselves these two analyses don't indicate that the university is doing a good or bad job, and they are too few in number to indicate any trends. However, they are an important starting point and benchmark for future more detailed and accurate analyses. We recommend that in addition to the many specific metrics that are used in the Annual Environmental Report, that the university conduct an LCA annually to help measure overall institutional environmental impact. In addition, we did an LCA for specific applications in waste treatment options and the Office Supply Reuse Program.

Material Flow Diagrams

U-M has a myriad of material flows and over many years has had numerous green initiatives to better manage them. It appears that these initiatives have typically been beneficial, but they have not been as coordinated or supported by rigorous analysis as is ideal. This is largely a function of our complexity, our decentralization and the lack of good data. After interviewing a number of people it was clear that no one on campus had a comprehensive understanding of all material flows. As a result we embarked on a first effort to develop campus-wide material flow diagrams. These appear in Appendix A. These diagrams are obviously incomplete, but they provide a template for future work. We strongly recommend that the University charge some staff group, perhaps the Office of Sustainability, with developing and annually updating comprehensive material flow diagrams that show quantities of material flows (e.g., tons), dollar value of flows and responsibility centers (e.g., Purchasing, a specific academic unit, outside vendor, etc.). Flow diagrams of this sort are very important for planning, data acquisition, communication, coordination, and measuring monetary and green effects of initiatives. Without them it is virtually impossible to understand and measure the network effects of material intensive greening initiatives on campus. Flow diagrams will make it much easier to prioritize and select greening initiatives, manage and coordinate them, do cost-benefit analysis, and track long-term progress. Because they are visual, they facilitate communication and understanding.

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INTRODUCTION

The Graham Institute gave the Purchasing and Recycling Team four charges in Phase 2:

- Develop a detailed action plan and associated targets to improve the efficiency and profitability of Property Disposition by reducing transport and increasing resale of goods.
- Develop a detailed action plan and associated targets to improve waste management traceability and efficiency, and improve landfill diversion rates.
- *Develop guidelines for implementing a university-wide sustainable purchasing policy.*
- *Assess the viability, complexity and resource requirements associated with conducting a full Life Cycle Assessment and footprint of the University of Michigan.*

Furthermore, at least 80% of team effort was expected to focus on items shown in regular font, *with up to 20% of effort directed toward items in italicized font or other ideas from Phase 1.* For each item shown in regular font appropriate staff from Facilities & Operations and other campus units should join the corresponding team to work on these issues.

The team comprised one undergraduate, six master's level students, one PhD student, one staff member from the Office of Sustainability and one faculty member. In addition, one member from the IA Culture Team regularly attended the entire group meetings. One master's student and one PhD Student carried over from Phase 1. Everyone else including the faculty lead joined the team in September. The entire team met bi-weekly from September 28 through December 6 to coordinate efforts. In order to accommodate conflicting team member and staff personnel schedules and to make effective use of everyone's time, the entire team was broken down into four sub-teams with overlapping membership that focused on each of these topical areas. The sub-teams met frequently, generally at least once a week, with appropriate U-M staff. Sub-teams also participated in off-campus site visits to the Ann Arbor City Recycling Center and the Michigan State Surplus Store and Recycling Center.

This report is organized into major sections corresponding to the above four charges. In addition, because Life Cycle Assessment (LCA) is a generic tool rather than a functional area of the university, its use is also described in each of the first three sections. In each functional area two questions guided our work: how can we make this area "greener" and how can we reduce costs, while recognizing that these two implied goals are not always aligned. To measure the former, we attempted to use LCA. To measure the latter we tried to use standard accounting methods. In both cases, our analyses were constrained by the non-existence of relevant data or our inability to obtain sufficient data in the time available. For some situations where data are incomplete we show an analytical framework useful for decision-making. All recommendations were crafted based on key staff insights, best practices at peer institutions and results from financial and sustainability analyses and research specific to the needs of the U-M.

1 PROPERTY DISPOSITION

- **Develop a detailed action plan and associated targets to improve the efficiency and profitability of Property Disposition by reducing transport and increasing resale of goods.**

1.1 Introduction

The University of Michigan purchases about two billion dollars worth of goods and services every year. The vast majority of goods which have some value or require special consideration at end of life become the responsibility of Property Disposition (PD). (Note to reader: many U.S. institutions use the terms “surplus goods” and “surplus stores” as alternatives to what we call “used goods” and “property disposition” at U-M.) On average PD receives, sorts, sells and otherwise disposes of five truckloads of used goods they receive daily from university academic units, research centers and institutes, support services, athletics, housing and the hospital system. Upon arrival at the PD warehouse-retail-office facility on Baker Road, goods are “triaged” depending on their value and whether they require special disposition because of their material content. Goods that have economic value are sold on consignment through a variety of mechanisms including their retail/warehouse store, EBay, closed bidding and special auctions. Some are sold to recyclers, some are sent for disposal or neutralization according to Federal and State law under the direction of U-M’s OSEH (Occupational Safety & Environmental Health). PD generates about $2 million in revenue annually for the university from their sales. The variety of goods received and sold is in the thousands. To illustrate this point, in any given week PD may receive dialysis machines from the hospital, furniture from dorm rooms and offices, used computers from all over campus, framed paintings and prints from office walls, trucks and busses from Transportation and baby high chairs from Mott Children’s Hospital. PD is organized as a combination cost and revenue center (but not a profit and loss center) charged with maximizing revenue and environmental benefits while minimizing operational costs associated with the reuse or sale of used university goods.

The university could become greener by purchasing less and reusing more “used” property. It could also become greener if transportation of used property was reduced, if less property ended up in landfill and if the PD facility was greener, for example by being less energy intensive. Costs to the university could potentially be reduced substantially if the lifetimes of property were extended and if operational improvements were implemented at PD. However, there are many obvious legitimate reasons why the university shouldn’t extend the lives of property just to become greener or to reduce costs. These include intangible reputational benefits from purchasing new (e.g., functional but beat up fifty year-old furniture isn’t associated with a world-class organization) as well as those related to adopting newer technologies to fulfill primary teaching, research or patient care objectives. Given the complex tradeoffs involved in the above, our team approached our PD charge by assuming that it would be beneficial if we could simultaneously reduce operational costs, increase sales revenues, and increase the likelihood that used goods would be reused by the university. Trying to mandate reuse would be impractical and illogical. Likewise, setting arbitrary goals to increase internal reuse of products by x% per year doesn't make sense. Reuse in general is desirable, but the green, functionality, aesthetics and monetary implications of particular product reuse can't be generalized. These decisions are very specific to time, place, needed functionality, quality of used product, technological alternatives, etc.

1.2 Assessment of Current Processes

1.2.1 Current Used Material Flow at the University of Michigan

University of Michigan policy generally requires that every unit (school, research facility, athletic office, etc.) send used property of value to PD for sale or disposition. The few exceptions to this policy are noted in the material flow diagram in Appendix A. When a unit has used items they want to dispose of, they inform PD, complete an on-line property manifest, arrange for pickup by a private trucking firm or by U-M Transportation and have it delivered to PD at an agreed upon time. PD personnel "triage" (price, categorize, position) property as it is unloaded from the trucks. If the property is deemed to have value, it is priced (unless closed bidding or auction is appropriate as for expensive items) and made available for sale in the warehouse/retail facility on Baker Road. Efforts are made to sell products within 30 days in order to free floor space for the five additional trucks of used product that arrive every day. PD keeps 10% of the revenues generated by sales to support warehouse operations, but largely depends on General Funding for its capital costs and operations.

Although most used goods must go to PD, the actual flow is controlled by a number of fairly independent organizational units. While decentralization has its plusses, it makes it more difficult to understand flows, to collect data from disparate sources and for coordinated decision-making. In some cases we feel it leads to sub-optimal performance on both green and monetary criteria.

1.2.2 Case Study in Integration: Michigan State University

Michigan State University (MSU) has an alternate model. In contrast to our fragmented system, MSU has integrated their recycling, reuse and waste programs within one facility. This facility, the MSU Surplus Store and Recycling Center (referred to hereafter as the Surplus Store), services 45,000 students and 10,000 faculty and staff. The different approach to consumed materials is clear in their mission:

> *By continuously moving from reliance on solid waste disposal to programs in waste reduction, reuse, recycling and recycled product procurement, we contribute to a comprehensive, campus-wide waste reduction strategy which helps MSU use resources more efficiently; simultaneously reducing the volume, cost, and environmental impacts of the university's waste.*[ii]

By combining waste management, regulated waste and property disposition, the Surplus Store fosters collaboration and innovation to reduce costs and environmental impact, as well as share in the benefits of education and outreach. These departments are housed in five adjacent buildings, covering 74,000 square feet. The Surplus Store is Leadership in Energy and Environmental Design (LEED) silver certified. The facility houses an education center; recycling and waste management; campus surplus resale; semi-trailer storage containers; and compost and scrap metal bunkers.

There are a number of other differences in the facility's operations that add to the efficiency and profitability of the program. For example, MSU's waste management includes an on-site Materials Recovery Facility. At this facility, student workers help separate the recyclable materials. The staff also works with 700 stewards to provide education and outreach about MSU's recycling initiatives through email and newsletter communications. To further educate the university community, the Surplus Store has conference rooms and educational facilities. Unlike the University of Michigan, MSU bids on construction recycling services. This includes providing bins for the construction contractors. They are able to salvage valuable materials (including copper, etc.) and reduce labor costs. However, it is the responsibility of the contractors to perform the labor. Given the integration of the departments, they are able to offer services through the combined recycling and property disposition at the Surplus Store. At U-M, OSEH is in charge of all regulated waste including ballasts, batteries, and Freon. Rather than having Freon removal being controlled by OSEH, the MSU property disposition staff is able to perform this service themselves. They invested $600 for the removal equipment and an additional $1,000 for certification and education of their staff. This investment is mitigated by charging each department for disposal. A refrigerator, for instance, has a charge of $50 for proper disposal. By providing this service themselves, they maintain a well-trained staff, limit potential negative reputational risk associated with improper disposal and claim to save MSU money.

MSU is also able to leverage their organization to reduce the cost of disposals. Through a contract with HP®, they receive ~$15,000 per year credit for recycling used ink cartridges. This is an economic incentive for recycling that the U-M does not have. By coupling these types of contracts with Procurement, there might be cost-savings as well as environmental benefits.

Computer recovery, resale and disposal are also handled very differently at MSU. The Surplus Store takes ownership of all university computer waste. The Surplus Store is responsible for the up-front cost of hard-drive wiping software and performs this task on all computers. By accepting the responsibility of confidentiality and electronic waste costs, they do not return any money to individual departments. The sold computers and parts make up for approximately 25% of total revenue for the Surplus Store. In contrast, the policy at the University of Michigan is that all computers must go to Property Disposition. These computers are tracked and on consignment like all other products, with 90% of the sale returning to the university department. This system doesn't take into account the additional time requirements of the staff at Property Disposition to prepare computers for sale in comparison to other resale items. In effect, the U-M General Fund subsidizes the costs of proper disposal.

Sending surplus property to the Surplus Store is not a university-wide requirement (unlike at U-M), yet it appears to be the preferred option. This is no doubt in part due to the fact that Surplus Stores provides free pickup and transportation of items from organizational units to the Surplus Store. The Surplus Store has its own moving services which includes two 18' box trucks and a crew of at least two people per trip. Their facility is purpose-built with proper unloading docks and staging areas to minimize heat loss.

As already discussed, computer revenues are not returned to the departments. Likewise, revenue from any products worth less than $100 is not returned. This is especially important to consider given that they accept office supplies and many other low-value, higher-volume products including such things as used comic books and used football team uniforms. (MSU’s management confidently stated they even make a profit on these items.) Furthermore, the Surplus Store sells items online through their own website's sales function and online retailers. This averages to 10-20 packages per day. There is no set consignment value (unlike the flat 10% fee at U-M Property Disposition), but MSU estimates they keep 1-15% of sales on items over $100 (excluding computers). $1 million of the $1.7 million revenue of the Surplus Store was returned to MSU departments this past year. Overall what this means in terms of green impact or revenue reduction for new purchases at the unit or university level because goods are being reused more intensely are important questions we couldn’t answer within the time and resources we had available.

MSU's property disposition services appears to have many benefits compared to that of the U-M's. We do not believe this is because the staff at MSU work harder or are more efficient than U-M’s staff. It is due to strategic, organizational, facility and structural differences along with a host of operational detail differences. In simple terms theirs is organized as an independent profit and loss center. Ours is organized as a subsidized cost and revenue center. Whereas it makes sense for most service operations (libraries, computer services, etc.) in a university to be organized as cost centers, this is not so obvious for Property Disposition. This seems to be one of those rare exceptions where organizing it so that it can be run as a subsidy-free profit making sub-unit makes more sense economically, environmentally and in terms of service quality provided to units.

1.3 Recommendations

1.3.1 Reevaluate current systems within Property Disposition and consider new software options

The current software in use at Property Disposition, CounterPoint, was reviewed to determine if it is the best choice for the needs of their system. The varying product type and quality of the used products, as well as the tremendous quantity, makes this inventory management and point-of-sale software cumbersome at best. Based on this software and current training of the staff, they are currently unable to perform detailed inventory analysis (e.g., aging, flow rates of individual products, space and labor efficiency), financial analysis (e.g., holding and transaction costs associated with specific products) or sales analysis (e.g., forecasting, tracking of specific customer purchases, the effectiveness of specific marketing efforts). Currently, it is not possible to assign unique identifying numbers to surplus items (less than $5000 in original value) to follow their flow through PD. It is not clear if this is a limitation of CounterPoint or a PD process design characteristic. But its absence makes it impossible to physically and financially track individual items from home units through PD to final customers. This limits the types of system analysis, and hence, improvement initiatives, management can identify and accomplish. It also increases the probability of "losses" between home units and PD. (Important note: we found no evidence of theft, but there is not iron clad physical or financial control of all property from home units to PD in part because of lack of individual item traceability.) Furthermore, the current software system is not linked electronically to the university's Asset Management System for tracking property with original purchase value greater than $5000 resulting in additional office work for the small staff at Property Disposition.

To assess other software options, a comparative analysis of software systems was performed between the current system and those used by Property Surplus at institutions with leading surplus programs: Ohio State University and Arizona State University. At both institutions, the software Webdata is used to follow used property pickup, manage inventory, and track sales. Michelle Tiburzi, manager of the Property Surplus system for OSU, reports that she has been using Webdata for the past four years with very good results. The program has capability for a whole series of options: online sales, auctions, disposal and recycling reporting, and inter-department transfers. Each can be tailored to specifically match the needs of the user. While the process of customizing the software for their needs took several months, Ms. Tiburzi is very pleased with the system they have built and is looking forward to performing an upgrade to the next phase of Webdata.

Webdata enables the OSU Property Surplus staff, which is no larger than the staff at U-M, to assign inventory codes to items as they are picked up, which remain with the inventory at their site and are retained through the sale process. Lastly, all staff members are trained to use this software, allowing them to monitor their operations and analyze the data collected by the system. OSU's Property Surplus worked with their Information Technology group to create simple reports which are run regularly, for example to assess the average time items are in-stock, average prices for categories and the breakdown of mechanisms for selling and which are working best. OSU's leadership feels that good data acquisition overall permits management to explore other areas for improvement.

We recommend that U-M research options for replacing CounterPoint as the point-of-sale and inventory-tracking system for Property Disposition. Whether a system like Webdata proves to be the best option, or another choice emerges, requires careful additional study. It is clear to us that without upgrading, or without use of currently unknown to us inherent CounterPoint capabilities, it will be very difficult for PD leadership to dramatically improve their unit's operational, marketing, financial or "greenness" performance. It is also clear to us that simply purchasing a more sophisticated software package without carefully rethinking (and possibly changing) current processes and assessing future needs has a good chance of just creating major headaches and wasting money for PD and U-M. New software needs to be sufficiently comprehensive, easy to use for daily operations, provide good reports for regular management tracking, and accurate accessible data for system analysis so opportunities for on-going improvements can be identified. To be used effectively, adequate staff training is also crucial.

1.3.2 Improve visibility and sales through advertising and university engagement:

Property Disposition has engaged in sporadic advertising campaigns in the past few years, with varied success. Placing ads in "Back-to-School" publications, the Michigan Daily, and other newspapers has resulted in increased exposure for the facility, but more is needed in this arena. "Bid-items", including vehicles and lab equipment, are generally more specialized and not of interest to the general campus population. These items have been successfully advertised through The Detroit Free Press. The more general inventory would benefit from similar exposure, targeting the specific communities likely to have interest.

Currently, Property Disposition expects 2-3 very busy weeks near the beginning in the school-year but consumer traffic throughout the rest of the year is much lower. With more targeted advertising strategies, utilizing existing communication mechanisms as well as new ones, Property Disposition can better engage the university community and the larger public to raise awareness of their products. The new crop of advertising should focus on the university community, specifically upper-classmen and graduate students, as well as the public, that are likely to have access to transportation to Property Disposition, (located 3.5 miles north of central campus). Newly matriculating undergraduates may not be the best audience for these advertisements. Instead, advertising should focus on the undergraduate community living off-campus and graduate students. These groups have not been a specific target in the past but it is very likely that their need to furnish apartments and houses, and the fact that they are more likely to have access to automotive transportation, makes this group a good target. To reach them, information sheets can be placed in welcome packets for graduate students newly arriving to Ann Arbor. In addition, there is an annual Housing Fair held in the U-M Union where realty companies can meet with students about options for rental housing. Having PD flyers, or PD representatives, at this event will alert students preparing to move off-campus to the services available at Property Disposition.

Email "blasts," are another effective means of reaching out to customers. These are being utilized more and more by the retail and service industry and participation is low-cost or free. The Property Disposition department here at U-M already maintains a list of customers that have expressed interest in specific types of items and, when these come into inventory, an email is sent to this designated group. Expanding this to include individuals interested in general furniture or office supplies would be a fairly simple way to raise awareness about the activity and inventory of Property Disposition. Newly emergent technologies such as Facebook and Twitter, and applications for smart phones, should also be explored. We were told that MSU's Surplus Store already uses Facebook.

1.3.3 Update website to improve sales and communications

Currently, Property Disposition utilizes its website to disseminate information to the U-M community, such as how-to schedule used property pickups, as well as to the public by listing its schedule of open business hours. In addition, there is a generic description of items that Property Disposition often has ready for purchase. (See Appendix B.) In comparison to U-M's static website, the websites for some of our peer institutions have much more functionality that allow them to communicate with the public about specific items that are in stock and are capable of accepting online transactions to purchase them. MSU has recently reworked their website to allow exceptional functionality and ease of use. As seen in Appendix C, the MSU site enables users to view items, create an account, and purchase items all online. Inventory is separated by category along the left side of the page for ease of navigation. A new or updated website at U-M could link real-time Property Disposition inventory information with existing university web pages on Sustainability, and On- or Off-Campus Housing to facilitate student procurement of these items. Also linked could be the E-Bay sale items, to facilitate the use of the website as a home base for anyone looking to procure items from any of the mechanisms used for sales. We recommend that these options be explored more thoroughly.

1.3.4 Hold seasonal outlets to clear inventory

It may be helpful for the Property Disposition staff to plan an outlet for peak seasons such as move-in and holiday time. This outlet could possibly exist at the Michigan Union, League, or Pierpont Commons, to bring the most popular Property Disposition items to students as an example of what is offered. This sort of retailing is becoming increasingly common where temporary small retail outlets are set up in shopping malls during holidays. Many individuals within the campus community are not aware of the services of Property Disposition. To change this reality, it will be helpful to temporarily bring these services to the hub(s) of activity on campus. In addition, it may make sense for the university to invest in a small fleet of trucks for Property Disposition to facilitate transportation tasks without requiring coordination through University Moving and Trucking. However, more data collection and analysis is needed to determine if PD should have their own trucks and provide free pick-up services as is done at MSU or even delivery services (paid or free) which none of our peer institutions currently provide as far as we are aware. Having their own truck fleet would be a major structural change in how PD operates and requires further study.

1.3.5 Investigate the construction of a proper loading dock at the Property Disposition facility

The existing PD warehouse was designed as a bus maintenance facility. Hence, it has grade-level access for busses to drive inside through large exterior roll-up doors. It also has a high bay to permit lifting of busses for servicing. We don't know if it was ever used as a bus facility, but it is clearly not ideal for PD purposes. Virtually all floor space in the warehouse is used for inventory for sale. Hence, internal loading or unloading from trucks with facility doors closed is impossible. As a result, significant amounts of heat are lost during the many hours per week during the cold months of the year when the exterior doors are open for unloading. Since sales are typically in far smaller quantities than deliveries and don't need triaging, pickup poses a much smaller heat loss issue. The high bay also wastes energy and wouldn't be practical for storage even with significant and costly building modifications (e.g., adding a second level or using high bay racks). In addition to the heat losses, there is a significant labor cost to current unloading. Unloading is slowed by the fact that every item on each truck has to be moved from the truck bed to ground level via a truck mounted hydraulic lift. This is due to the existing grade-level design and the absence of a proper loading dock. How much faster unloading would be with a proper dock is a function of a number of operational details, but we received the same estimate of twice as fast from two independent sources: the MSU Stores manager, who had personal experience with no dock and a proper dock at MSU, and Mark Burns the supervisor of LS&A's surplus property pick-up and delivery service. Prof. Talbot, who has many years of research and consulting experience in supply chain management in industry, estimates that with careful implementation it wouldn't be unusual to unload five times faster with a proper dock. Hence there appear to be significant cost and greening benefits from installing a proper dock or modifying the external eastern approach to the warehouse where at one time a dock-level exterior ramp was installed perpendicular to the building.

We decided to do a rough cost-benefit analysis of installing a proper dock on the west side, leaving the analysis for the eastern alternative for a future team. From a monetary perspective, this involves comparing the one-time cost of constructing a proper dock with the annual savings in labor and energy obtained by speeding up unloading. From a green perspective, the primary benefit is from warehouse heat loss reduction. Eliminating the use of lifts will also improve ergonomics and reduce the risk of injury to workers. Reducing the time the doors are open will also improve the comfort level in the warehouse for employees and customers.

We obtained an estimate of the dock installation from Wade Fields in Architecture, Engineering and Construction (see Appendix I). It shows a range of from $175K - $250K with an <u>expected cost of ~$200K</u>. Annual maintenance cost is negligible and will be ignored in our analysis. For our calculations we assume a conservative 2X speed improvement factor for unloading. According to Mark Burns, it takes on average 90 minutes to unload at PD currently with a range of 30 minutes to 150 minutes. On average there are five trucks per day arriving at PD. This means that 5x90=450 minutes per day there is at least one door open. Based on our own visits to PD, we think this is high, but it is a starting point. Because we have insufficient information for making more detailed analysis, we apply the following logic to estimate what the impact of faster unloading would be on heating the PD facility. If heating costs were uniform throughout the day (a simplifying assumption) then a door is open 2250 minutes/week (=5 loads/day * 5 days/week *90min/load) out of a possible 10080 minutes per week (7days/week * 24 hours/day *60 min/hour), or roughly 22% of the time. If all the heat was lost through the doors and we could magically unload the trucks without opening the doors we could theoretically save 22% of $100,000 (approximate current annual utility cost) = $22,000 per year. This is arguably an upper bound on heating savings, but even it is only a guess because heat gain and loss is tricky in this situation. For argument sake, we will assume it is an upper bound and that by keeping the doors open half the time we could save $11,000 annually in heating. (Another approach is to find a building of similar size, insulation, etc., on campus without roll doors and compare its heating bill in a recent year. We didn't have time to pursue this approach.)

For labor costs, we will also have to apply estimates. U of M truck drivers and helpers make ~$20/hour plus benefits. Benefits at this wage level are at least 25% which effectively brings the hourly rate to at least $25/hour. There are two people per vehicle, so hourly labor costs are $50. (We will ignore the truck cost because we have no good estimates on this hourly savings. But our approach would free up a comparable amount of truck time and may reduce the total number of trucks needed.) If we cut unloading time in half, then instead of 450 minutes we will need 225 minutes per day. This translates into an annual labor savings of close to $10,000. ($50/hour * 225 min/day *5 days/week *52 weeks/year / 60 min per hour = $9750) So the simplest economic model has capital investment at about $200K and annual savings of about $20K for a payback of ten years. If unloading could be reduced by 5X which Prof. Talbot thinks is very doable if a few other minor improvements (e.g., faster triaging) were made, then payback could be brought down to five years or less largely by reducing current annual unloading labor costs from about $100,000 to about $20,000. The important point of this exercise is not to show precisely how much money can be saved or precisely how much we can reduce our carbon footprint by using a proper dock. It is to illustrate that it is very worthwhile to further investigate both east and west alternatives more carefully with better data. It also highlights an instance where potentially significant monetary and green benefits can be obtained simultaneously. Greening can save money.

1.3.6 Improve data tracking

Presently, the data tracking system maintained for Property Disposition is limited, which makes conducting a detailed analysis of potential improvement difficult. Any analysis done on the current system will be hindered by this factor, and efforts must be made to improve data collection, analysis, and tracking in the future. This could be improved by the procurement of new computer software that has sales tracking capabilities built into its functionalities. Each item type, time between the delivery as well as the item, its sale, price of sold item, and end-location if unsold, need to be tracked over time to judge the success and improvement of the Property Disposition system at U-M. The tracking of this data will be able to inform the future growth and evolution of the Property Disposition system.

The tracking of data will also be important as new advertising and engagement opportunities are explored. These new programs have the goal to increase visibility of Property Disposition and its services and increase revenues for the department. However, without tracking, there will not be adequate metrics to measure the success. This is why, through the recommendations outlined in this report and the conversations within the working group for this project, better data recording and tracking will be a key part of Property Disposition moving forward. Creating an iterative and adaptive process, where continued assessment of the advertising, software and website is encouraged, will ensure that Property Disposition is as efficient, profitable and green as it can be.

1.3.7 Organizational Review

We strongly recommend that the university undertake a high level organizational review of PD. We also want to emphasize that this is not a criticism of how current staff run PD. They appear to do a good job with the resources and infrastructure they have available. In addition, we want to note that the above suggestions for incremental improvement don't require such a high level strategic review to add value. However we are convinced, especially after visiting the MSU facility, that even many incremental improvements over a period of several years will unlikely take PD to the next level of efficiency, cost effectiveness and greenness. Incremental improvements will almost certainly not make U-M a leader in this area. The broader questions that should be answered include, but are not limited to these: Should PD be a subsidized cost-revenue center or a profit and loss center? What is the best organizational structure for PD? Should they be combined organizationally and physically with other groups in a purpose-built facility? Should their charge be expanded to include an educational and branding component as MSU has done? Ideally, this review will be done before significant additional investments (such as a $200,000 loading dock) are made. If U-M postpones such a high level review for more than a year, then we recommend that the lower cost recommendations described above be pursued vigorously.

1.4 Conclusion

We feel that significant improvements in efficiency and sales volume can be made in the Property Disposition system, which would have environmental, financial and possibly branding benefits for the university. Increased sales should reduce the volume of waste disposed, as well as potentially reduce new product purchases and the environmental footprint associated with them. Property Disposition could increase revenues and reduce costs for individual departments and the university as a whole, through reduced transportation, labor and inventory costs, and reduced disposal costs. In order to accomplish all these goals, however, the Property Disposition system requires significant improvements.

To move Property Disposition to the next level of 'greening' and financial viability, the existing physical infrastructure must be updated to accommodate deliveries and sales in a more efficient manner. This can be helped through the use of a proper loading dock, which should see a financial payback in a relatively short period of time while simultaneously reducing the university's carbon footprint. Also necessary for increased usage of the Property Disposition system by the university community as well as the public will be increasing the attention spent to audience-specific advertising and outreach. Through an improved website presence, virtual marketing such as email blasts and use of Facebook and specific, centrally-located outreach events, Property Disposition will be able to raise awareness about its presence and services. In the near-term, this may lead to increased use of Property Disposition, increasing sales and reducing the purchase of new items.

What should be the stretch goals for PD? Setting numerical goals at this early stage without good quantitative baselines is difficult and may even lead down the wrong path. For example, it doesn't make any sense to use and reuse equipment or furniture within the university until it turns to dust just to be greener. How much reuse is ideal within the university is virtually impossible to state. It is, however, possible to set a theoretical goal of zero to landfill or zero to incineration for the university as a whole where PD plays an important role. A systemic answer to this question yields this answer: a five-year stretch goal is to make PD completely self-sufficient financially while simultaneously increasing its greening effectiveness 20% above its current state and while reducing university-wide costs associated with surplus property by 10%.

What are the hurdles? Our sense is that PD staffing is stretched pretty thin making it difficult for them to even find the time to further analyze and implement all these recommendations on their own. In some cases, such as software evaluation, the development of a website that permits on-line purchasing, or the use of new marketing tools like Twitter, they may not have sufficient in-house expertise to do the evaluation or implementation without outside help. An overall organizational evaluation and redesign will require high level university leadership and involvement. In addition, the university's legitimate focus on unit operating cost reduction may be shortsighted. In this case increasing PD's budget for thoughtful marketing expenditures will most likely increase greening effects and PD "profits" (revenues net of costs). In addition, unit focus makes it difficult to identify cross-unit improvements. An example of the latter is where capital investments in one unit (e.g., proper dock in PD) will reduce transportation and labor costs in other units (LS&A, etc.), and hence, will likely reduce overall costs for the entire university. This sort of cross-unit analysis is not naturally done within units. They require leadership and resources from central staff. MSU discovered that they required vice presidential attention before they were able to reorganize and build their new Surplus Stores and Recycling facility. That is likely the case for U-M as well.

2 RECYCLING AND WASTE DIVERSION

- **Develop a detailed action plan and associated targets to improve waste management traceability and efficiency, and improve landfill diversion rates.**

2.1 Introduction

The objective of the Recycling & Waste Diversion team was to determine the most practical ways to divert waste from the landfill, primarily though improving recycling rates. Built upon research done in Phase 1 of the Integrated Assessment, this section will describe viable waste reduction strategies for the University of Michigan. Overall, these recommendations aim to achieve a reduction in waste of 40% by 2020, in tandem with overall cost reductions for university operations. Notably, the increased diversion of recyclables from the landfill will lower tipping fees for the university providing an opportunity to reduce the cost associated with waste disposal.

2.2 University waste

2.2.1 Background

In 2009, total university waste was 17,355 tons, an overall addition of nearly 4,000 tons from the 13,833 reported for the 2004 fiscal year representing an absolute growth rate of 25.46%. Waste generation in 2009 was 438 lbs per capita[iii], less than the national average. Growth rates in waste generation align with national projections of increased waste generation per American. The recycling rate on campus has also continued to increase and is currently at 33%, up from 29% in 2004. While the trend is positive, there is room for significant improvement. There is an opportunity for U-M to stand out among its peers in this domain, as it is one of the most tangible areas to simultaneously be greener and lower costs.

Within this report we will highlight changes needed in academic and athletic solid waste disposal. Hospital waste is largely excluded from the analysis due to lack of time, but their recycling statistics are included within the noted totals. The reader is referred to Appendix A to gain an appreciation for the various material flows, including the inputs to waste, on campus. We discovered that no one on campus understands all these flows, the multiple players that affect them, their green implications or costs. Appendix A is a first, albeit incomplete, effort to close this important informational gap.

The data we have been able to obtain highlights the need for university-wide waste reductions programs that are strongly endorsed by senior administrative officials from the president and other campus leaders of the university that create a culture of change and infrastructure for further reductions over time.

2.2.2 Projections for Future Waste Diversion

As noted early in this assessment, the overall total of waste is increasing at the university resulting in higher overall tipping fees assessed. It is in the university's best interest to minimize waste and optimize recycling due to a cost sharing agreement established with the local Material Recovery Facility (MRF), which is owned by the City of Ann Arbor and operated by FCR a subsidiary of Casella Waste™. As of February 2010, the university was *receiving* $51.88 per ton of recycled paper and *paying* $28.77 for each ton of waste to be put in a landfill. The more aggressively the university promotes and expands its waste minimization and recycling efforts, the less it will pay annually to bury the waste accumulated on campus.

2.3 Recommendations

2.3.1 STRETCH GOAL: Reduce waste by 40% by 2020

We believe with firm commitments and brisk, coordinated action, U-M has the capability, drive and leadership to reach a 40% reduction in waste compared to current levels within a decade. The following portfolio of recommendations, as well as those detailed in the rest of the Purchasing & Recycling section and other sections such as composting efforts detailed in the Food Section, will help achieve this goal. However, without firm commitment from senior administrative officials, and enabling infrastructure and sharing information, the staff and student body will lack the guidance and mindset to work collectively to achieve this goal. A detailed implementation plan that encompasses this and subsequent recommendations is included later in this report.

2.3.2 STRETCH GOAL: Increase the university's recycling rate to 55% by 2020

Tipping fees, the fees charged by the municipality to carry and transfer waste from campus to landfill site, are predicted to rise over time as well. "Landfill tipping fees increased at a rate of 7 percent annually until 1998, when the fees remained relatively constant... This deviation from historical trends is unlikely to continue because many facilities have announced tip fee increases.[iv]" When considering farther distances that the waste has to travel (as the nearest landfill reached its limit, U-M's trash is now taken to a landfill in Canton), the environmental impact becomes even greater. "Landfilling, the most common waste management practice, results in the release of methane from the anaerobic decomposition of organic materials. Methane is 21 times more potent greenhouse gas than carbon dioxide.[v]" Unless the methane is used to create energy or sequestered, it is released into the atmosphere. This has negative effects on human and ecosystem health, especially since the waste is locally landfilled. See the graphic in Appendix D to view the life cycle of products, including the waste management effects on environmental health.

<u>Environmental and economic benefits of recycling</u>
Recycling is viewed as one of the most comprehensive ways to prolong the life of a given product, and ensure it is diverted away from landfill, and towards continued utilization.

- Recycling reduces the overall waste stream entering landfill annually, accounting for environmental and economic benefits for U-M and the surrounding community.
- Products that come from recycled content use fewer resources than one sourced from virgin materials. Aluminum cans manufactured from recycled content for instance produce 95% less GHG emissions than a virgin sourced product.[vi]
- Single-stream collection enables higher participation rates through an easier and more user friendly system.

Recycling practices at leading universities

- **Harvard University:** With an annual recycling rate of 55% in 2008, Harvard has the highest rate in the Ivy League. Currently the institution has aimed to reduce GHG emissions 30% below the 2006 baseline by 2016 and waste reduction will be a crucial component of this goal.
- **Georgetown University:** In 2010, Georgetown successfully diverted 85% of their waste from landfill with an annual 45% recycling rate. Between fiscal year 2008-2010, Georgetown reduced their waste stream by 1/3.
- **Princeton University:** Currently at a 43% recycling rate, Princeton has set a goal of 50% recycling rate by 2012.

The below recommendations will guide U-M in achieving a 55% recycling rate, ensuring higher diversion from landfill while providing financial incentives through lower tipping fees.

Phase I: Promotion and expansion of single stream collection process

Single-stream collection will be integral to increasing the current recycling rate and although most of the infrastructure is already in place additional education and promotion will be necessary to effectively engage the university population and ensure buy-in.

In 2010, the University of Michigan transitioned over to a single stream collection program in tandem with the City of Ann Arbor's municipal launch of this revised collection system. This altered program has enabled a streamlined approach to both collecting and recycling disposal, which is deemed to be more convenient for patrons and staff. In addition, the single-stream program enables diversion of plastic bottles and tubs #1, #2, #4, #5, #6, #7, paper products, bulky plastics, ferrous and non-ferrous metals, and glass. This expansion of additional materials under the new collection program provides both an environmental and economic incentive for the university to vastly reduce the current waste stream.

During the transition to single-stream the university has to alter the collection bins in order to reflect the revised system. University staff are currently altering recycling receptacles to have a universal collection top that infers that the container accepts both circular, three dimensional items such as soda cans, and flat, one dimensional items such as paper. Although the altered tops offer an intuitive sense of guidance on what is accepted, there has been minimal information provided about the changes to university students, faculty and staff, thus limiting the effectiveness of the program. Every container should have either a label affixed directly to the unit or a laminated sign displayed above the receptacle that clearly states the items that are eligible to be recycled as is done for Ann Arbor City residential bins. Labels with pictures and graphics are especially helpful as they allow communication across language barriers, ensuring optimal diversion rates.

Because of the U-M's decentralized nature, many of the recycling receptacles currently utilized are not consistent across campus. Many departments have containers that are unique to their buildings, thus making the task of providing a universal revised receptacle top arduous if not impossible for university staff. In tandem with the altered top, it would be beneficial to relabel the receptacles to reflect that the program now accepts both paper and containers since many of the current containers still discourage the integration of both streams as they prominently state either "paper" or "cans and bottles" on their sides. Eventually switching over to one container that clearly states materials accepted would very likely increase recycling quantities and make collection by staff more efficient and cost-effective. It will be important to integrate staff training that emphasizes keeping the recyclable items separate from trash collection as the co-mingled material may confuse some, causing unanticipated additions to the waste stream and undesirable contamination of recyclables.

Because U-M is such a diverse academic community, students and staff come from around the world where recycling programs vary considerably from our program in Ann Arbor. It would be beneficial to provide educational supplements in addition to altering infrastructure. Orientations would be an ideal setting to welcome students and staff into their new sustainable community, and address how the recycling program works and distribute information about what they can recycle within this program. The more eligible material that enters the recycling bin, the less the university pays in tipping fees, a clear environmental and economical win for the university.

<u>Phase II: Fully utilizing OSEH resources and assessing current barriers</u>

The Occupational Safety & Environmental Health Department (OSEH) promotes healthy, safe and protected environments in addition to ensuring that the university is compliant with current laws and regulations that promote such environments. OSEH has many responsibilities, but those that primarily pertain to our report include the regulated collection and disposal of biological, chemical, industrial, and radioactive waste. Federal, State and local laws specify how particular hazardous wastes are to be collected, transported, inventoried, traced and disposed of or neutralized. Staff, specialized vehicles, and facilities are certified and regularly monitored by various governmental agencies. Given this highly regulated environment, it is not obvious to us how to significantly reduce OSEH's operational costs or improve their ultimate greening effects. The OSEH staff is currently small, and appears to be very effective at fulfilling their mission. The obvious way for the university to improve OSEH's greening effects and to reduce their operational costs is to change material purchasing and use patterns. However, it is not obvious how to do this given the multi-faceted objectives of the university. For example, it doesn't make any sense to restrict the amount of radioactive materials the hospital needs to save patient lives simply to reduce the quantity of radioactive waste OSEH processes. This doesn't mean there are no opportunities for improvement. Research should be done on alternative organizational structures, treatment and disposal processes at peer institutions to evaluate the potential for reducing environmental impact and costs. The hospital does have its own budget, but the waste still falls within OSEH, which is important to note in trying to compare to other, potentially more efficient appearing Occupational Safety & Environmental Health Services.

OSEH has been very successful at integrating electronic recycling into the operational structure at U-M. From 2004-2009, OSEH has expanded its program to annually recycle 149 tons of electronics waste, up from 0 tons per year in 2004. Additionally, with the expansion of the electronics recycling program, OSEH has improved their collection of fluorescent bulbs on campus with a current annual 58 tons recovered. There is an effort made by this department to recycle and recover all bulbs on campus and currently they successfully divert 100,000 bulbs annually towards recycling and away from landfill. Planet Blue works with OSEH to promote facility and academic unit participation in these programs and to ensure that optimal recycling results are achieved. It should be noted, however, that OSEH, and hence the university, is charged a fee for each bulb recycled. Landfill is reduced and people feel good about recycling, but this is a costly program that argues for lifecycle costing analysis before bulbs are purchased. It is now important to consider initial purchase price of bulbs, efficiency during use, installation and removal costs and end-of-life costs. It is not clear that this is done at U-M in any systematic fashion.

Despite the challenges in hazardous waste selection, use, collection and disposal, reducing the overall use of hazardous chemicals should be a priority of the university. In addition to overall waste reduction, further advertisement and promotion of collection procedures for commonly disposed of items such as batteries and light bulbs could be more visible and more easily accessible on campus. OSEH issues white plastic buckets for collecting used batteries. It is unclear where these collection buckets are located. A web-based map of collection sites, along with better awareness, may increase use of this program. Light bulbs containing mercury, particularly compact fluorescents, must also be properly disposed of by OSEH. Students, faculty and staff currently have to submit requests to have bulbs picked up by Plant Operations and Facilities Maintenance. Streamlining and advertising this process will build awareness and boost participation.

<u>Phase III: Integration of incentive programs and university engagement</u>
Recycling rates will be highest when student, faculty and staff feel engaged and included in the campus transformation. The below recommendations detail programs that would be conducive to higher participation rates and a more enthused student-body.

- Student and Staff Pledges:
  Signed commitments are proven to encourage durable behavior change. Cialdini, an important scholar in the subjects of influence and persuasion notes: "If people commit, orally or in writing, to an idea or goal, they are more likely to honor that commitment because of establishing that idea or goal as being congruent with their self image. Even if the original incentive or motivation is removed after they have already agreed, they will continue to honor the agreement." Harvard, a peer

institution, has all incoming students and staff electronically sign a sustainability pledge (http://green.harvard.edu/pledge/). Adoption of a similar pledge at U-M may provide similar benefits.

- Recycle Mania:
  Recycle Mania is a nation-wide competition encouraging the reduction of waste on college campuses. It is a ten-week competition and will be held this upcoming February 6, 2011 – April 2, 2011. There are multiple levels to the competition, and the U-M competes in the Gorilla Prize. This competition specifically targets larger universities and focuses on the gross tonnage of total paper, cardboard and bottles and cans. Each college formulates a pledge for how they will reduce waste to reach their goals each year. The U-M has over 10 specific programs and applications to reach our goals, one being the Office Supplies Program that we discuss elsewhere in this report. In addition to reformatting the Office Supplies Program, more research should done concerning programs such as TerraCycle. Implementing additional recycling programs can help increase our recycling rates within the incentive program. The inclusion of additional recycling programs can help validate their effectiveness within Recycle Mania, and help staff decide if they should be implemented more frequently or even year-round. The rules and competition levels do need to be researched thoroughly before adjusting our recycling rates with regards to the competition. The most significant advantage to participating in Recycle Mania is the opportunity to educate the campus community and build momentum for recycling on campus. In addition to nation-wide competitions such as this, many colleges and universities host inter-departmental or inter-residence hall community recycling, and sometimes energy reduction, competitions that further educate the campus community and build awareness.
- TerraCycle:
  TerraCycle is a company that focuses on utilizing waste that cannot be recycled or reused through conventional practices. Their program advocates the collection of trash to form new items for resale. TerraCycle reduces the amount of trash going to landfills, as well as manufactures new products without using raw materials. By the reuse of materials such as granola bar wrappers or chip bags that would normally be trash, they reduce the amount of new materials used to make a new sellable product. This not only produces a new market for companies selling the products, but reduces the amount of inputs into the market, hence decreasing the amount of potential products resulting as waste. This program may not only be beneficial for the U-M to include into settings where they see fit, e.g. cafeterias or U-go's, but would also be a potential project to add to the yearly competition of Recycle Mania. There are some barriers with cost, but on a great enough scale, this program could add reputational effects for the U-M, especially given the publicity and marketing strengths of the company. Also, as no other school has implemented such a program on a large scale, the first-mover advantage and the publicity generated would put U-M in good standing among its peers. There should be more research done to evaluate the environmental, cost and reputational impacts of this program if implemented at the U-M. The visibility of programs like TerraCycle on campus also increase community awareness and promote overall waste consciousness.
- RecycleBank:

RecycleBank™ is an incentive program that works primarily with municipalities to encourage recycling participation through allocating points to households based on their weekly contribution rate and the overall weight of materials on their route. Although RecycleBank™ has not traditionally partnered with academic institutions this program, or a similar model, may be of interest if the university wanted to incentivize student, staff and faculty participation. The program runs in tandem with a single-stream collection process (already instituted by the U-M) and essentially scans each household's cart to verify participation, and then allots points based on the overall load of their route. The company has an online interface that enables easy access to promotional material, and the ability to scan through your designated account and select rewards. The RecycleBank™ program runs on an individual household basis, so allocating accounts to individual students would be logistically challenging. It is possible that the university could set up accounts on a departmental basis, however the current collection structure and decentralized nature of the university could make even this difficult. Multiple departments within a building often share dumpsters, so assigning quantities of volume collected to an individual department would be especially challenging based on the current collection infrastructure. At this time, due to logistical limitations, it does not seem like a viable partnership. If there are alterations in Recyclebank™'s operational structure or the university's collection systems, it should be considered in the future.

2.3.3 Increase occurrence and prominence of zero-waste sporting events

The University of Michigan could greatly benefit from hosting zero waste sporting events periodically throughout the athletic season. If zero waste is deemed feasible for a particular event, there would be potential for expanding the program, and perhaps extending the concept to a zero waste sporting facility. The reputational benefits from engaging in such an effort would be immense and the opportunity to showcase the university's greening efforts on a national stage would be unique among peers. This represents a significant branding opportunity for the university that should be seized.

Environmental and reputational benefits of zero-waste sporting events

Since U-M's athletic activities have such high visibility nationally and engage so many people on and off campus as participants or spectators, zero-waste sporting events are a great opportunity for U-M to take a significant step towards sustainability.

- Reduce the amount of waste generated at sporting games going to land-fills as well as total waste generated at U-M
- Align our sustainability initiatives with peer institutions through our athletic department
- Gain potential income from sponsorships from companies that want to be associated with universities that promote green practices

Zero-waste sporting events at leading universities

- **University of Colorado, Boulder:** Entire football season, home games (7) were zero-waste events. Estimated cost: $7000 for season (Only accounts for compostable products purchased for games, excludes cost associated with compost disposal)

- **Ohio State University:** Sponsored zero-waste tailgating event that successfully diverted 96% of waste from the landfill. (73% compost, 23% recycled, 4% landfill)

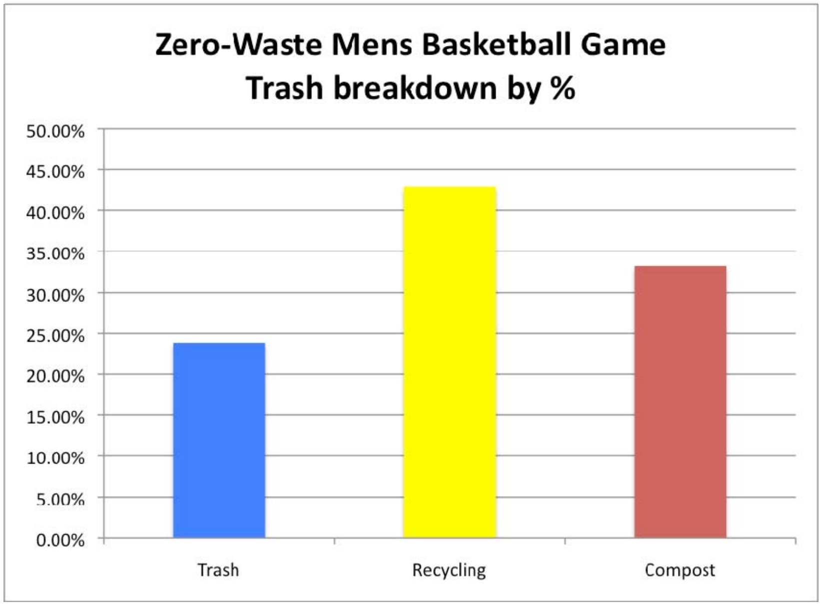
Phase I: Facilitate research and cost-benefit analysis

The current data on post-consumer composting suggests that it is not an economical choice for the university to consider. The average cost of composting is currently $750/ton pertaining to a zero-waste sporting event, compared to disposal of refuse at $160-$220/ton (this includes tipping fees and an estimate of transportation costs). Additionally, the frequency of composting pick-up may result in higher costs. Please refer to the Food Team Report for more detailed information for campus-wide composting.

Although there are cost barriers, it is in the U-M's interest to thoroughly research other universities that have held zero-waste sporting events. U-M could possibly be granted sponsorship money from corporations that are interested in associating with zero-waste events. The University of Colorado for instance spent approximately $7,000.00 over the course of 6 home football games for zero-waste events. However, this was compensated by sponsorship. Although there is a scale difference in the size of the football stadiums and attendance at games, further research may identify ways for composting to be economically and environmentally beneficial.

Phase II: Assess incorporating zero-waste sporting events at the University of Michigan

The Zero-Waste Men's Basketball Game on December 4, 2010 which we helped staff provided many learning opportunities. Firstly, the educational component was largely unsuccessful. This signals a need for greater support of the event from senior administrative leaders to secure better marketing, educational materials, and funding to hire additional temporary help and purchase appropriate receptacles and other materials. Even without the broad impact hoped for, over 75% of waste was diverted from the landfill. Additional detail can be seen below. This demonstrates the potential waste reduction that can take place when it becomes part of the culture of the school and part of the collective community awareness.



Although the Men's Basketball Zero-Waste Sporting Event at U-M showed great improvement vs. normal waste disposal procedures, it is important to note that further adjustments need to be implemented before hosting another event. Our own learnings should be incorporated with information from other successful zero-waste sporting events at peer institutions before we try again.

Barriers to implementation

The largest hurtles to successful implementation of zero waste sporting events, besides education to community members, are: 1) contractual arrangements established with vendors; 2) possible increased cost to accommodate compostable serveware or different packaging; 3) the additional labor associated with more complex sorting and disposal operations; and, 4) compost hauling costs. The most recent Zero-Waste Event (12/4/10) at the University of Michigan was able to successfully divert 76.3% of the total waste away from the landfill, with 43% recycled and 33.3% composted. This accounts for greater recycling than in the course of business as usual scenarios (43% vs. 33%) and provided composting which is not generally available. Although not all waste is able to be diverted due to package design or contamination of otherwise recyclable packaging, the zero-waste event promoted recycling and composting of all eligible items. Integrating compostable materials and hauling the subsequent materials away post game were the most expensive components of the zero-waste event. Approximately 1 ton, or 35 cubic yards of compostable material were accumulated during the game which incurred a $750 hauling fee.

Potential solutions to implementation barriers

If the University of Michigan sought to integrate zero waste sporting events into their broader athletics objectives a few key alterations would need to be instituted to accommodate this transition. Notably, if the university sought to implement this on a regular basis, the cost of purchasing and disposing of compostable materials is a major consideration. This event, and further events, may benefit from using recyclable plastic cups for beverages and ice cream service, instead of more expensive compostable cups. For items that would be especially susceptible to food contamination, such as containers for nacho dip, compostable containers could be maintained. Under the current economic conditions, with the cost of composting still vastly surpassing recycling and waste disposal costs, it makes the most financial sense for the university to promote sporting events that minimize overall waste, without shifting that towards compostable materials. Because the U-M pays to dispose of waste and compostable materials, and makes money or pays no fee to dispose of recyclable materials, the current dynamics encourage increasing recycling to the extent possible. General waste minimization and establishing infrastructure and standards of practice that promote recycling and composting should be incorporated into long term goals for the Athletics Department.

2.3.4 Provide an on-campus composting facility

The cost of composting for zero-waste is currently prohibitive due to the hauling fee of $750/ton, which is why it is important to emphasize more recycling at the zero-waste games or Union programs. It also motivates us to consider the possibility of an on-campus composing facility (described below), where hauling costs should be significantly lower.

<u>Environmental and reputational benefits of an on-campus composting facility</u>
In tandem with the Integrated Assessment Food Team, the Purchasing and Recycling Team recognizes the importance of seeking viable alternates to disposing of organic waste. The methane produced from these organic products contributes to green house gas emissions (GHG) globally and should be minimized wherever logistically possible.

- Increasing demand for municipal composting facilities with methane-capture energy generating technologies may drive the creation of additional facilities in Southeastern Michigan. For further proposals for on-campus composting programs at Matthaei and the Arboretum, please see the Food Team's report. In the future, additional consideration should be given to near-campus sites such as Stinchfield Woods and Saginaw Forest. Remote sites such as Camp Davis and the U-M Biological Station are much smaller, but may be able to justify their own composting sites.
- Reduce amount of general refuse at U-M, increasing sustainability at the campus and in the community
- Reduce costs regarding transfer of compost materials to outside facility
- Be a leader in composting among peer and leading institutions. Learn from current leaders which have large agricultural programs such as MSU and Penn State.

<u>Phase I: Evaluate financials of an on-campus composting facility</u>
Composting is currently cost prohibitive primarily because the university has to transport compost off campus. If the university was able to provide an on-campus facility for food disposal, cutting down on the resources expended and bringing the service in house, substantial savings may be realized. In 2003, Seattle University built an on-campus

compost facility only handling pre-consumer compost material and landscaping waste. The total cost of the composting facility was $182,000, but the amount of pre-consumer composting is considerably less, given their student body is approximately totaled at 8,000 students. The waste management staff is in charge of taking the compostable material to the facility located on campus but was unclear about whether the waste management staff tends the composting facility. There was no cost analysis of the upkeep of the facility.

Tracy Artley, Sustainability Programs Coordinator for U-M, is currently working with a consultant on the cost-benefit analysis of post-consumer composting

<u>Phase II: Solidify a location for an on-campus composting facility</u>
For the University of Michigan to fully take advantage of an on-campus composting facility, a location near or on campus must be considered in depth. The barriers and cost of a composting facility may restrict its location due to concerns of the campus and local community. Further research should include peer institutions which currently have a composting facility, as well as those who have maintained the facility in the long-term to assess additional costs as well as environmental and reputational benefits.

<u>Barriers to implementation</u>
Looking back to Seattle University's On-Campus Composting Facility, their current issues include:

- Neighbors to the Composting Facility have complained about odor and noise
- There were issues with proper mixing of compost to receive greatest benefit
- Understanding the long-term costs of upkeep of the facility
- Cost of hiring management or adding additional work to waste management crew

<u>Potential solutions to implementation barriers</u>
Not only does an On-Campus Composting Facility have the potential to reduce costs, but it could be a great reputational benefit to the university if we could implement a similar facility to Seattle University's Composting Facility on a larger scale.

To avoid potential issues from neighbor complaints, viable locations to research would be the Arboretum, Matthaei Botanical Gardens and Stinchfield Woods. These are not an exhaustive list of all viable locations, but are potential solutions for location barriers. Cost barriers would need a cost-benefit analysis of long-term facilities at leading universities to evaluate the potential environmental benefit as well as the upkeep and labor involved. Student groups could serve as volunteers at the Composting Facility or student internships could manage the facility.

2.3.5 Decentralize or Overhaul Office Supply Reuse Program

We recommend revising the Office Supplies Program because it is currently not cost or environmentally effective.

Environmental and economic benefits of decentralization or overhaul of the Office Supply Reuse Program:

- Reduce Environmental Impact (carbon emissions, reduce energy spent on housing material) of program wasting transportation costs of materials that are not being utilized in current program
- Reduce Cost by allowing student groups to facilitate program instead of paid labor
- Raise Money through facilitated sales run by student groups or sale through Michigan Student Assembly which can then sell to student groups they support

Office Supplies Reuse Program at leading universities:

- **California-Berkley:** Began their program in 2001 and have a shelved space with open hours for students and employees of the university to gather free supplies. Note that their program is different in that they can offer free supplies to students on campus. It would be useful to discover how Berkeley is able to do this without violating California state law, which if like Michigan's specifies that it is illegal to donate state property.

Phase I: Evaluate the potential for an overhaul of the Office Supplies Reuse Program

The Office Supplies program in its current form makes people feel good about recycling, but does not make sense economically or environmentally. The primary costs are staff time and transportation, and secondarily storage. The primary reason it doesn't make sense environmentally is that few items are ever reused making it impossible to compensate for the energy used for transportation. However there are opportunities to improve the system as noted below.

- Reduce Costs by collaborating with student groups on campus that are interested in the green effort to create a similar, annual or bi-annual sale, to that which was done by the undergraduate team. Research ways to sell the excess office supplies at a minimum cost to university funded organizations, such as the Michigan Student Assembly, which can then sell to the student groups they support. (It is important to note that State law prohibits giving State property away for free to the public.)
- Utilize individual departments to decentralize the program and create more convenient spaces for faculty and staff to access extra office supplies. It can be stored in a current storage, at a much smaller volume. The undergraduate team had concluded that the Philosophy department and Library Systems already have a system similar to this that should be evaluated further.

Phase II: Research environmental and economic benefits of discontinuing the program

Discontinue the program as it is currently structured. This appears to be a "feel good" and "look good" program that doesn't justify itself on either environmental or monetary grounds largely because of the labor and transportation needed for centralized storage, and the low rate of reuse of the inventoried items.

2.3.6 Support and adopt new and innovative solutions to further divert waste from the landfill

Waste sorts

Waste sorts have been done periodically on campus in order to decipher the composition of the university waste stream. In 2007, a student group coordinated by the Recycling Coordinator conducted a comprehensive analysis of the University of Michigan Union in order to determine what types of materials were entering the waste stream at this location and to propose improvements to the current collection process. This study examined the current collection structure at the union and suggested viable ways to increase recycling participation and reduce overall contamination in the collected streams. The report broke down suggested improvements into 3 categories, with the quick wins, or efforts that were lowest in cost and likely to garner considerable benefits noted as: installation of recycling specific lids, improved training for staff, and better signage for both users and staff edification. Harder to reach goals that were likely to have a profound impact on recycling diversion rates included incentivizing recycling on campus and altering packaging in order to facilitate recycling and composting for end of life disposal. The report anticipated that the quick wins proposed could improve the university recycling rate to 39%, up from the current 26%. Notably, successfully altering packaging and altering behavior could bolster the university towards further waste diversion for recycling eligible items. Additional findings from a 2010 U-M Union trash sort that we participated in are provided on the Graham Institute website at http://www.graham.umich.edu/education/campus-2010projects_fall.php under "Zero Waste" University Unions.

Incineration

Consider the economic, health and environmental impacts of hauling waste to alternate disposal locations or local incineration facilities. The Holcim cement facility in Dundee, MI for instance is able to take waste with high BTU levels in order to process their energy intensive cement production.

Waste Payment Structure

The University of Michigan currently charges individual academic units for their energy consumption, which creates an incentive to reduce usage. The solid waste operations however come from the General Fund so individual units do not directly see the cost impact of their waste generation. Altering this incentive structure would lower overall costs for the University, and allow individual academic units to be more cognizant of the waste they generate.

Increase data collection efforts and data quality

Data drives entire projects from feasibility analyses to program effectiveness evaluation. Good information systems would allow the following:

Confident decision-making based on precise and reliable statistics
Ability to data mine and extract trends or anomalies for further analysis
Historical archives by which to measure against benchmarks over time
Ability to accurately assess whether programs reached goal levels
Facilitates planning of future goals and projects
Higher transparency of costs

Rapid data extraction and ability to present information as per user needs
Thus, Management Information Systems are a key towards successful goal realization.
Higher data quality will aid operations personnel greatly
Recycling Coordinator to provide accurate metrics to stakeholders

Construction & Contractor Code of Conduct
Collaborating with the Integrated Assessment Buildings Team, our team feels that it is essential to acknowledge the environmental goals of the Architecture, Engineering and Construction Sustainability Master Plan. We would like to note their plans for greener construction practices such as material recycling, purchasing of durable material and promotion of safe and healthy materials. The Buildings Team is also focusing on a stretch goal for a "Materials" Library for smaller construction purposes and projects. This would promote the re-use of materials within demolition and construction. Market demand for salvaged materials has increased in recent years and promoting de-construction instead of demolition and the reuse of these materials has great financial and environmental benefits. For further information regarding possible construction practices within the University of Michigan, refer to the Buildings Team report.

2.4 Conclusion

Reputational benefits from being a leading institution in this realm should not be understated. Currently the University of Michigan is lagging behind other peer institutions in public rankings and should emphasize recycling not only for the reputational and environmental benefits, but because of the considerable potential cost savings. Peer institutions, such as Harvard, Georgetown and Princeton have set waste reduction goals in order to challenge and engage their students, staff and faculty. U-M risks falling behind if further action is not taken.

The proposed improvements to waste collection and recycling promotion are challenging yet feasible. We recommend that U-M adopt a goal of 55% recycling rate by 2015 which Harvard achieved in 2008.

3 PURCHASING

- ***Develop guidelines for implementing a university-wide sustainable purchasing policy.***

3.1 Introduction

The Purchasing sub-team explored a number of institutional opportunities and barriers associated with implementing a sustainable purchasing policy and improving purchasing overall through efficiency, technology and education.

The U-M spends approximately $2 billion on goods and services each year, more than half of which is spent on purchasing and plant operations.[vii]

Purchases can be made through a variety of ways. The majority of orders go through M-Pathways and are non-Marketsite ePro requisitions. P-cards, which function much like a credit card, are primarily used for travel, catering, rental equipment and other services. They are occasionally used for purchases from vendors with whom we seldom do business. For fiscal year 2010, p-card purchases accounted for approximately $106 million in spending.[viii] P-cards can be used for purchases with non-strategic preferred vendors and as such do not allow for data collection on spending patterns that is as rich as the data available from M-marketsite.

M-Marketsite is an online ordering system provided by Sciquest, an eprocurement software application used by many university procurement departments. The service links to whole or partial preferred vendor catalogues and has functionalities for placing and tracking ordering data. There are approximately 4,000 registered users in the M-Marketsite system. Users log in with their UM-ID through Wolverine Access to place orders. In fiscal year 2010, 149,000 orders were placed through M-Marketsite, accounting for $51.5 million in spending. In addition to M-Marketsite, M-Pathways is U-M's procurement method for placing purchase orders.

Purchases can be made with preferred vendors through the use of short codes. However, data for short-code orders placed by fax, phone, e-mail or through sales reps are not standardized and are thus more difficult to obtain for analysis than data from M-Marketsite.

More data collection and analysis is necessary to determine what percentage of commodities purchased through p-cards, M-Marketsite, M-Pathways and short codes have sustainable alternatives.

The university community has been charged with reducing and reallocating overall costs to the U-M general fund by $120 million over the next six years.[ix] General improvements to purchasing through gains in efficiency, better utilization of available technology and training university purchasers in best practices have great potential for realizing cost savings that can contribute significantly to this goal. Improved purchasing can not only reduce costs, but also reduce the university's environmental footprint.

Prioritizing local and environmentally preferred purchasing practices will further advance the university's vision of stimulating economic growth in the State of Michigan to "sustain and grow a vigorous and dynamic economy" and further demonstrate the U-M's dedication to "ethical and responsible stewardship of financial, physical and environmental resources."[x]

3.2 Considered Recommendations and Ideas

Purchasing related recommendations in Phase One of the Integrated Assessment were:

- Institutionalize sustainable purchasing by adopting a sustainable purchasing policy and creating institutional structures to support implementation of this policy.
- Centralize purchasing so as to enhance the U-M's ability to negotiate with suppliers for green products and to coordinate efficient deliveries.

The Purchasing sub-team explored each of these recommendations in more depth and developed the following recommendations for this second phase of the process:

1. Establish a Taskforce for Sustainable Procurement to develop and monitor an Environmentally Preferable Purchasing (EPP) Policy.
2. Institute a robust and ambitious Environmentally Preferable Purchasing Policy that defines standards for evaluating the environmental and life cycle costs of commodities, incorporates best practices and requires training for university purchasers.
3. Identify additional high volume products that meet EPP policy standards, and survive pilot testing and evaluation by end users as candidates for the M-marketsite automatic-substitute feature to realize cost savings and increase the quantity of accessible, affordable and sustainable alternatives.
4. Increase the percentage of orders placed through M-market site to better manage data collection on ordering behavior and optimize the M-Marketsite user interface to improve communications between users and the Procurement Department, and increase the visibility of environmentally preferred products.
5. Further educate the university community on responsible purchasing practices that support sustainable economic growth and reduce waste.

Lastly, the purchasing sub-team considered maintaining the current purchasing culture and procedures and evaluated the costs and benefits associated with no change at all. In our research we found that there is significant room for improvement, not only in terms of promoting sustainable purchasing but simply in the potential for cost savings through efficiencies and best practices. While some recommendations may require initial time and financial investment, the long term cost savings and environmental benefits associated with improvements are significant and worthy of serious consideration.

3.3 Recommendations

3.3.1 Establish a Taskforce for Sustainable Procurement to develop and monitor an Environmentally Preferable Purchasing (EPP) Policy.

To facilitate the development of an EPP Policy, it will be necessary to establish a Taskforce for Sustainable Procurement made up of university stakeholders representing different aspects of the procurement system. The goal of this task force will be to increase environmental benefits and decrease costs over time. This will be accomplished first by drafting a U-M EPP policy and then through periodic revisions to account for improved technology and availability of sustainable alternatives to necessary commodities. A successful policy will create a set of basic requirements for university departments as well as outline future goals for the evolution and development of sustainable purchasing at the U-M.

<u>Forming a taskforce</u>
Specifically, this taskforce should include representatives from the following stakeholder groups:

- Taskforce for Sustainable Procurement Core group:
    - Procurement Services
    - P-card holders, M-Pathways and M-Marketsite users
    - Administrative staff from various offices
    - Paid student representatives (one graduate and one undergraduate)
    - Office of Campus Sustainability and the Graham Institute
    - Preferred vendors representation from local businesses

For consultation services and particularly during the initial drafting of the policy, input from the following stakeholder groups should also be taken into consideration:

- Taskforce for Sustainable Procurement consulting offices:
    - The Provost's Office
    - Academic Affairs
    - LS&A, Rackham and professional schools
    - University Health System
    - Facilities and Operations
    - Property Disposition
    - Housing

Limiting the size of the taskforce, while also utilizing the diverse array of perspectives from the consulting offices, will maximize perspectives while keeping coordination and organization of the taskforce manageable.

Members of the taskforce should form a representative cross-section of the university community to integrate as much diversity of perspective and experience as possible. These individuals will be representing their departments and so should be well-versed in the purchasing practices and procedures there. An interest in promoting cost-savings and efficiency within the university will also be a valuable asset, as well as a personal interest or experience in sustainability. Paid hourly student representatives would provide an inexpensive and dedicated workforce for researching and documenting ideas for sustainable procurement. They would work directly under the Sustainable Procurement Coordinator to aid in organizing and implementing the Taskforce for Sustainable Procurement initiatives and EPP policy. It would also be a leadership and educational opportunity for the students selected. The Sustainability Users Working Group will aid in identifying specific individuals to fill these appointments however, members of the taskforce will be appointed through means deemed appropriate by the home department. Precise term lengths will be determined by the taskforce, but should be staggered throughout the group to ensure institutional memory is maintained.

Hire a Sustainable Procurement Coordinator

To further ensure institutional memory and implementation of plans and ideas identified by the taskforce, a permanent and salaried Sustainable Procurement Coordinator position within Procurement Services should be created and hired as soon as possible. It would be important to consider a broad search to fill this position from outside the U-M to bring in an individual with significant sustainability and procurement experience and new ideas. While this position will require annual funding on the order of $100-125K, the opportunity for resultant cost savings should far outweigh the cost of a salary and benefits. (Switching from conventional to remanufactured toner cartridges resulted in $1.6 million in savings by implementing the auto-sub feature. In addition to environmental benefits, returning used cartridges results in waste reduction as well.) The Sustainable Procurement Coordinator would potentially lead the taskforce but also work within procurement to identify and implement efficiencies, evaluate and recommend environmentally preferred products and seek collaborative partnerships for further cost savings and environmental benefits.

Responsibilities and deliverables of the taskforce

The primary responsibility of the task force will be to draft the EPP Policy based on recommendations for this policy found on subsequent pages of this report. Once this policy has been written and approved, the full taskforce will convene every two to five years to review and update the policy. A specific policy review timeline will be determined by the taskforce. Data from M-Marketsite, feedback from the university community, and developments within sustainable purchasing best practices will inform the taskforce throughout this process. It can be expected that the review process of an EPP policy will include special attention to these areas, and related certifications, as they evolve.

The taskforce core group will convene regularly to produce an annual report in non-policy review years outlining additional data needs and market analysis as well as tracking progress and identifying new challenges to be overcome.

Benefits

The creation of an EPP taskforce to foster and monitor the progress of Sustainable Purchasing at the university will allow for regular audits and reports on financial savings and environmental benefits realized through sustainable purchasing. Constant reevaluation of vendors, product availability and longer-term strategic organizational changes will permit the taskforce to modify specific objectives over time. Regular auditing and reporting will incentivize long-term, integrated solutions that respond to repeated audits, rather than shorter-term cost-cutting measures.

The task force will be empowered to convene both as a full working group or to break topics down by subcommittee to more thoroughly address them. This will allow for the appreciation of the complexity of many of the tasks that they are charged with. Annually, the required reporting on the progress of the previous year, as well as a detailed agenda for the next, will maintain momentum and consistency from year to year and build-in metrics by which to measure success.

A representative task force will provide a forum for multiple view points and perspectives that will create robust recommendations and institutional buy-in at multiple levels. Term limits provide individuals incentive to accomplish things during their tenure and new members continuously bring in new ideas. Granting decision making authority to the task force (e.g. to approve a preferred product for auto-substitution) increases efficiency through a reduction in bureaucratic controls.

Barriers to Implementation

The Procurement sub-team identified the following barriers to creating this task force.

- Costs associated with an additional staff person may be prohibitive. While identifying funding for a coordinator position within procurement would be a challenge, resultant cost savings from gains through efficiencies and even reputational benefits through sustainability initiatives and simple job creation, would likely far outweigh the cost of an additional salary.
- Availability of key stakeholders to participate may be limited. Many individuals who would contribute key insights to this taskforce likely already participate in a variety of committees and may not want to take on additional work. While this taskforce wouldn’t constitute an onerous commitment, it is possible that key individuals may choose not to participate for this reason. Term limits and encouraging participation may help alleviate these concerns.
- Too many stakeholders could mean high coordination cost or inability to consider all opinions. Too few does not provide enough institutional knowledge or buy-in. Striking a balance will be challenging. Participation is key to develop and monitor a policy that works but coordinating efforts can be cumbersome. Identifying a task force core group with consultation from major departments and offices will create a small, productive working group yet include as many viewpoints as possible. A full time Sustainable Procurement Coordinator may ease this process.
- There is a lack of clarity in which department should host the taskforce. It would be necessary for an existing department or office to take on the role of convening the taskforce. The Sustainable Procurement Coordinator in Procurement Services, Provost’s Office or Office of Student Affairs may suit this role.

3.3.2 Institute a robust and ambitious Environmentally Preferable Purchasing Policy that defines standards for evaluating the environmental and life cycle costs of commodities, incorporates best practices and requires training for university purchasers.

Identifying Environmentally Preferred Products
A successful Environmentally Preferable Purchasing (EPP) policy will provide guidelines for sustainable purchasing in all categories of products procured by the U-M. The contents of such a policy should also be flexible enough to adapt to advances in Life-Cycle Analyses and new product releases. The first requirement for the policy will be to define Environmentally Preferred Products. A variety of certification programs exist, with widely differing degrees of rigor, and it is important to evaluate which certification programs should be used to determine the preference of alternatives for given products. "Preferred Certifications" are those that have been evaluated and determined to be sufficiently rigorous and descriptive of products that are environmentally lower-impact than their more conventional counterparts. Appendix B of the ENV 391 Sustainability and the Campus Green Purchasing Report (Appendix E) shows an "Eco-label Matrix" of reputable certifications. Prioritizing these products provides incentive for certifying bodies to continuously monitor and improve standards to remain reputable and for industry to develop products that meet those standards.

Appendix E of the ENV 391 Green Purchasing report (Also found in Appendix E of this report) identifies the following desirable product attributes:

- Biodegradable
- Carcinogen-Free
- Chlorofluorocarbon (CFC)-Free
- Compostable
- Durable
- Energy Efficient
- Locally Manufactured or Grown
- Lower Embodied Energy
- Made from Renewable Materials
- Persistent, Bioaccumulation Toxin (PBT)-Free
- Recyclable
- Recycled Post-consumer Content
- Reduced Greenhouse Gas Emissions
- Reduced Packaging
- Refurbished
- Reusable
- Third-party Certified
- Upgradeable
- Volatile Organic Compound (VOC)-Free
- Water Efficient

In addition to these, a complete evaluation of the environmental attributes of commodities includes but is not limited to:

- Less toxic
- Water-conserving
- Remanufactured
- Rechargeable
- Bio-based
- Made from recycled materials
- Michigan-made and local products sourced and/or manufactured within 300 miles of campus.

*List adapted from Environmental attributes of products at stopwaste.org.

The purpose of identifying these key terms is to help university purchasers search preferred vendor catalogues for green alternatives.

Identify tools for evaluating the "greenness" of products

Varying availability and costs associated with green alternatives create a significant amount of uncertainty under which to design an EPP policy. Simply listing attributes does not account for the weighting of their potential environmental impact. Tools for evaluating green products and other alternatives to stagnant definitions of "green" will be explored by the taskforce as well. Ken Keeler in the Office of Campus Sustainability developed a "Green Choices" Tool (see Appendix F) to evaluate the supposed "green-ness" of a product. In Appendix D of the report referenced above, the Green Purchasing group from Dr. Shriberg's ENV 391 course identified a series of user-friendly questions, or a Green Product Assessment, to help evaluate the different sustainability features of a product (see Appendix E of this report and the Graham Institute website at http://www.graham.umich.edu/education/campus-2010projects_fall.php). Costs and time associated with testing products with these and other evaluation tools is noteworthy, however not all products will need to be evaluated. In general, identifying green alternatives will rely on trusted certifications and key terms, however for promoted or auto-subbed products, evaluation tools are more appropriate mechanisms for determining "greenness" and therefore worth the added time and money.

Require EPP training for all university purchasers

A required educational training program for university purchasers should be included as a policy component. This is a unique feature of the U-M EPP policy that would show leadership and serve as a model for peer institutions. P-card holders and other university purchasers with spending authority are currently asked to participate in a training module when they receive their p-card. However, it is possible to circumvent the training and still sign the appropriate documents to be granted purchasing authority. Technology such as online or electronic training modules and recertification or continuing education procedures could be used to ensure that all university purchasers receive basic information on best practices for responsible spending. Training modules would be developed by the Taskforce for Sustainable Procurement and describe the impact of individual and department-level purchasing decisions on university budgets as well as the environmental, social and economic impact of commodities.

Such a program could become part of the existing training program and would be able to highlight the advantages and disadvantages to different purchasing behaviors such as the use of M-Marketsite, use of p-cards, and responsible purchasing behavior such as requesting less or reused packaging, bulk ordering and reduced delivery schedules. This education will be a key component of the success of the EPP policy, which is why it is critically important that a brief description of the required educational program should be written into the policy itself. Methods to disseminate this information to all university purchasers could include a straightforward online module that would be completed before purchasing privileges begin.

Regular review and development for such a training program will be necessary to ensure that the training is effective for purchasers. Soliciting feedback from the purchasing community is essential and will allow the program to continuously improve. Effective training modules will include information about best practices, how to identify green products and responsible purchasing behavior.

Accountability and Code of Conduct

Vendors and university purchasers must be held accountable for their use of or benefit from university funds. At the vendor level, the current Code of Conduct outlines specific guidelines for behavior of university suppliers, but promoting additional compliance by vendors will incentivize them to meet university standards for sustainability. At the level of the individual purchaser, the educational component will include a Purchaser Code of Conduct, to be developed by the taskforce, whereby purchasers commit to following guidelines and practices outlined in the EPP Policy. This will increase awareness of university expectations and accountability regarding spending behavior.

Transportation and Packaging

Providing support and incentives for vendors to reduce packaging and for purchasers to reduce transportation by placing $50 minimum orders and bulk ordering will also contribute to cost savings and environmental benefits. Office Max, one of the most commonly used preferred vendors, recently cut back on the number of delivery days from five to four days a week. A few select vendors now deliver some product in reusable bags to reduce packaging. Further commitments to transportation and packaging reductions should be part of the vendor code of conduct for all vendors. The reasoning and advantages, both in cost and environmental benefits for these measures should be clearly communicated to purchasers. Down stream savings would also be realized through reduced packaging initiatives as there would be less packing material to collect and dispose of or recycle. To ensure accountability, purchasers should be encouraged to report over-packaged products and shipping materials to Procurement Services and vendors. In addition to identifying vendors guilty of non-compliance, vendors demonstrating significant commitments to environmental stewardship should be recognized and rewarded for their contribution, perhaps through profiles on M-Marketsite, or special opportunities to showcase their products on campus.

Reductions in overall spending

Reducing spending on commodities overall will save money. These reductions can be realized through optimal purchasing behavior, bulk ordering for multiple departments on commonly needed products, and the reuse, repurposing and sharing of goods and equipment amongst U-M community members.

Benefits

Consistent standards for evaluating vendors and individual products will allow for equitable selection of preferred vendors and incentivize current and potential vendors to meet or exceed standards set by the university. After implementation of the policy, a grace period (possibly one year) will enable vendors to improve their practices to meet these new standards, thereby decreasing the potential loss of good will in the relationships that currently exist with U-M vendors.

A strong EPP policy that includes training and educational components will provide positive reputational benefits and demonstrate leadership amongst peer institutions.

The required training program will streamline operations for university purchasers, resulting in operational cost-savings over time and standardizing practices to reduce sub-optimal behavior outside of the purchasing guidelines. By targeting key positions or individuals for initial training and continuing development, visible purchasers will become early adopters of the preferred practices and act as role models for other staff members. Over time, gathering feedback on policy initiatives, use of product evaluation tools, training sessions and addressing transportation and packaging issues will increase institutional buy in and further streamline purchasing processes.

Barriers to Implementation

The Procurement sub-team identified the following barriers to creating this policy.

- There is currently a lack of clarity in the factors defining a green product. This is due in part to the complexity of the topic and the lack of trustworthy data, most of which is supplied by vendors. In addition, there is a perception, which is sometimes true, that affordable environmentally-preferable products are not widely available. However, further building demand for sustainable products will begin to drive down prices.
- The wide variety and volume of products purchased within the university adds to the difficulty and complexity of sustainable procurement. Products spanning the range from construction materials to fume hoods to paper must be considered, as well as ways to disseminate specific information to the appropriate purchasers for each.

3.3.3 Identify additional high volume products that meet EPP policy standards, pass testing and evaluation by end users as candidates for the auto-substitute feature to realize cost savings and increase the quantity of accessible, affordable and sustainable alternatives purchased by the U-M.

Increase use of the auto-sub feature in M-Marketsite

Technology is a key component to facilitate the purchasing of environmentally-preferred products in cases where their benefits have been proven through Life-Cycle Analyses or other evaluation tools as mentioned above.

One key example of using existing technology more effectively is the automatic substitute, or "auto-sub" feature available through M-Marketsite. When a product has been identified as "preferred," selecting a standard product will prompt the computer to automatically substitute the preferred product for the selected product in an order. Procurement Services recently implemented the auto-sub feature for remanufactured toner cartridges. Remanufactured toner cartridges are available for most printers. Now, when an order is placed for a conventional toner cartridge, the purchaser receives a remanufactured cartridge instead.

Use of this feature should be promoted and expanded within M-Marketsite, both to increase the purchase of products with substantial "green" benefits as well as to provide leverage and economies of scale for negotiating strategic contracts for these products. By "auto-subbing" preferable products where they are equivalent in quality to conventional products will guarantee suppliers the sale of a certain threshold quantity that may encourage vendors to reduce the cost per unit. An auto-substitution must be accompanied by education campaigns, which may be as simple as an emailed notice to keep purchasers abreast of changes so alternative products are accepted and not rejected because they are unexpected.

Prior to auto-subbing any product it should be fully vetted by users. This could include pilot testing, monitoring of repeat orders and surveys from product users. In addition, once products have met the necessary guidelines any changes should be clearly communicated to users prior to and during the first few weeks the auto-substitute is in place. This could be done through a newsletter, pop-ups during log-in to M-Marketsite, e-mails to purchaser groups or explanatory text in order confirmations.

To aid in identifying products to be auto-subbed, monitoring and data collection on high volume items such as paper and pens, as well as high cost items such as electronics and lab equipment like fume hoods, should be evaluated and approved by the Taskforce for Sustainable Procurement.

Substituted products will also be evaluated on the cost associated with the life cycle of the product. An idea submitted by Ms Jennifer Reed from the Michigan Sea Grant asked why shorter lasting, less efficient light bulbs were being used in place of slightly more expensive longer-lasting bulbs that might be more cost effective over time considering the complete life cycle of the bulb.[xi] Examples like this serve as reminders that upfront costs rarely indicate the life cycle costs of a product – something seemingly less expensive may prove to actually cost more over time due to shortcomings in efficiency, maintainability and durability.

<u>Benefits</u>

There are significant gains associated with further vigilant implementation of the auto-sub feature. For example, the initiative to switch from conventional print cartridges to remanufactured ones resulted in a savings of $1.6 million. While indeterminable, yet presumably minimal costs were incurred in the implementation of this initiative, environmental and economic benefits were gained. An assessment could be performed to measure the environmental benefits of these types of programs. One study performed by WSP Environment & Energy that considered "the environmental impact of a toner cartridge throughout its lifetime - from raw materials extraction, production, distribution and use until end of life...reduces the overall carbon footprint of that cartridge by up to 60 percent."[xii]

The project to automatically substitute remanufactured print cartridges for conventional ones has resulted in significant cost savings. Further utilization of this feature for high volume office supplies, such as paper, could generate further savings. Implementation of this feature should take into account modern standards of product assessment including Life Cycle Assessment (LCA) and Total Cost of Ownership (TCO) models.

While using the auto-sub feature requires improved communications to be successful, it does not require a significant amount of learning on the part of the user to be effective. The research in identifying the preferable product is taken care of which saves purchasers time and energy having to become experts in what makes a product preferred. To benefit from the cost savings and environmental benefits associated with the auto-sub feature requires no additional training or effort on the part of the user.

Barriers to Implementation

The Procurement sub-team identified the following barriers to further use of the auto-sub feature.

- The initial roll-out of the auto-sub feature came with it significant challenges. Interviews with administrative staff revealed real and perceived issues with the quality of the substituted product. While the change was presented to Deans and the Budget Administrator Group, there was no direct communication to end-users prior to the implementation of the toner cartridge auto-sub. Because the change was not clearly communicated to these purchasers, a number of individuals used p-cards at local chain stores to purchase the older and more expensive conventional toner. Also, vendors began re-labeling products so they could still be ordered without triggering the auto-sub. Clearly, communicating information to the university community of purchasers and making sure substituted products are fully vetted will be an integral to the success of this initiative.

3.3.4 Increase the percentage of orders placed through M-market site to better manage data collection on ordering behavior and optimize the M-Marketsite user interface to improve communications between users and the Procurement Department, and increase the visibility of environmentally preferred products.

The primary site used by university staff to place orders is M-Marketsite (http://www.procurement.umich.edu/mmarketsite.html). This site serves as the main portal to the university's collection of online catalogs from preferred vendors, as well as a system for placing orders and tracking purchasing data. The site can also be used to disseminate information about Procurement Services.

Redesign the M-Marketsite interface to promote sustainable purchasing

The current ordering system (accessible via Wolverine Access) does not place a strong emphasis on sustainable products. Products made from recycled materials or meeting "made in Michigan" guidelines are indicated with icons below product descriptions. In order for the purchasing of sustainable products to become commonplace, preferred products should be the default option. In addition to automatically substituting products, the website can offer green recommendations and suggestions (e.g. "Consider purchasing post-consumer recycled paper instead of conventional printer paper").

Currently some catalogues within M-Marketsite will prompt users to choose a less expensive equivalent to the product they initially selected. When searching and placing an order, for a stapler for example, if there is a similar product at a lower price, the system will highlight the product and ask the user if they want to substitute for that product. Products with significant cost savings and/or environmental benefits could use this same technology to appear either at the top of product search lists or in pop-ups. Administrative staff interviewed suggested that if they knew a product was preferred by the U-M and identified as such on M-Marketsite, they would likely choose that product because it had been vetted by the university even if the cost was slightly more than what they usually order. This would be a useful tool for products that are suspected to have cost savings or environmental benefits associated with them but may not be appropriate candidates for the auto-sub feature. Prior to any changes, user surveys and pilot testing will be used to gather information on optimal design interfaces.

Make "green" products information more visible.

Currently, accessing information on "green" products is not as clear as it could be. Under "U-M customized supplier catalogs" there is a list of catalogs and product lists by supplier. Another click leads users to a list of green products by category as well as links to the associated vendors. With this method users would have to actively seek out green alternatives to conventional products. It is also possible to search for key words such as "recycled" or "post-consumer," however, this would require that the user has knowledge of what these terms mean and which are a reliable way to find better products. Overall, the process of finding and identifying green products is not as user friendly or straightforward as it could be. A new Procurement Services website was in the process of being created and launched during the publication of this report and will likely begin to address some of these issues.

Utilize the welcome page, pop-ups, e-newsletters and log in screen messages to disseminate information.

The main page is not currently optimized to effectively disseminate information. Part of building awareness for sustainable products requires creating a "buzz" around it. Real estate on the main page could be used to promote, for example, a new product or supplier relationship. Suppliers might be able to feature sustainable products on the main page.

This way, suppliers receive valuable marketing space, and sustainable products are promoted. In the long run, one of the best ways to build awareness for a new online initiative is to give the website a different feel, as this creates a sense of change. There are further opportunities to share information with users either with messages that appear on the welcome log-in page regarding new product auto-substitutions or policy changes send out by e-mail, not only to authorized purchasers but to all relevant administrative staff tasked with placing or helping to place orders or search for products. The p-card newsletter is currently hidden amongst a number of other links. Important newsletter information should be distributed widely and promoted on the home page. Opportunities for better communications on the home page are not limited by the Sciquest platform. Other peer institutions such as Yale University, take advantage of this technology to promote their new sustainable procurement standards. (See for example http://www.yale.edu/procurement/)

Benefits

The main benefit of following these recommendations will be increased likelihood and frequency of the use of M-marketsite through buyer education. If the goal of the website is to promote the usage of sustainable products, it follows that creating buy-in from users will help spread the word, especially if the website provides transparency in the metrics used to measure benefits. Having a standardized system on the website will also reduce errors, by automatically substituting sustainable products and promoting information in a systematic manner. Finally, an improved website will create an informal social network of purchasers, motivating others to join.

Barriers to implementation

The Procurement sub-team identified the following barriers to improving the M-market website and related communications efforts.

- Barriers to implementation could include the cost of revamping the website. There could also be some initial confusion from people who were used to the old website. It could also be difficult to determine what is user-friendly and functional across different functions (i.e. buyers vs. suppliers). However, a targeted education and outreach program can mitigate this risk.

3.3.5 Further educate all members of the university community on responsible purchasing practices that support sustainable economic growth and reduce waste.

The strength of any policy lies in how well the values and instructive qualities of the policy are communicated to those most likely to implement it on a day-to-day basis. Required staff training as well as voluntary education programs improves user buy-in and compliance with the policy as well as addresses the desire for an overall cultural shift in purchasing behavior. We have already addressed mandatory training. However there are currently other ways in which the Procurement Department disseminates information to purchasers which could be improved overall as well as further expanded to include aspects of the EPP policy.

Current education
Current purchaser education includes Users Group Meetings, Vendor Shows, and Sustainability events and fairs. With the exception of the later, these outlets for disseminating information about sustainable purchasing are directed solely at staff. During interviews with administrative staff it became clear that Users Group Meetings are not widely known about and Vendor Shows are somewhat infrequent and not always the most effective means of sharing information.

Current training and education does not sufficiently address best practices in sustainable purchasing or take into account additional audiences of purchasers that impact and influence the U-M. Faculty, students and staff, particularly those without primary purchasing authority, all make purchasing decisions. The autonomy of individual departments and offices to make the purchasing decisions that best meet their needs is a strength of this institution. However, the opportunity for significant cost savings is lost by keeping the scope of university purchasing too narrow. Anything brought onto campus, originally procured by students, faculty or staff, becomes the problem of, and potentially a cost to the university when it is disposed of on university property. Educating the entire university community on upstream consumption will reduce operating costs of handling that waste downstream. In addition to cost savings, buy-in is incredibly important in the implementation of the EPP policy. Involving staff early and often and explaining the process will improve support for broad policy changes. Educational programs and campaigns surrounding sustainable purchasing should be realized as an investment in the economic sustainability of the campus and surrounding region. Promoting sustainability literacy, particularly in upstream purchasing behavior, demonstrates leadership in environmental stewardship and social responsibility.

And lastly, as an educational institution we are not only obligated to the mission of education for the entire U-M community but we have the skills and resources to do so. Sustainability on and off the U-M campus can be improved by educating the public on what sustainable purchasing means and creating more demand thus improving the availability of green products for all, and of course for the U-M as well.

Educational workshops will be designed following the collection of survey data demonstrating how and why daily purchasing decisions are made and what kind of information could be used to improve them.

Benefits
Educating the campus community will further foster a culture of sustainability at the U-M and result in greater community awareness and institutional buy-in. As more educational programs are instituted, information will spread over formal and informal networks to create a campus of environmentally literate university purchasers. In addition to educational campaigns and modules, continued emphasis on sustainability at vendor shows will allow purchasers to build networks and aid in future decision making.

Barriers to Implementation
The Procurement sub-team identified the following barriers to additional education.

- Funding for additional educational programs that provide qualitative benefits are difficult to justify in typical cost-benefit analyses. However, as a mission-driven educational institution, the U-M understands that education, in and out of the classroom, is integral to the success of any new initiative. Additionally, as described above, there is potential for cost savings in more sustainable purchasing practices. Directly linking educational campaigns to cost savings will be a challenge, but data collection and measuring campus understanding of sustainability over time may aid in identifying a correlation.

- It is unclear which campus office or program should host educational workshops or email and flyer campaigns. Procurement Services, Planet Blue, and the Office of Campus Sustainability could be considered potential candidates. And lastly, with such a large and diverse decentralized campus, disseminating consistent information across the university will continue to require creative ideas and solutions.

3.4 Conclusion

Phase 1 of this report highlighted the challenge of identifying green products, cost benefits and, in some cases, up front cost premiums associated with green purchasing and the cultural shift needed to encourage university purchasers to minimize deliveries.

In Phase 1I, we identified more detailed barriers to implementation. The maturity of the green product market cannot currently meet the demand of a large public institution without incurring significant costs. However, the availability of green products has improved in recent years and promises to continue growing. In addition to product availability, there are significant opportunities for cost savings through negotiated contracts with green product suppliers. While it is clear that a cultural shift is needed, the challenge of creating that shift will most likely be met by training, education and clear communications amongst the Procurement Services department and university purchasers.

As noted in phase 1 of the report, while there is a growing trend of green purchasing policies in higher education, the enforcement of those policies represents a more difficult challenge. Meeting this challenge requires not only a robust campus-wide policy that clearly defines “green” purchasing but also addresses implementation through purchaser education and a purchaser code of conduct, similar to the vendor code of conduct already in place for suppliers.

With limited financial resources in today’s economic climate, spending of available funds communicates institutional values. While sustainability is quickly becoming a priority, not only for the U-M but for many colleges and universities across the globe, how we spend the precious funds we do have does not yet reflect this trend. University procurement has made incremental steps to facilitate prioritizing sustainable purchasing however a number of institutional and cultural barriers create significant difficulties in meeting this challenge.

Through discussions with staff, both administrative and procurement staff, it became clear that training, education and improving communications are crucial factors in creating sustainable infrastructure that will further facilitate the adoption of more sustainable practices and behaviors over time.

We have heard from both university purchasers and Procurement Services staff that improved communications and customer service has great potential for improvement. Utilizing technology and requiring purchaser training and education will help Procurement Services effectively disseminate information to university staff. A responsive and easy to access system for purchasers to report issues and provide feedback to Procurement Services will be integral to instituting changes that work. Furthermore, providing incentives for users to submit ideas, such as rewarding and recognizing individuals or departments for submitting ideas that result in significant cost savings for the university would leverage the vast diversity of knowledge and expertise and all levels of the university.

Since M-Marketsite allows for good data tracking, provides a platform for interfacing with university purchasers and provides easy access to preferred vendors which can positively impact strategic contract negotiations for competitive pricing, M-Marketsite should be the primary avenue by which orders are placed. Short codes and p-cards would be used only in situations when ordering through M-Marketsite is infeasible.

Procurement touches almost every aspect of the U-M community and encompasses potential for improvements in climate change mitigation, eco-system health, reducing the U-M's materials footprint and engaging the university community through awareness and education. Even within the Integrated Assessment teams, sustainable purchasing is part of food procurement, bottled water consumption and renovation and construction supplies. Coordinating a university-wide policy for best practices is not without its challenges but the opportunities for the U-M to realize cost savings and show leadership in this arena are too worthwhile to ignore.

4 LIFE CYCLE ASSESSMENT

- ***Assess the viability, complexity and resource requirements associated with conducting a full Life Cycle Assessment and footprint of the University of Michigan.***

4.1 Introduction

Life Cycle Assessment (LCA) is a useful tool to estimate the overall environmental impact of goods and services; in the evaluation of a good's impacts, production, use, and disposal can be considered. LCA has been widely used in assessing environmental impacts of industrial products but it is rarely seen in analyzing the environmental impacts of large institutions such as universities. One major reason is that the complexity of large institutions' activities makes it extremely difficult to collect sufficient data for a Life Cycle Inventory (LCI, i.e. the total resources consumed and total emissions generated) to conduct a LCA based on the material flows of individual processes. In this section, a feasible method based on monetary flow is introduced and implemented to estimate the environmental impact of U-M as an example. It can then be applied to sub-sections of U-M or possible policy changes in order to better understand their potential environmental impacts and therefore provide guidance for decision making.

4.2 Methodology & Database Used

The methodology & database used in this section are similar to that in Phase 1 and are summarized below.

4.2.1 Database

Among different LCI databases, the USA Input Output Database (I/O database) enables a preliminary calculation of the impacts caused by various materials and services based on total expenditures in over 500 categories[xiii,xiv]. It can be used to conduct LCA even if the detailed individual processes are unknown which is the major barrier for LCA on large institutions. Given the spending of the U-M on different goods and services, it is possible to estimate the overall environmental impacts.

Detailed accounts of spending for the U-M during the fiscal year 2009 (FY2009) and fiscal year 2010 (FY 2010) recorded in M-pathway were provided by Procurement Services[xv]. The expenditures for FY 2009 and FY 2010 include detailed information of the spending of U-M on over 700 accounts. Excluding expenditures that will not directly generate environmental impacts such as salaries and scholarships, these accounts can then be individually paired with the items in the I/O database (See Appendix G). Note that due to time limitations, the data of Flint Campus and Dearborn Campus were not excluded.

The expenditures of U-M are grouped into 10 categories as follows:

1. building constructions, renovations

2. plant operation and maintenance
3. furniture & equipment
4. laboratory research supplies
5. IT services and supplies
6. fees and services
7. food and beverage
8. medical expenses
9. sports and entertainment
10. travel, hosting and transport

Since the I/O database does not include the LCI for the use phase of products/services, it is recommended to analyze the use phase separately. This can be accomplished by obtaining the amount of fuel, electricity, and natural gas used in U-M or other sections of interest and applying them to process based LCI database (e.g. Ecoinvent 2.0). The detailed consumption of fuel, electricity and natural gas by U-M can be found in the annually published Environmental Report. However, the Sustainability Report does not cover the Flint and Dearborn Campuses. To avoid data inconsistency, the use phase analysis is not included in this section.

The data was then analyzed with IMPACT 2002+xvi to evaluate the environmental impacts of U-M for FY09 and FY10. Four endpoints were selected: 1) Human health, measured in DALY (Disability Adjusted Life Year); 2) Ecosystem health, measured in PDF*m2*yr (Potentially disappeared fraction of species*m2*yr); 3) Climate change, measured in kg CO2 equivalent; 4) Primary resource consumption, measured in MJ.

4.2.2 Results of LCA on U-M for FY09 and FY10

The results of this analysis are summarized in Table 1 below.

Despite slightly decreased in total expenditures, each category in FY10 shared the similar percentage in both total monetary and environmental impact compared to FY09. For most categories, the environmental impacts (in all four endpoints) increased proportionally with the increase of expenditures. Fee and services and medical expenses had smaller environmental impacts (3.2~9.8% across endpoints in FY09 and 3.8~12.3% in FY10) considering their percentages in expenditures (16% combined for both FY) while furniture & equipment had more significant shares of impacts on human health (31% in FY09 and 32% in FY10) and ecosystem health (40% in both FY09 and FY10) than its share in the total expenditures (17% in both FY09 and FY10). It is also notable that although food and beverage only took up 1.3% of the expenditures in both FY, it was responsible for 2.6-4.2% of the total environmental impacts.

Table 1. Environmental impacts from U-M expenditures on goods and services during FY09 and FY10.

FY	Category	Expenditure		Endpoints							
				Human Health		Ecosystem Health		Climate Change		Resources	
		million $	%	DALY	%	PDF*m2*yr	%	kg CO2 eq	%	MJ	%
FY09	Building constructions, renovations	533.78	35%	2.18E+03	33%	1.65E+09	27%	3.89E+08	37%	4.23E+09	29%
	Fees and services	179.10	12%	1.79E+02	2.7%	1.13E+08	1.9%	6.60E+07	6.3%	1.17E+09	8.1%
	Food and beverage	20.12	1.3%	1.73E+02	2.6%	2.49E+08	4.1%	3.26E+07	3.1%	3.89E+08	2.7%
	Furniture & equipment	266.94	17%	2.05E+03	31%	2.42E+09	40%	1.82E+08	17%	2.52E+09	17%
	Laboratory research supplies	198.56	13%	7.29E+02	11%	5.89E+08	10%	1.36E+08	13%	2.29E+09	16%
	IT services and supplies	98.56	6.4%	4.19E+02	6.4%	3.53E+08	5.8%	4.99E+07	4.8%	7.51E+08	5.2%
	Medical expenses	54.47	3.5%	1.01E+02	1.5%	7.96E+07	1.3%	1.54E+07	1.5%	2.49E+08	1.7%
	Plant operation and maintenance	94.63	6.1%	4.63E+02	7.1%	4.52E+08	7.4%	7.56E+07	7.2%	1.20E+09	8.3%
	Sports and entertainment	7.89	0.5%	3.32E+01	0.5%	2.08E+07	0.3%	5.34E+06	0.5%	8.54E+07	0.6%
	Travel, hosting and transport	89.51	5.8%	2.13E+02	3.3%	1.87E+08	3.1%	9.64E+07	9.2%	1.63E+09	11%
	Total	1543.56	100%	6.53E+03	100%	6.12E+09	100%	1.05E+09	100%	1.45E+10	100%
FY10	Building constructions, renovations	474.35	32%	1.93E+03	31%	1.47E+09	25%	3.45E+08	34%	3.75E+09	27%
	Fees and services	180.46	12%	1.79E+02	2.9%	1.13E+08	1.9%	6.60E+07	6.6%	1.17E+09	8.3%
	Food and beverage	19.73	1.3%	1.73E+02	2.8%	2.49E+08	4.2%	3.26E+07	3.2%	3.89E+08	2.8%
	Furniture & equipment	253.27	17%	1.99E+03	32%	2.37E+09	40%	1.71E+08	17%	2.35E+09	17%
	Laboratory research supplies	224.07	15%	8.12E+02	13%	6.56E+08	11%	1.52E+08	15%	2.57E+09	18%
	IT services and supplies	90.86	6.1%	3.64E+02	5.8%	3.08E+08	5.2%	4.40E+07	4.4%	6.63E+08	4.7%
	Medical expenses	64.40	4.3%	1.46E+02	2.3%	1.11E+08	1.9%	3.54E+07	3.5%	5.59E+08	4.0%
	Plant operation and maintenance	82.47	5.6%	4.16E+02	6.6%	4.08E+08	6.9%	5.99E+07	5.9%	9.25E+08	6.6%
	Sports and entertainment	6.24	0.4%	3.10E+01	0.5%	1.98E+07	0.3%	4.17E+06	0.4%	6.39E+07	0.5%
	Travel, hosting and transport	89.02	6.0%	2.12E+02	3.4%	1.89E+08	3.2%	9.78E+07	10%	1.66E+09	12%
	Total	1484.88	100%	6.25E+03	100%	5.90E+09	100%	1.01E+09	100%	1.41E+10	100%

4.3 Recommendations

4.3.1 Quantitatively monitoring the sustainability of U-M and evaluating the environmental impacts/benefits of possible policy changes

LCA is a useful tool to estimate the environmental impacts of products and services. In this section a feasible methodology with available databases was shown using the expenditures of U-M in FY09 and FY10 as examples. Conducting LCA on U-M can provide quantitative data about the sustainability of U-M for benchmarking, goal setting and measurement of progress. By analyzing each category in more detail, it can also provide insights of what specific category yields the greatest potential to be improved for elevating environmental impacts with the smallest effort or cost (for details, please refer to the Purchasing and Recycling team's report in Phase 1). The general methodology presented in this section can be employed easily for other purposes such as evaluating the sustainability of individual U-M departments and/or possible policy changes.

To further demonstrate the use of LCA for these purposes, case studies on the Zero Waste Sort event for the Michigan Union and the Office Supply Reuse Program were conducted. Analysis revealed that by proper disposal treatments (recycling/composting versus landfill or incineration), the environmental impacts from disposal of wastes could decrease up to 4-fold; the Office Supply Reuse Program will be truly effective only if the supplies are actually reused and the environmental impacts from transporting the supplies play a small role. (See Appendix H.)

<u>Benefits</u>
The LCA results cover themes of climate change, human health, ecosystem health, primary energy. Conducting LCA for U-M can help the university gain more insights on its performance on sustainability as a benchmarking tool. It can reveal on what vector U-

M should invest efforts to achieve reducing the highest potential environmental impacts. LCA can also help in justifying possible policy changes in terms of "greenness" and identify the most crucial factor to ensure the policy changes reach their aims in sustainability.

Barriers to implementation

To conduct a LCA using the I/O database, monetary flows of the system being studied should be paired with the items in I/O database. This requires careful examination of the nature of expenditures. However, the nature of certain expenditures might be difficult to identify due to data ambiguity and it is recommended to consult personnel who are familiar with the expenditures to make the most appropriate pairings.

On the other hand, the I/O method has its own limitations and process based LCI database should be used when:

- Use phase of a product/service is important
  The I/O database does not include information of the use phase which could be the major contributor of the environmental impacts for certain products/services (e.g. appliances, transportation vehicles, etc.). Data regarding the use phase must be collected and analyzed accordingly with process based LCI. The major drawback of the analysis presented in this section is the lack of use phase analysis. After bridging data gaps, M-pathway and the annual Environmental Report can together provide a hybrid of I/O database and process based LCI analysis to better characterize the environmental impacts of U-M.

- Detailed information of processes available
  Although the I/O database provides the LCI of various products and services, the information regarding resource consumption and emissions is highly averaged across the United States. It is entirely possible that this generalized data does not accurately enough reflect the actual system under study. Also the possibility of incorrect pairing between expenditures and I/O database items may cause errors in the analysis. Therefore, if detailed information of processes in the system is available, it is recommended to use the process based LCI database instead of the I/O database. This is shown in the analysis of Zero Waste Sort.

4.4 Alternative campus footprint assessments tools

In addition to Life Cycle Assessment, there are other mechanisms for assessing the environmental footprint of the university. National rankings hosted by third party organizations such as the Sierra Club and The Sustainable Endowments Institute evaluate and compare sustainability initiatives at colleges and universities. The Sierra Club's 'Cool Schools' ranks the University of Michigan at number 46. The U-M also received a letter grade of "B," down from a B+ last year, in the Sustainable Endowments Institute's 'College Sustainability Report Card.' Controversy surrounding these programs was highlighted in a letter to these organizations that often rankings were made with incomplete information and did not allow for institutions to opt out of being ranked. The

Association for the Advancement of Sustainability in Higher Education's (AASHE) Sustainability Tracking Assessment and Rating System (STARS) program is a voluntary and transparent self-reporting framework to gauge relative progress towards sustainability at colleges and universities. To date, 238 colleges and universities have registered for STARS including peer institutions such as Michigan State University, UC-Berkeley, Columbia, Duke and Yale Universities. Assessing the usefulness of participation in STARS is outside the scope of our report. However, considering the limitations of LCA and reports that STARS is quickly becoming considered the industry standard[xvii], more information is needed. In order to take control of how the U-M is ranked in sustainability rating and ranking systems, the university should seriously consider participating in STARS as a way to transparently track progress towards sustainability.

5 INTEGRATION AND CONCLUSION

Material purchasing, usage and ultimate disposition are integral to the functioning of the University and have among the highest financial and environmental impacts. Our team examined only a portion of the several billion dollars in annual material flows, with the Energy, Food, Transportation and Building teams examining other major segments. Although our primary charge was to focus on Property Disposition and Recycling, conceptually at least the greatest cost savings and environmental benefits long term can be obtained by better purchasing. This is much easier said than done, but we have provided a number of recommendations to enhance green purchasing, hopefully without increasing cost to the University. We have also provided a number of incremental suggestions to improve the effectiveness of Property Disposition. However, we believe that a major organizational restructuring is necessary to permit PD to function at the next level of excellence. Recycling activities and infrastructure are fairly mature at U-M, but again improvements can be made. Among the most important are better internal communication and education, setting public stretch goals and sponsoring events such as zero-waste varsity games that increase recycling at the events, but more importantly enhance community awareness and our external reputation as a green campus. The surplus office supply program as currently implemented makes people feel good, but isn't cost or environmentally beneficial. We provide a number of fairly simple ideas on how to make this program successful. Life Cycle Assessment is a powerful tool for measuring greenness. We strongly endorse its use as a means for goal setting, tracking performance and cost/benefit analysis.

Our greatest challenge was identifying and understanding all the material flows on campus and the many initiatives underway to either reduce related costs or make the campus greener. We learned fairly quickly that no one understands all material flows on campus or is aware of all initiatives. Relevant data are often compartmentalized, unknown, tough to access, or non-existent. As a result, we assumed the task of developing a first-pass comprehensive material flow diagram with dollar and material flows and responsibility centers for all flows. Our efforts were a start, but hardly complete. We strongly recommend that some unit on campus take responsibility for completing this task and updating these diagrams at least annually. Without this information, it is very difficult to carefully select, manage, evaluate or coordinate greening initiatives or understand their full financial implications. It's even hard to know what questions to ask without first knowing the current status supported with good and accessible data. If such diagrams existed, it would dramatically simplify future IA efforts.

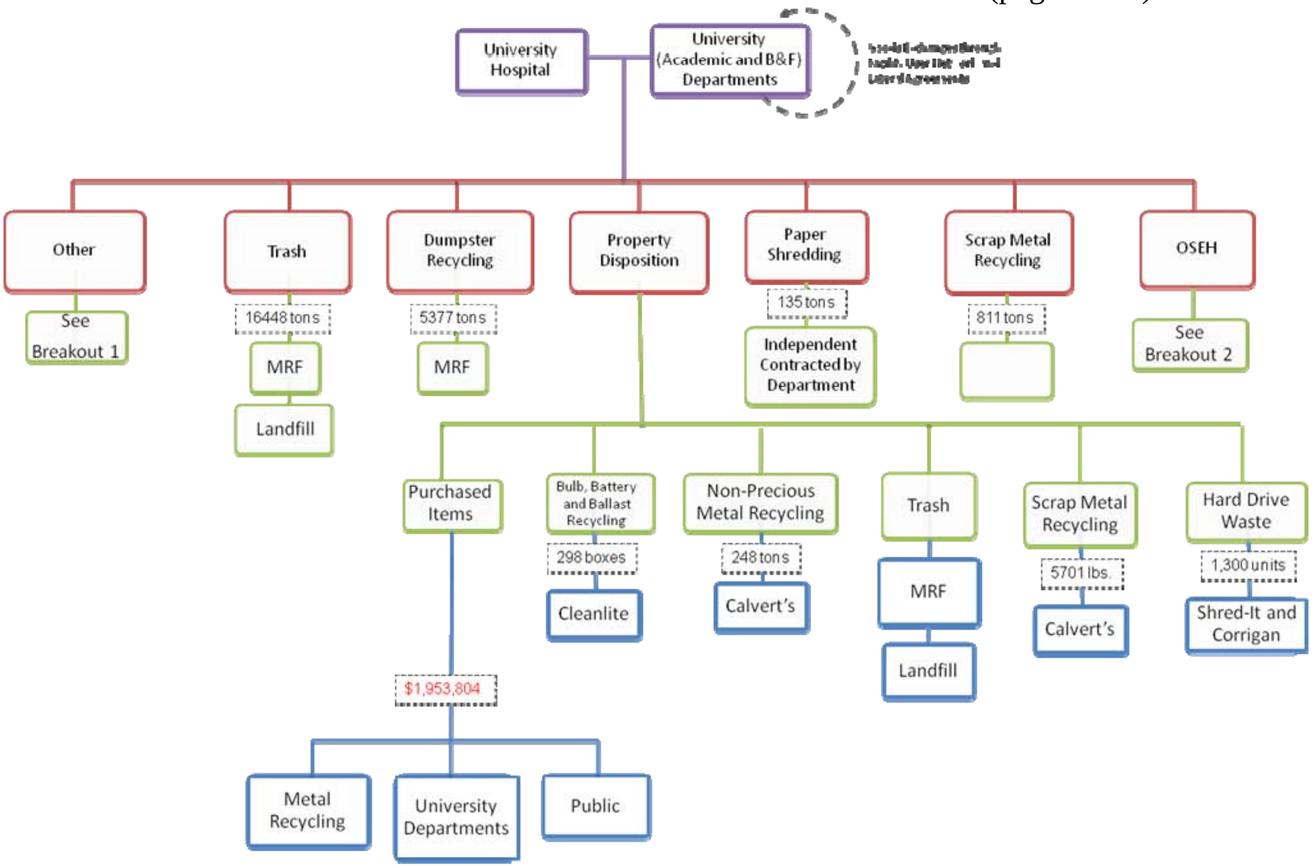
We were asked to complete the matrix below, but found it very difficult to do so. For example, all of our initiatives deal with materials in one way or another. Only one has an identifiable capital cost (dock at PD), but others might once more thorough analysis is completed. Because of lack of data and time we could only do one payback analysis (for PD), and that involved some pretty grand assumptions. If material purchasing becomes greener, then in one way or another there will be (very) indirect climate and health benefits. Also, it is not clear what the baseline is for the rankings. For example, is a "$"

$1000 or $100,000? Etc. This all seems very subjective. In spite of these reservations, we have tried our best to provide meaningful scores.

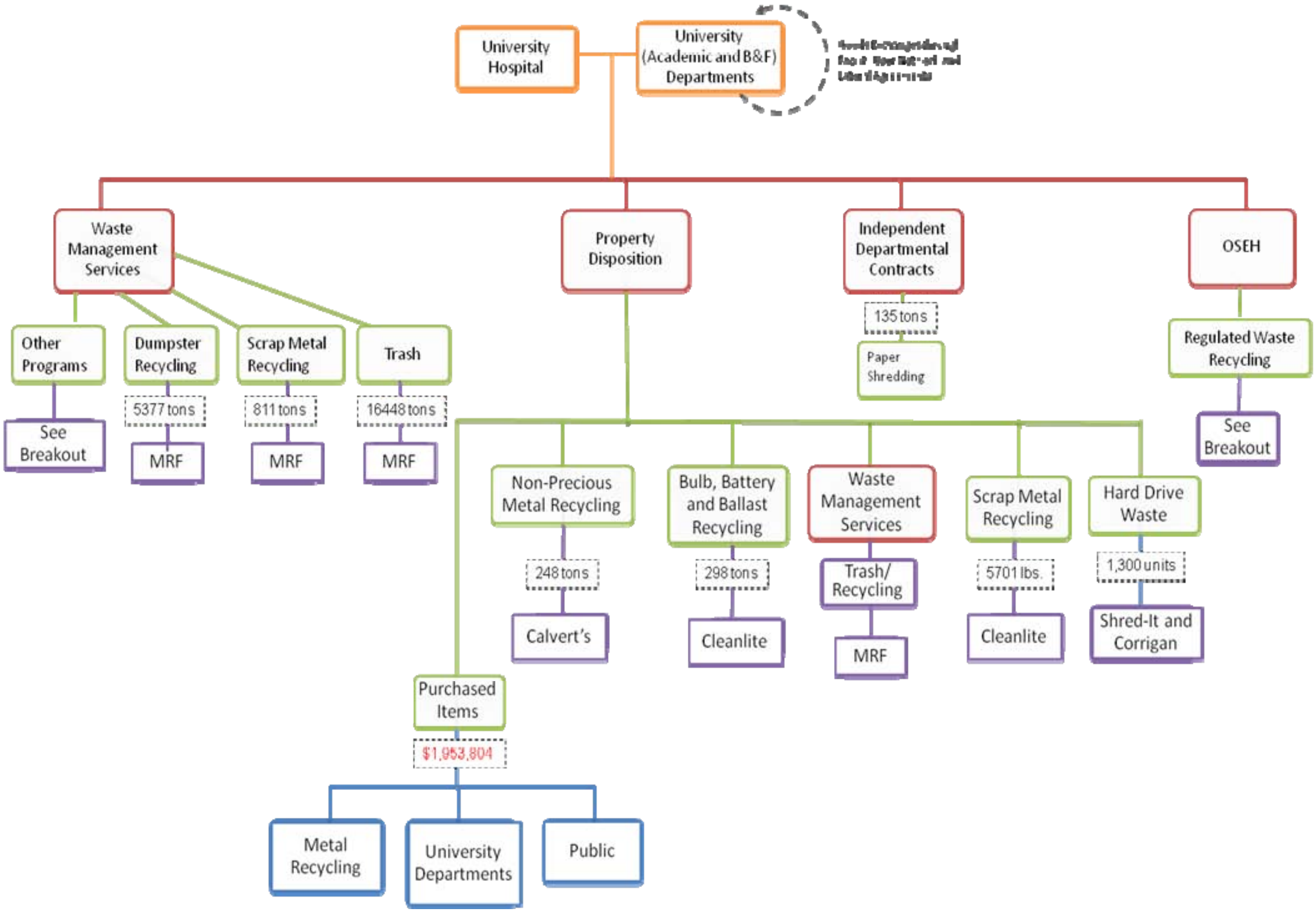
Phase 2 Prioritization Matrix

		Economic Aspects			Environmental Aspects			Social Aspects		
	Economic Aspects: 1 1=$, 5=$$$$$ Environmental & Social Aspects: 1=low positive impact, 5= high positive impact	Capital Costs	Operating Costs	Payback	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
		(1-5 scale)								
Purchasing and Recycling Team Recommendations	Property Disposition									
	1.3.1 Reevaluation of software	1	1	4	1	1	2	1	1	2
	1.3.2 Visibility and sales	1	1	4	1	1	2	1	1	2
	1.3.3 Website improvements	2	2	4	1	1	2	1	2	2
	1.3.4 Seasonal outlets	1	1	4	1	1	2	1	1	2
	1.3.5 Loading dock	2	1	4	1	1	2	1	1	2
	1.3.6 Data tracking	1	1	3	1	1	2	1	1	2
	1.3.7Organizational Review	3	2	5	1	1	2	1	3	5
	Recycling and Landfill									
	2.3.1 Reduce waste by 40% by	1	1	2	3	2	5	1	4	4
	2.3.2 Increase recycling to 55%	1	2	3	3	2	5	1	4	4
	2.3.3 Zero-waste sporting events	1	3	5	1	1	3	1	5	4
	2.3.4 On-campus composting	3	4	3	2	1	2	1	2	4
	2.3.5 Office supply reuse	1	1	1	1	1	1	1	3	1
	2.3.6 Innovative solutions	2	2	2	1	1	2	1	2	2
	Purchasing									
	3.3.1 Taskforce for sustainable	1	2	3	2	2	4	1	2	3
	3.3.2 Environmentally preferable	1	3	3	2	2	4	1	2	3
	3.3.3 Automatic-substitute	2	2	4	2	2	4	1	3	3
	3.3.4 M-marketsite	2	3	4	2	2	4	1	3	3
	3.3.5 Education	2	2	4	2	2	4	1	3	3
	LCA									
	4.3.1 Monitor quantitatively	1	1	5	3	3	3	1	3	5

APPENDIX A (page 1 of 4)

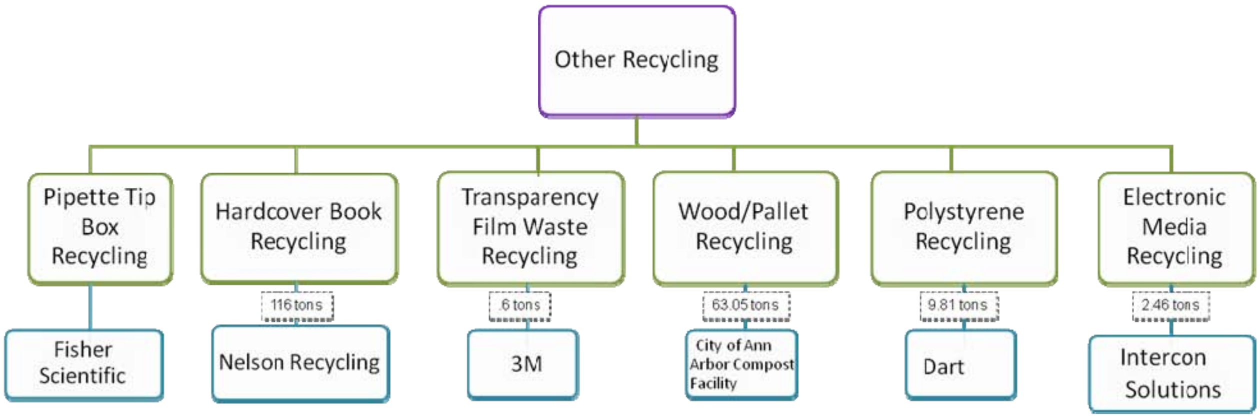


APPENDIX A (page 2 of 4)



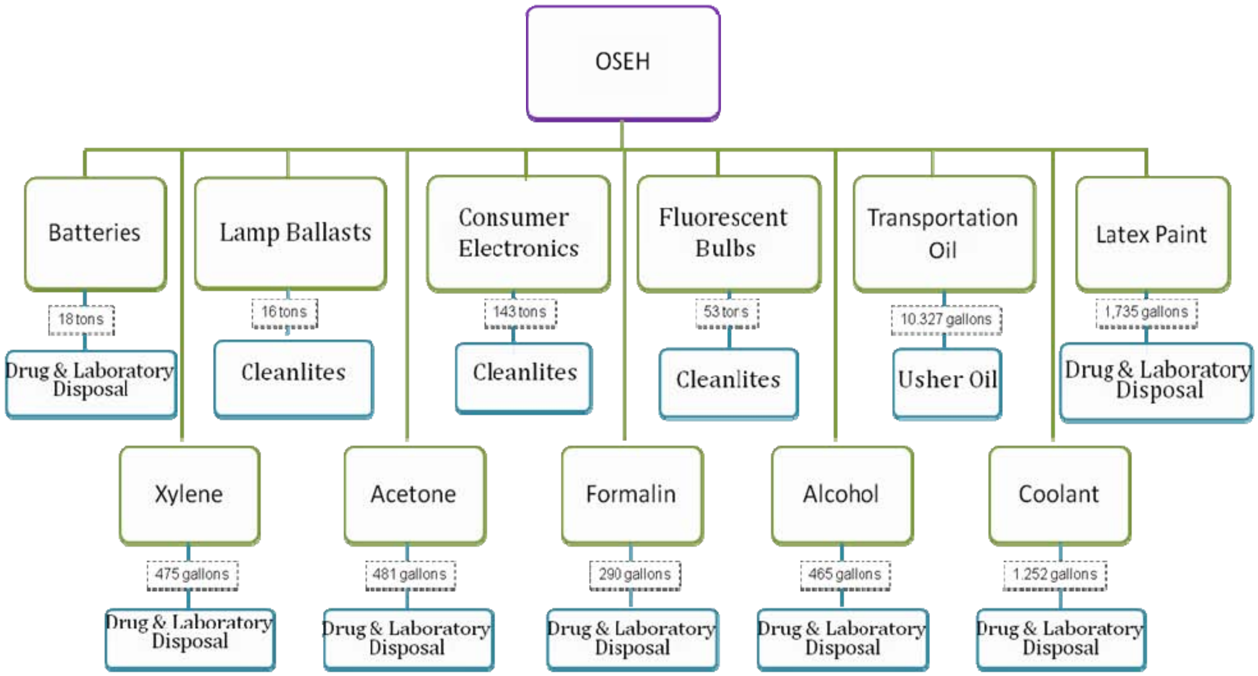
APPENDIX A (page 3 or 4)

BREAKOUT 1: WMS - OTHER RECYCLING



APPENDIX A (page 4 of 4)

BREAKOUT 2: OSEH

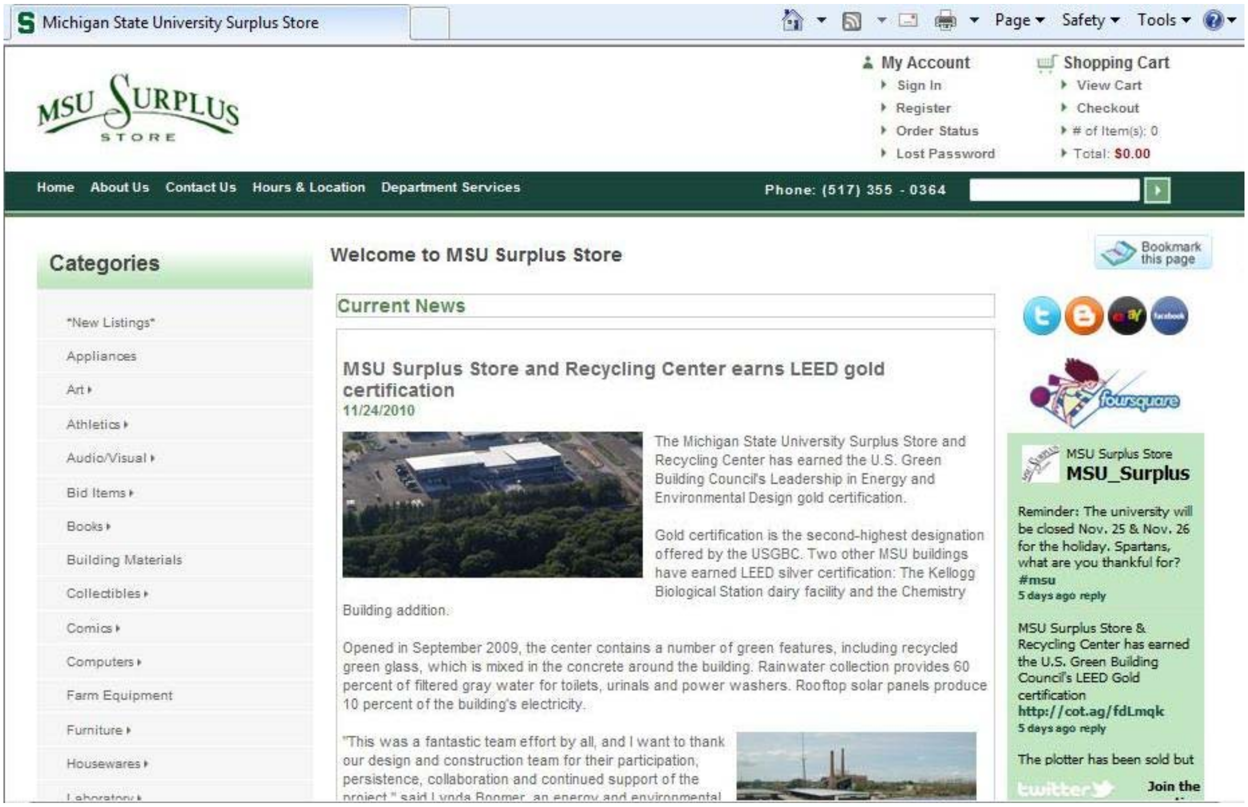


Property Disposition disposes of their own regulated waste, through Calvert's and Cleanlite, however OSEH is financially responsible for this.

APPENDIX B

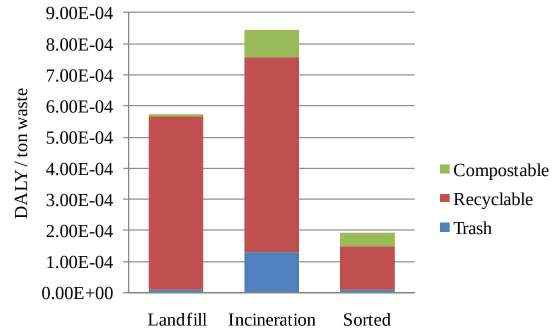
Screenshot of University of Michigan Property Disposition Website, 05 December 2010

APPENDIX C

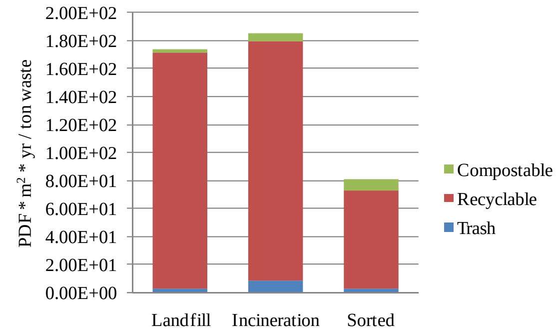


Screenshot of Michigan State University Property Surplus Website, 05 December 2010

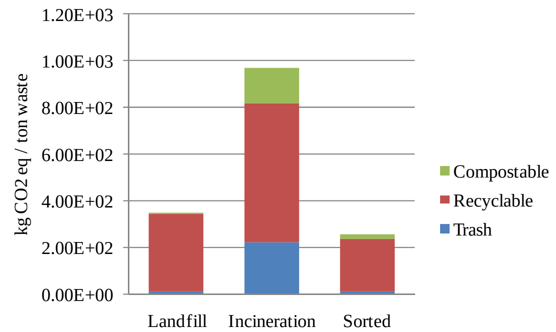
LCA of Zero Waste Sort



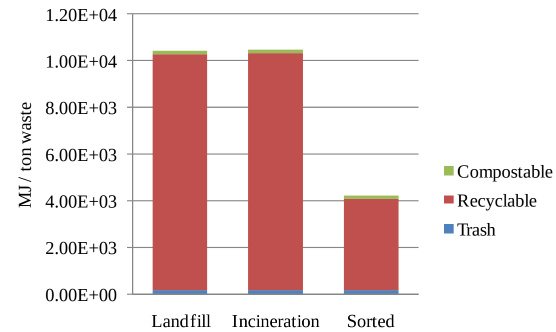
Human health impacts of different types of waste under different treatment scenarios



Ecosystem health impacts of different types of waste under different treatment scenarios



Climate change impacts of different types of waste under different treatment scenarios



Primary resource consumptions of different types of waste under different treatment scenarios

One day's waste from the Michigan Union was sorted by compostable, recyclable, and trash. Data was analyzed using Ecoinvent 2.0 as the Life Cycle Inventory database and IMPACT 2002+ as the Life Cycle Impact Assessment method with human health (in DALY, Disability Adjusted Life Year), ecosystem health (in PDF * m^2 * yr, Potentially disappeared fraction of species * m^2 * yr), climate change (in kg CO_2 eq), and primary resource consumption (in MJ).

Within each treatment scenarios, the results show that the environmental impacts from either trash or compostable are minimal except when incinerated; recyclables are responsible for the majority of the impacts no matter how treated. Across scenarios, sorted waste treated properly will minimize the environmental impacts for all endpoints; incineration will result in the greatest environmental impacts especially in climate change.

APPENDIX E (page 1 of 11)

Purchasing Our Way to a Greener Campus

December 2010

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Appendix B: Eco-Label Matrix

Ecolabel Matrix							
Name	**Reliable**	**Governing Organization**	**Products Covered**	**Certified By**	**Goal**	**Notes**	**Label Website**
Blue Angel	Yes	German Federal Ministry for the Environment	11,500 Products and Services in 90 categories	3rd Party	Promotes the concerns of both environmental protection and consumer protection		www.blauer-engel.de/en
Chlorine Free Products Association	Yes	Chlorine Free Products Association (CFPA)	Recycled content paper and virgin fiber papers	3rd Party	Provides market awareness by providing facts, drawing direct comparisons, and highlight process advantages.		http://www.chlorinefreeproducts.org/
Cradle to Cradle	Yes	McDonough Braungart Design Chemistry (MBDC)	Any	3rd Party	Use of safe materials that can be disassembled and recycled as technical nutrients or composted as biological nutrients.		http://mbdc.com/detail.aspx?linkid=2&sublink=9
Design for the Environment	Yes	Environmental Protection Agency (EPA)	2,000+ chemical-based products	3rd Party	Analyze products at the ingredient level to ensure the product contains only those ingredients that pose the least concern among chemicals in their class.		http://www.epa.gov/dfe/
Eco-Label	Yes	European Commission	Many Product Groups	3rd Party	To encourage businesses to market products and services that are kinder to the environment.		http://ec.europa.eu/environment/ecolabel/
EcoLogo	Yes	Environmental Choice Program of Canada	90+ product certification standards	3rd Party	Performs audit of a full product life-cycle, using a publicly-created standard. Only the top 20% of products in a category qualify for the EcoLogo certification.		http://www.ecologo.org/en/
Energy Star	Yes	EPA and U.S. Department of Energy	Home appliances, to building supplies, to computers and electronics,	3rd Party	Reduce greenhouse gas emissions and other pollutants caused by the inefficient use of energy; and make it easy to identify and purchase products that offer savings without sacrificing performance and comfort.	Only the"new" Energy Star Label coming out January 1, 2011 is considered reliable	http://energystar.gov/
Forest Stewardship Council (FSC)	Yes	Forest Stewardship Council	forest products/paper	3rd Party	Ensures that the forest products used are from responsibly harvested sources	Certifies forests and individual products	www.fsc.org
Green Guard	Yes	Green Guard Environmental Institute	Building materials, furniture, furnishings, cleaning products, electronics	3rd Party	Focuses on indoor air quality, working to control the source of environmental pollutants.	Certifies individual products or entire product lines	www.greenguard.org
Green Label Plus	Yes	Carpet and Rug Institute	Carpets, Rugs, Adhesives	3rd Party	Focuses on indoor quality in terms of the release of organic compounds and other particles into the air		http://www.carpet-rug.org/commercial-customers/green-building-and-the-environment/green-label-plus/

Green Seal	Yes	Green Seal	Janitorial/cleaning, office, household, paper products; paints & coatings, construction materials, food packaging	3rd Party	Develops sustainable standards based on product life-cycle		www.greenseal.org
Green Shield Certified	Yes	Green Shield Certified	Pest Control Items. Non-Chemical Pesticides	3rd Party	Provide an effective service of pest control in an environmentally friendly way		http://www.greenshieldcertified.org/
Rainforest Alliance Certified	Yes	Rainforest Alliance	Agriculture and Forestry	3rd Party	Promotes and guarantees improvements in agriculture and forestry that balance ecological, economical and social considerations		www.rainforest-alliance.org
Sustainable Forestry Initiative	No	Sustainable Forestry Initiative Inc.	Paper/forest products			If buying paper or wood products, buy ones with FSC certification	www.sfiprogram.org

Appendix C: Eco- Label Descriptions

Blue Angel1[6]

Blue Angel was the first eco-label for products and services, initiated by the German Government in 1978. Its purpose is to promote the concerns of both environmental protection and consumer protection. Blue Angel has a clear and reliable identifying symbol with definite information value. The label shows the benefit of the product relating to its 4 protection goals- health, climate, water and resources, and the reason the certification is given. Its criteria is developed by the Federal Environmental Agency and the award is given by an environmental jury made up of diverse representatives.

Chlorine Free Products Association[17]

CFPA's standards minimize the environmental impacts associated with chlorine and chlorine compound use in manufacturing, water purification, old growth timber and increased use of recyclable products. This label identifies products that are designed and manufactured in a Totally Chlorine Free in an environmentally preferable manner. Certification Marks are valid for a 60-month period. Totally Chlorine Free (TCF) is a term reserved for virgin fiber papers. TCF papers do not use pulp produced with chlorine or chlorine containing compounds as bleaching agents. Processed Chlorine Free (PCF) is a term reserved for recycled content papers. All recycled fibers used, as a feedstock must meet EPA, or regional governing authority, guidelines for post consumer content and have not been re-bleached with chlorine containing compounds. If a paper contains any virgin fiber that fiber is Totally Chlorine Free.

Cradle to Cradle1[8]

Cradle-to-cradle is a multi-attribute eco-label that assesses a product's safety to humans and the environment, and is designed for future life cycles by ensuring the use of safe materials that can be disassembled and recycled as technical nutrients or composted as biological nutrients. The materials and manufacturing practices of each product are assessed in five categories: Material Health, Material Reutilization, Renewable Energy Use, Water Stewardship, and Social Responsibility. Based on this assessment, products achieve a silver, gold or platinum level.

Design for the Environment[19]

This label is for any chemical-based product and is governed by the U.S. Environmental Protection Agency. This certification analyzes products at the ingredient level to ensure the product contains only those ingredients that pose the least concern among chemicals in their class, identify negative synergies between product components, uncover "masked chemicals of concern" and hazardous chemicals used in small concentrations. The program uses EPA's chemical expertise and resources to ensure that manufacturers who earn the right to display the Design for the Environment logo on recognized products have invested heavily in research, development and reformulation, to ensure 19 that their ingredients and finished products have met the program's highly protective standards.

EcoLogo[20]

EcoLogo is currently the largest environmental standard and certification mark in North America. EcoLogo is a certification system comparing products to competitors in their category using a rigorous and transparent analysis of the product's complete life cycle.. Only the top 20% of all products in a category based on performance based on EcoLogo's test can qualify. In order to receive the certification, they must undergo a 3rdparty audit of this test. There are currently over 90 different product standards within the EcoLogo certification system.

Eco-Label[21]

Eco-Label Certification is an independent program developed by the European Commission to clearly identify environmentally friendly products. It is awarded on an individual product/service basis and is not determined by any single factor. Product assessments analyze the impact of the product throughout its life-cycle, starting from raw material extraction in the pre-production stage, continuing through distribution and disposal. Eco-Label covers a wide range of products and services with product specific criteria being developed as new products are introduced.

Energy Star[22]

Energy Star is a voluntary government-backed program dedicated to helping individuals protect the environment through superior energy efficiency. Products that earn the Energy Star mark prevent greenhouse gas emissions by meeting strict energy-efficiency guidelines set by the U.S. Environmental Protection Agency. Energy Star has devised 60 different standards that are adapted for regional, local, and national conditions. Recently, Energy Star revised its standards to include third-party evaluation which will be effective starting January 1, 2011.

Forest Stewardship Council[23]

The Forest Stewardship Council (FSC) certification ensures that the materials used for products with this label were harvested in a sustainable manner. Forests with this certification indicate that they are managed in a responsible and sustainable way. The FSC certification is meant for paper products, and its standards address multiple social and environmental issues, such as labor rights, indigenous peoples' rights, maintenance of integrity and ecological function, and reduction of environmental impact.

Green Guard[24]

Green Guard focuses on providing manufacturers and consumers with solutions and resources to provide them with tools to legitimize their sustainability efforts and ensure healthier buildings. This label specifically focuses on indoor air quality and works with manufacturers to certify individual products or entire product lines. Green Guard runs three certification programs- its most popular Indoor Air Quality Certification, Children 20 and Schools Certification, which focuses on products used around children, and Premier Certification, which is a health-based certification and all products are eligible.

Green Label Plus[25]

Independently tests carpeting and adhesives over 14 days for emissions of 15 different chemical compounds in accordance with California's Section 01350 and the Carpet and Rug Institute. It primarily seeks to identify carpets and adhesives with very low levels of VOC (Volatile Organic Compound) emissions. Carpet and adhesives both must undergo an independent and annual test; carpet also requires quarterly tests while 25% of adhesives are randomly selected for semi-annual tests.

Green Seal[26]

Since 1989, Green Seal has been developing sustainable standards based on a product's life-cycle. These standards are created in a clear, objective way with stakeholder involvement. They also take into account all aspects of the product's life cycle. Green

Seal has 31 standards for over 180 products. They abide by guidelines from the Environmental Protection Agency and the Federal Trade Commission.

Green Shield[27]

Green Shield Certified in an independent, non-profit, prevention-based organization for pest control. Through the use of advanced pest management practices and a “non-chemical first” approach to pest control, Green Shield Certified strives to offer non-toxic solutions to pest problems whenever possible. Chemicals that are employed are industry tested by the IPM Institute of North America and results are corroborated by a Technical Advisory Committee of scientists and environmental experts. Pesticides are rarely used, and if so, have undergone scrutiny to reduce, as much as possible, the environmental impacts associated with their use.

Rainforest Alliance[28]

Rainforest Alliance Certified promotes and guarantees improvements that balance ecological, economical and social consideration in agriculture and forestry. Its goal is to protect the environment, wildlife, workers and local communities. Rainforest Alliance Certified follows standards set by the Sustainable Agriculture Network designed to promote tropical conservation and steer commercial agriculture practices in the tropics.

Sustainable Forestry Initiative[29]

The SFI certification is not a reliable eco-label. Their environmental and forest protection standards are very weak. They also allow logging, chemical use, and large-scale clear-cutting practices in endangered and old growth forests. In addition, products that carry the SFI label may not actually be certified due to their new chain of custody rules that do not specifically verify the origins of the fiber and wood. Instead of buying SFI certified products buy products that are Forest Stewardship Council (FSC) Certified.

[16] "The Blue Angel – Eco-Label with Brand Character." *The Blue Angel*. Web. 11 Nov. 2010. <http://www.blauer-engel.de/en/blauer_engel/index.php>.

[17] *Chlorine Free Products Association*. Web. 1 Nov. 2010. <http://www.chlorinefreeproducts.org/>.

[18] "Certification Criteria." *Cradle to Cradle Design*. MBDC. Web. 11 Nov. 2010. <http://mbdc.com/detail.aspx?linkid=2&sublink=9>.

[19] "Design for the Environment." *US Environmental Protection Agency*. Web. 11 Nov. 2010. <http://www.epa.gov/dfe/>.

[20] *Ecologo Program*. Terrachoice. Web. 11 Nov. 2010. <http://www.ecologo.org/en/>.

[21] *EU Ecolabel*. European Environment Commission. Web. 11 Nov. 2010. <http://ec.europa.eu/environment/ecolabel/>

[22] *Energy Star*. US Department of Energy. Web. 11 Nov. 2010. <http://www.energystar.gov/>.

[23] *Forest Stewardship Council*. Web. 11 Nov. 2010. <http://www.fsc.org/>.

[24] *GREENGUARD Environmental Institute*. Web. 11 Nov. 2010. <http://www.greenguard.org/>.

[25] "Green Label/Green Label Plus." *Carpet and Rug Institute*. Web. 11 Nov. 2010. <http://www.carpet-rug.org/commercial-customers/green-building-and-the-environment/green-label-plus/>.

[26] *Green Seal*. Web. 11 Nov. 2010. <http://www.greenseal.org/>.

[27] *Green Shield Certified*. Web. 11 Nov. 2010. <http://www.greenshieldcertified.org/>.

[28] *Rainforest Alliance*. Web. 11 Nov. 2010. <http://www.rainforest-alliance.org/>.

[29] "Overview." *Credible Forest Certification*. Alliance for Credible Forest Certification. Web. 1 Dec. 2010. <http://credibleforestcertification.org/sfi_facts/overview/>.

Appendix D: Green Product Assessment

This green screen is to be used to evaluate products by the University of Michigan's Office of Procurement Services to determine whether an individual product should be considered green. Answer all questions that apply to the product you are evaluating; if the question does not apply,
put N/A in the answer column. Points are awarded only for "yes" answers. At the end, add all of
the points awarded together and divide by the total number of questions answered. Multiply this
by 100% to get a final score in the form of a percentage. A score of 75% or higher will qualify the product for "U of M green product label."

	Question	**Pts Possible**	**Answer**	**Pts Awarded**
1	Did the product come without packaging?	1		
1a	Is all packaging material recyclable?	0.5		
1b	Does the vendor utilize reduced packaging alternatives?	0.5		
1c	Does the vendor agree to accept and reuse packaging material?	0.5		
2	Was the product entirely produced within 300 miles of the purchasing destination?	1		
3	Is it made from 75-100% post-consumer content?	1		
3a	Is it made from 1-50% post-consumer content?	0.5		
3b	Is it made from pre-consumer recycled content?	0.5		
4	Is the product Compostable?	1		
5	Was the product sustainably harvested/extracted?	1		
6	Was the product produced from renewable/sustainable sources?	1		
7	Is the product 100% biodegradable or bio-based?	1		
8	Does the product contain non-toxic alternatives?	1		
9	Is the product Carcinogen-free	1		
10	Is the product CFC (chlorofluorocarbon) free?	1		
11	Is the product durable/reusable?	1		
12	Is the product free of VOC (Volatile Organic Compound) Content?	1		
12 a	Is the content less than .01 threshold limit value for the compound?	0.5		
13	Is the product free of PVCs (Polyvinyl Chloride)?	1		
14	Is the product free of Phthalates or Persistent, Bioaccumulative toxins (PBTs)?	1		

15	Is the product free of Halogenated Organic compounds? (i.e. chlorine, bromine or fluorine)	1		
15 a	If no, is the content less than 1000 ppm?	0.5		

16	Was the product processed without using organohalogen content?	1		
17	Is the product free of toxic heavy metals? (i.e.	1		
	Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, Nickel)			
17a	If no, does the total concentration of these 4 metals fall below 100 ppm?	0.5		
18	Is the product made without pigments, dyes or other unnatural colorants?	1		
19	Is the product in the upper 25 percent of energy efficiency for all similar products, or at least 10 percent more efficient than the minimum level meeting US federal government standards?	1		
20	Is the product in the upper 25 percent of water efficiency for all similar products, or that is at least 10 percent more efficient than the minimum level meeting US federal government standards?	1		
21	Is the supplier Green-e certified?	1		
21a	If no, does the supplier utilize renewable energy sources?	0.5		
22	Has the producer committed to a carbon reduction goal?	1		
22a	Does the producer purchase carbon offsets or renewable energy credits?	1		
23	Is the product transported using alternative fuel?	1		
24	Were no planes used to ship this product?	1		
25	Is it a refurbished product?	1		
26	Is the product refurbish-able	1		
27	Can the product be retrofitted?	1		
28	Can the product be up-cycled?	1		
29	Does the producer address corporate social responsibility in a publicly available statement?	0.5		
29a	Is this statement signed by the Chairman or CEO?	0.5		
29b	Does the producer address fair labor practices and is it Internally developed within the company or adopted as a set of principles from another organization, such as the UN Global Compact?	0.5		
29c	Has the producer earned a social accreditation from either Social Accountability International (SAI) or Social Accountability Accreditation Services (SAAS)?	0.5		

30	Is the product not tested on animals?	1		
Total Points awarded				
Total Questions Answered				
Final Score				

APPENDIX E: Green Purchasing Policy

The University of Michigan is committed to the procurement of environmentally responsible products that have a lesser or reduced negative impact on the environment. This document outlines the requirements that must be met when purchasing for the University. The creation and implementation of this policy demonstrates the University's commitment to environmental stewardship and sustainability.

Reducing overall purchasing is the most sustainable form of green procurement. Therefore, departments should actively strive to find creative ways to reuse and reduce purchasing.

When purchasing is necessary, buyers must purchase products that have minimal negative environmental impacts. All aspects of a product's life-cycle need to be considered when assessing its sustainability, ranging from pre-production raw materials to post-consumer disposal. Additionally, products should contain some, if not all, of the following list of desirable environmental attributes:

- Biodegradable – The product can decompose in the natural environment into raw materials that are not harmful to the ecosystem they are in. This process should take months or years, not centuries.[30]
- Carcinogen-Free – Product shall be free of carcinogens (cancer causing agents). Look at a product's MSDS sheet to check the carcinogenic content.[31]
- Chlorofluorocarbon (CFC)-Free – CFCs are hydrocarbons that contain chlorine and fluorine. They cause ozone depletion in the stratosphere.[32]
- Compostable – Substances are able to break down into organic matter when placed in the proper composting receptacle.
- Durable - Product with a long lifespan that does not deteriorate substantially throughout its life.
- Energy Efficient – Product must be in the upper 25th percentile in energy efficiency of all products of a similar caliber.[23]
- Heavy Metal Free – Product must be free these heavy metals: Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and Nickel.
- Locally Manufactured or Grown – Product must be grown or manufactured within 300 miles of Ann Arbor, MI.
- Lower Embodied Energy – The product required minimal amounts of energy for production.
- Made from Renewable Materials – Materials used to manufacture the product must be renewable (not finite resources that cannot replenish themselves).

- Persistent, Bioaccumulative Toxin (PBT)-Free – These toxins, when in the natural environment, increase in concentration as they move up in the food chains through animals.[23] Products should be free of these toxins.

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- Recyclable – Upon the need for disposal, one hundred percent of the product must have the ability to be recycled.
- Recycled Post-consumer Content – Product must be made of materials that were recycled once the consumer was through with them.
- Reduced Greenhouse Gas Emissions – Greenhouse Gases(GHGs) are gases that trap heat in the earth's atmosphere and absorb infrared radiation. The two main GHGs are carbon dioxide and water vapor. The product's supplier must make an active effort to reduce its GHG emissions and the product must in some way reduce its emissions.[23]
- Reduced Packaging – The product must be delivered with significantly less packaging than its conventional alternative.
- Refurbished – Product that has been restored to its previous condition, instead of being disposed of as waste.
- Reusable – Product that can be reused. Reuse does not require any additional resources (i.e. energy, new materials).
- Third-party green certification – Product contains a certification that is verified by a party independent of the organization that distributes the label.
- Upgradable – Product can be improved without replacing the entire product.
- Volatile Organic Compound (VOC)-free – VOCs are the gases emitted from solids and liquids that include various chemicals that can have negative effects on human health. Products should be free of these.[33]
- Water efficient – Product must be in the upper 25th percentile in water efficiency for all products of a similar caliber.[23]

Products should be evaluated using full-cost accounting as well. It is critical that considerations of the environment, human health, land use, social costs, as well as economic costs are included in the purchasing process. Mainly, all externalities need to be accounted for.

Finally, preference should be extended to local suppliers within a 300 mile radius. Purchasing from local contractors supports local economies and significantly reduces carbon emissions related to the transportation of goods. [26]

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[32] Biology Online. "Dictionary: Chlorofluorocarbons." Biology Online. N.p., n.d. Web. 5 Dec. 2010. <http://www.biology-online.org/dictionary/Chlorofluorocarbons>.

[33] United States Environmental Protection Agency. "An Introduction to Air Indoor Quality (IAQ)." EPA. United States Environmental Protection Agency, n.d. Web. 6 Dec. 2010. <http://www.epa.gov/iaq/voc.html>.

APPENDIX F (page 1 or 5)

The University of Michigan Green Choices Tool

The University of Michigan supports Green Purchasing and encourages University departments to buy products which minimize environmental impact. The Green Choices Tool (GCT) is an excel spreadsheet designed to assist purchasers with making environmentally preferable choices. The GCT rates a product's Green potential by granting points for each environmentally friendly trait the product provides. Point values are determined based on the relevance of the individual trait. For instance, a product made from 100% Post Consumer Recycled (PCR) material is granted 15 points where as a product made from only 30% PCR is given 5 points. The GCT recognizes that purchasers are responsible for providing their department with quality goods at a reasonable price. Therefore Responsible Purchasing Characteristics are also considered. Environmentally preferable (EP) products which come with a higher price tag, are not readily available, or do not meet quality expectations are granted negative points which will count against the total. Once all traits have been identified, the GCT calculates a total score from which, a letter grade is determined.

Final purchasing decisions are the responsibility of the individual departments. The GCT is simply a tool designed to insure that Green Purchasing is included in the decision making process. The GCT can be adapted to individual circumstances. If an individual purchasing agent does not agree with the point system, or believes that additional items should be included, they may see fit to edit the tool.

General Instructions:

In order to determine the Green Grade for a particular item, go to the "Green Choices Tool" worksheet, and place an x in the "Check Box" column for each trait the item possesses. The GCT will calculate each trait's "Green Rating", EP Trait Points, Responsible Purchasing Points, Total Points, and a "Green Grade". The higher the number of points, the greater the grade, and therefore the "Greener" the product. While there is no set grade which defines a "Green" product, most EP products should receive a B+ or greater. The GCT is also a good method to employ when comparing similar products. For example, refer to the 100%PCR_Paper, the 30%PCR_Paper and the 0%PCR_Paper example worksheets.

Environmentally Preferable (EP) Traits

EP Production:

Post Consumer Recycled content: What percentage of the product is made from previously used and recycled material?

Pre-Consumer Waste Recycled: Pre-Consumer recycled material comes from manufacturing waste.

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Produced from renewable/sustainable resources: Renewable resources include vegetable based products such as soy ink, or wood products taken from sustainable forests such as those certified by the Forest Stewardship Council.

Produced using renewable energy sources: Does the manufacturer use renewable energy such as solar, wind, or geothermal to power it's plant's?

Product is operated by renewable energy sources: Does the product contain solar voltaic cells, such as calculators or some lighting systems?

Contains non-toxic alternatives: Some products, such as cleaning supplies are made with non-toxic substitutes.

Energy efficiency claims: Does the vendor claim that product uses less energy to operate than comparable products?

Energy Star Certified: Is the product Certified by the US Energy Star program?
http://www.energystar.gov

Green Seal Certified: Is the product certified by Green Seal?
http://www.greenseal.org/

Other Environmental Certification: Is the product certified by an additional recognized organization?

EP Disposal:

Product is compatible with current UM recycling/reuse efforts: For a complete list of UM recyclables go to:
Waste Management & Recycling, University of Michigan

Product container is compatible with current UM recycling/reuse efforts: For information concerning containers recycling:
Waste Management & Recycling, University of Michigan

Recyclable content but is not compatible with current UM recycling/reuse efforts: Many vendors claim that their products are recyclable. While UM encourages vendors to produce recyclable products, if the facility to recycle is not available the item may very well end up landfilled.

Compostable: Many vendors claim that their products are compostable. While UM encourages composting, current landfill
technology inhibits items from composting once they are added to a landfill. Therefore, the majority of compostible material becomes in essence landfill waste.

Landfill disposal required: Material that cannot be recycled is disposed of in landfills.

Hazardous Waste disposal required: Compounds which meet RCRA or other regulatory definitions for hazardous waste must be disposed of in an environmentally safe manner. This results in increased cost and increased safety risk.

Sustainable Ordering/Shipping:

Product is produced within the state of Michigan: Buying locally produced items supports local economy while reducing shipping cost and energy use.

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Product is produced within the continental United States: Buying locally produced items supports local economy while reducing shipping cost and energy use.

All packaging material is recyclable: For a complete list of UM recyclables go to:
Waste Management & Recycling, University of Michigan

Vendor agrees to accept and reuse packaging material: While vendors will not usually accept used packaging material, there are instances such as with large items and specially shipped items where packaging can be returned.

Vendor minimizes shipping through use of local warehouses: Check your vendor's Web site to find out where items are being shipped from.

Orders placed through electronic format: Is ordering available on line?

Vendor catalogs available electronically or by CD/DVD. Electronic based catalogs reduces paper use.

Miscellaneous

Additional EP traits not accounted for above (Purchaser discretion): Because purchasing is the responsibility of the individual departments, it is encouraged that buyers be as informed as possible concerning the environmental impacts of their purchases. Therefore, the GCT provides a venue whereby individual purchasers can add or subtract points based on personal knowledge. The "Multiplier" can also be edited to reflect the importance of an item at the discretion of the buyer.

EP Traits Total Points: Equal to the sum of the Green Rating points awarded.

Responsible Purchasing Characteristics

Pricing

Often price is quoted as a reason for continuing to purchase traditional "non-green" items. For example, copier paper from virgin wood sources is less expensive than 100% PCR.

Availability

Availability is an important consideration when ordering supplies as well.

Quality

Product quality exceeds "Non Green" alternative

Product quality equals "Non Green" alternative

Product quality is less than "Non Green" alternative

Product quality does not meet purchaser requirements

Responsible Purchasing Total Points: Equal to the sum of the Responsible Purchasing Rating points awarded.

Total Points: Equal to the sum of the Green Rating points and the Responsible Purchasing points.

Green Grade: A letter grade (A meaning most green, E meaning least green) is calculated based on Total Points.

Green Choices Tool (DRAFT)

Environmentally Preferable (EP) Traits	Check box	Multiplier	"Green Rating"
EP Production			
51-100% Post Consumer Recycled		15	0
31-50% Post Consumer Recycled		10	0
11-30% Post Consumer Recycled		5	0
1-10% Post Consumer Recycled		2	0
Pre-Consumer Waste Recycled		1	0
Produced from renewable sustainable resources		5	0
Produced using renewable energy sources		4	0
Product is operated by renewable energy sources		5	0
Contains non-toxic alternatives		4	0
Energy efficiency claims		2	0
Energy Star Certified		10	0
Green Seal Certified		7	0
Other Environmental Certification		5	0
EP Disposal:			
Product is compatible with current UM recycling/reuse efforts		8	0
Product container is compatible with current UM recycling/reuse efforts		4	0
Recyclable content but is not compatible with current UM recycling/reuse efforts		1	0
Combustible		2	0
Landfill disposal required		-2	0
Hazardous Waste disposal required		-5	0
Sustainable Ordering/Shipping:			
Product is produced within the state of Michigan		4	0

Product is produced within the continental United States	☐	2	0
All packaging material is recyclable	☐	5	0

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Vendor agrees to accept and reuse packaging material	☐	5	0
Vendor minimizes shipping through use of local warehouses	☐	2	0
Orders placed through electronic format	☐	4	0
Vendor catalogs available electronically or by CD/DVD	☐	2	0
Miscellaneous			
Additional EP traits not accounted for above (Purchaser discretion)	☐	2	0
EP Traits Total Points			**0**

Responsible Purchasing Characteristics
Pricing

Product is priced less than-10% more than “Non Green” alternatives	☐	4	0
Product is 11-50% more than “Non Green” alternatives	☐	-2	0
Product is priced l51-100% more than “Non Green” alternatives	☐	-4	0
Product is priced >10% more than “Non Green” alternatives	☐	-10	0
Availability			
Product is readily available	☐	2	0
Product requires additional one week delivery time	☐	-2	0
Product requires additional one month or greater delivery time	☐	-5	0
Quality			
Product quality exceeds “Non Green” alternative	☐	5	0
Product quality equals “Non Green” alternative	☐	2	0
Product quality is less than “Non Green” alternative	☐	-2	0
Product quality does not meet purchaser requirements	☐	-10	0
Responsible Purchasing Total Points			**0**
Total Points			**0**
Green Grade			**E**

APPENDIX G

This is a title page only for two Excel Spreadsheets used in the Life Cycle Assessment. They are too large to reproduce as Word documents in this appendix.

The file names are

1) **FY09 pairing with IO data.xls**
2) **FY10 pairing with IO data.xls**

These Excel files have been sent to the Graham Institute separately from the text report. They can also be obtained from Prof. Brian Talbot (btalbot@umich.edu)

APPENDIX H

LCA of Office Supplies Reuse Program

Assuming all office supplies currently stored during one year can be reused, the environmental impacts avoided by reusing and impacts generated by distributing them to individuals are calculated. The detailed categories and amounts of office supplies are provided by Tracy Artley from the Waste Management Services. This information is then coupled with the labeled market prices from Office Max to calculate the costs from replacing these supplies by purchasing new ones. The I/O database and IMPACT 2002+ are then used to estimate the possible environmental impacts that can be avoided by reusing, i.e., instead of purchasing new supplies.

The transportation costs are calculated based on the following assumptions:

- Under the current operation of the Office Supply Reuse Program, individual pickups will be made by passenger cars, 40% of which go to North Campus and 60% go to Central Campus, all supplies will be picked up in 50 trips.
- The program is operated with student groups which will facilitate the distribution of supplies to the community on campus. The student groups will ship supplies in 4 trips using box trucks from the current warehouse, 2 trips to North Campus, 2 trips to Central Campus.
- The decentralized storage of office supplies does not require transportation to reuse the supplies.

Results are summarized in Table A1.

Table A1. Environmental impacts that can be avoided by reusing the office supplies and impacts generated by distributing the office supplies under 3 scenarios

Scenarios	Types	Endpoints			
		Human Health DALY	Ecosystem Health PDF*m2*yr	Climate Change kg CO2 eq	Resources MJ primary energy
Current 50 trips	Office supplies	2.57E-02	1.59E+04	7.00E+03	1.06E+05
	Transportation	4.01E-05	1.50E+01	7.67E+01	1.32E+03
Student groups 4 trips	Office supplies	2.57E-02	1.59E+04	7.00E+03	1.06E+05
	Transportation	8.53E-05	2.16E+01	1.03E+02	1.80E+03
Decentralized 0 trips	Office supplies	2.57E-02	1.59E+04	7.00E+03	1.06E+05
	Transportation	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Major findings of this analysis are:

- Transportation has little environmental impacts compared to the gain from reusing the supplies. The differences are in 2 to 3 magnitudes.
- Taking all items to campus one time for give away may not be the most environmental friendly approach - if all supplies can be taken away less than 67 trips by individuals, the impacts from transportation is higher from the box trucks carrying them to campus 4 times per year.
- However, this analysis is based on the assumption that no matter how the program is operated, all supplies will be reused. It could be entirely true that most of the supplies will not be reused under the current scenario (individual pickups). And based on the first finding, it is really the reuse that matters.

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UNIVERSITY OF MICHIGAN
ARCHITECTURE, ENGINEERING AND CONSTRUCTION

ARCHITECTURE & ENGINEERING
326 East Hoover Avenue, Mail Stop B
Ann Arbor, MI 48109-1002
Phone: 734-764-3414
Fax: 734-936-3334

Memo

Date: December 10, 2010

To: **Brian Talbot**

From: David Stockson
Wade Fields

Subject: North Campus Storage Building
Provide OPC for Constructing Loading Dock
Project # P00004788

In response to your request, Architecture and Engineering has established the above referenced project. The intent of this project is to provide an opinion of probable cost regarding Constructing Loading Dock at North Campus Storage Building.

As you are aware, the exercise to establish the opinion of probable cost is not exhaustive, and it is based primarily on a review of existing documents and knowledge of the site and building infrastructure. The opinion of probable cost has been prepared on the basis of A&E experience and qualifications, and it represents the Estimating Team's judgment as professionals familiar with industry and U-M standards. However, in that A&E has no control over costs of labor, materials, equipment or construction methods, no guarantee can be provided that the actual construction cost will not vary from the opinion of probable cost.

Based on our analysis, the attached reflects the project scope and anticipated project costs associated with addressing the request. The following summarizes the scope of work considered in this opinion:

West Center Overhead Door Room 130
This project will install a new truck dock in the existing loading and unloading space.
At the existing overhead door on the west side of the building in the center of room 130 the existing exterior concrete and asphalt paving will be removed. The dirt/earth will be excavated to provide a new truck loading dock and the existing building footing and foundation wall be pinned/shored in place. New concrete footings, concrete retaining walls, concrete ramp, concrete curbs, asphalt paving, truck bumpers, guardrails, and storm drain

will be installed. This new work will construct a new loading dock for 24 foot box trucks and smaller. The existing parking lot will be modified as need to provide the required turning radius of the trucks. Although our budget cap sheet indicates a

cost of $210,000, we expect the work to fall in the range between $175,000 and $250,000 depending on the market conditions, escalation, and other considerations that will be better understood after the due diligence of design development has occurred.

Note that this project will require approval of the Exterior Elements Design Review committee before it can proceed and to verify it is acceptable.

Opinion of Probable Project cost: $175,000 - $250,000

Note: The attached opinion of probable cost is intended for preliminary budget purposes only.
If a more refined cost figure is required, please request that we reopen the project for schematic design or construction documents.

As this concludes the project to estimate the probable cost for the North Campus Storage Building Construction Loading Dock, this project has been closed and filed for future use in the event that this project is prioritized and funded by the authorized funding source. If this project is approved, please contact me and we will open a project, prepare appropriate project documents for client-contact and funding-approval signatures, and assign a team to follow-up with you on the new project.

Also, please let me know of you have any other questions.

Cc: Wade Fields, Steve Sinelli, Mary Ellen Lyon, Sharmesh Joshi, File

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UNIVERSITY OF MICHIGAN
ARCHITECTURE, ENGINEERING AND CONSTRUCTION

Building: 1000430 - North Campus Storage Building
AEC Project #: P00004788
Project Name: Provide OPC for Constructing Loading Dock
PEXT #: P00004788

Updated By: Wade Fields | Date Updated: 12/10/2010 | Version: OPC 12-10-10

Created By: Wade Fields | Date Created: 12/07/2010 | Program:

BudgetLine	Category Total	Sub Total	Sub Budget Amount	Detail
Construction Cost	**145,000**			
Bidpack 01 Construction		145,000		
Base Bid			145,000	
General Conditions				10,000
Architectural Trades				15,000
Mechanical Trades				120,000
Related Construction Cost	**5,000**			
City/Municipal Charges		0		
Landscaping		5,000		
Contingencies	**29,896**			
Construction Contingency		21,750		
User Contingency		7,250		
Rounding Contingency		896		
Subtotal Construction & Contingencies		**179,896**		
Professional Fees	**20,944**			
External A/E Design		16,704		
Basic Fee			16,704	
Internal Design		0		
Consultants		1,450		
Testing Consultant			1,450	
Inspections		2,790		
Internal Inspection			1,790	
Soil & Erosion Control			1,000	
Interior Design		0		
Commissioning		0		
State of Michigan		0		
Printing/Drawing Reproduction		0		
Architecture Engineering & Construction	**7,160**			
AEC Project Management		7,160		
Telecommunications	**0**			
Other Orders	**2,000**			
Other Orders		2,000		
Furnishings and Equipment	**0**			
Moving	**0**			
AEC Managed Total		**210,000**		
Unfunded Contingency	**0**			
User Managed Items	**0**			
Non-AEC Managed Total		**0**		
Budget Total	**210,000**			

Budget Notes:

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UNIVERSITY OF MICHIGAN
ARCHITECTURE, ENGINEERING AND CONSTRUCTION

Budget

Building: 1000430 - North Campus Storage Building
Project Name: Provide OPC for Constructing Loading Dock

AEC Project #: P00004788
PEXT #: P00004788

Updated By:	Wade Fields	Date Updated:	12/10/2010	Version:	OPC 12-10-10
Created By:	Wade Fields	Date Created:	12/07/2010	Program:	

Signed: ______________________________
David Stockson
Manager, Architectural Services
Architecture, Engineering and Construction

Be aware that any opinion of probable cost provided in association with this effort has been prepared on the basis of A&E experience and qualifications, and it represents the project team's judgment as professionals familiar with industry and U-M standards. However, in that A&E has no control over costs of labor, materials, equipment or construction methods, no guarantee can be provided that the actual construction cost will not vary from that opinion of probable cost.

APPENDIX J

Partial Log for Purchasing and Recycling Team Meetings

Property Disposition
12 October 2010: Amy Braun/Katie Dennis: Introduction to sub-team, idea generation, review of Phase I report
13 October 2010: Amy Braun/Katie Dennis/Brian Talbot/Steve Sinelli/MaryEllen Lyon: : First meeting with PD, brief tour of facility, review of Phase I recommendations
20 October 2010: Amy Braun/Brian Talbot/Steve Sinelli/MaryEllen Lyon at PD
26 October 2010: Brian Talbot/Steve Sinelli at PD review of operations
27 October 2010 Brian Talbot/Ken Keeler/Kathleen Thompson at ISR
10 November 2010: Katie Dennis/Steve Sinelli/Mary Ellen/Brian Talbot: Review of POS and warehouse procedures and short-codes, discussion of past advertising campaigns
17 November 2010: Amy Braun/Brian Talbot: Process flow review, discussion of progress and topics yet to be addressed
22 November 2010: Amy Braun/Dingsheng Li/Brian Talbot/Mary Ellen: Trip to MSU Property Surplus
30 November 2010: Amy Braun/Katie Dennis: Outline review and editing, process flow review
8 December 2010: Amy Braun/Katie Dennis: Discussion of draft generation
6 December 2010: Brian Talbot/Wade Fields Architecture, Engineering
14 December 2010: Amy Braun/Katie Dennis: Draft compilation and editing

Waste Diversion/Recycling
18 October 2010: Mary Sell/Katie Thudium/Rachana Patel/Brian Talbot: Meeting with Tracy Artley
19 October 2010: Mary Sell/Dingsheng Li/Brian Talbot: Recycling Plant Tour
26 October 2010: Mary Sell/Katie Thudium/Rachana Patel: Sub-team Meeting
28 October 2010: Mary Sell/Katie Thudium/Rachana Patel: Sub-team Meeting
4 November 2010: Mary Sell/Katie Thudium/Rachana Patel/Brian Talbot: Meeting with Tracy Artley
5 November 2010: Mary Sell/Katie Thudium: Food Team Joint Meeting
11 November 2010: Mary Sell/Katie Thudium/Rachana Patel: Sub-team Meeting
12 November 2010: Mary Sell: Zero Waste Student Group Meeting
16 November 2010: Mary Sell/Katie Thudium/Dingsheng Li/Brian Talbot: Zero Waste Sort
16 November 2010: Mary Sell/Brian Talbot: Recyclebank Pilot Meeting
19 November 2010: Mary Sell/Katie Thudium/Rachana Patel: Sub-team Meeting, determining draft objectives
30 November 2010: Mary Sell/Katie Thudium: SSI Roundtable
2 December 2010: Mary Sell/Katie Thudium/Ken Keeler/Brian Talbot: OSEH Meeting and Tour
2 December 2010: Mary Sell/Katie Thudium: Draft sub-team report
2 December 2010: Mary Sell/Katie Thudium/Rachana Patel: Zero Waste Training
5 December 2010: Katie Thudium/Amy Braun/Rachana Patel: Zero Waste Basketball Event
6 December 2010: Brian Talbot/MaryEllen Lyon/Ken Keeler/Tracy Artley at Kipke Drive
14 December 2010: Katie Thudium/Ryan (add last name): Zero Waste Meeting, Contributions to report
15 December 2010: Mary Sell/Katie Thudium: Meeting to discuss final draft edits

Purchasing
30 September 2010: Kate Harris/Bonny Webber: Background information and ideas
6 October 2010: Kate Harris/Katie Dennis: Sub-team meeting
22 October 2010: Kate Harris/Bonny Webber/ Ken Keeler/Brian Talbot
6 November 2010: Kate Harris/Katie Dennis/Ashish Vatsal
9 Novermber 2010: Kate Harris/Katie Dennis/Ashish Vatsal/Dingsheng Li
10 Novermber 2010: Kate Harris/Brian Talbot
16 November 2010: Kate Harris/Katie Dennis/Ashish Vatsal/ Ken Keeler
23 November 2010: Kate Harris/ Katie Dennis,/ Ashish Vatsal/ Ken Keeler
24 November 2010: Kate Harris/ Rachana Patel/ Dingsheng Li/ Brian Talbot/ Merrill Mullis

2 December 2010: Kate Harris/Katie Dennis
3 December 2010: Kate Harris/ Ken Keeler/ Merrill Mullis
8 December 2010: Kate Harris/ ENV391 Purchasing group
9 December 2010: Kate Harris/Ken Keeler/ OSEH administrative staff

LCA
26 October 2010: Dingsheng Li/Brian Talbot/Mary Sell/Ken Keeler/Gene Kim from Procurement Services

APPENDIX K (page 1 of 2)

Comment/Idea Response Log

1) Campus Sustainability Integrated Assessment - Comment and Idea Submission
Proposal Title: Are cost-benefits of purchasing decisions considered? Year: 2010
Submitted By: Ms Jennifer Read Submitted On: 12/6/2010
Organization: Michigan Sea Grant Proposal ID: 837
Department: Accepted?
Topics: Purchasing & Recycling Funded?
Description: Just had an interesting discussion w/ the building maintenance person changing out my lightbulbs â €“ she
noted that they now need to use the cheaper, but less long-lasting Phillips bulbs (due to supply
arrangements through purchasing) rather than the more expensive but longer-lasting Sylvania bulbs.
Which made me wonder: Is the campus sustainability IA looking at purchasing decisions to see if they are
full-cost accounting and take in factors in their cost-benefit decision of not only the cheaper and more
frequent (therefore higher labor cost per unit) but also more frequent also means more units for disposal
per time period and therefore the cost passed to the community (however defined) as a result?

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2) Campus Sustainability Integrated Assessment - Comment and Idea Submission
Proposal Title: plastic bag tax Year: 2010
Submitted By: Ms Leah Goldmann Submitted On: 10/13/2010
Organization: N/A Proposal ID: 803
Department: Accepted?
Topics: Purchasing & Recycling Funded?
Description: I feel as though it's overdue for AA to have a tax on plastic bags. Ideally, I think they should be banned

from campus, but i figure a tax would help moderate the change. I'm completely unsure as to how to go
about the process but a friend of mine also interested is willing to use her LSA student government
leverage into starting a gradual process. I figure we could start with University owned stores and hopefully
expand to local businesses.

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APPENDIX K (page 2 of 2)

3) Campus Sustainability Integrated Assessment - Comment and Idea Submission
Proposal Title: Single Stream recycling Year: 2010
Submitted By: Dr Patton Doyle Submitted On: 9/14/2010
Organization: None Proposal ID: 724
Department: Accepted?
Topics: Buildings; Culture; Purchasing & Recycling Funded?
Description: Although the University as begun to implement single stream recycling (most notably in the dorms), most
buildings still have mislabeled bins. In addition, all recycling stations lack information about what items are
recyclable. With a very minor investment, Michigan could drastically increase the amount of of material
recycled by simply relabeling bins and posting uniform recycling signs at all its recycling stations. By making
recycling easy, uniform, and straight forward, students and faculty will be much more inclined to recycle.

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Appendix E. VII. : Phase 2 Culture Team Report

Campus Sustainability Integrated Assessment: Culture Team Phase 2 Report

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EXECUTIVE SUMMARY

Background

During Phase 1 of the Campus Integrated Assessment (IA), the Culture Team's charge was to develop a set of recommendations aimed at promoting a "culture of sustainability" at U-M. Culture of sustainability was defined as one in which members of the university community were aware of environmental issues, committed to a lifestyle of sustainable practices, and acted or behaved in sustainable ways. The proposed recommendations addressed educating/training on campus, facilitating active engagement in U-M's Sustainability Initiative, and assessing and monitoring various sustainability initiatives and U-M's progress in moving toward a culture of sustainability. For Phase 2, the Culture Team focused on the latter. That is, it has developed a set of cultural metrics and suggested alternative approaches to collecting them so as to track U-M's progress. During Phase 1 it was revealed that programs aimed at collecting and monitoring cultural metrics or indicators over time are unprecedented in institutions of higher education. By complementing current sustainability initiatives with a cultural indicators program, U-M would become a global leader in sustainability.

Key Findings and Recommendations

Two types of cultural indicators were identified: individual and generic or aggregate. Individual indicators reflect what members of the university community know about sustainability and related environmental issues (awareness); the degree to which they are committed to dealing with sustainability issues and the extent to which they are collectively engaged in environmental activities; and individual environmental behaviors. Members of the university community include students, faculty, staff and alumni. In order to systematically measure individual indicators and track them over time, periodic surveys are proposed for each of these groups. Examples of survey-based indicators include: knowledge of climate change and resource depletion; awareness of U-M's Sustainability Initiative; use of different types of motorized vehicles (individual car, van pool, AATA, etc.) and other means of traveling (walking, bicycling) to and from campus; participation in environmental organizations on and off campus; use of bottled water; and turning off lights when leaving a room.

Generic or aggregate indicators reach across all members of the university community. These non-survey-based indicators are measured by observing phenomena or compiling and organizing existing information covering aspects of campus life. Examples of generic indicators include: number of students involved in sustainability organizations on campus; proportion of U-M's food that is locally grown or processed; number of parking permits issued; number of sustainability stories in major campus publications (i.e. Michigan Daily and University Record) and the proportion of bicycle racks occupied during different seasons.

Several recommendations are offered. First, efforts to collect and report environmental indicators should be expanded to include indicators identified as generic cultural indicators. Collection of these indicators annually will be relatively inexpensive and easy to measure. Second, it is recommended that a program of cultural indicators covering students begin with the implementation of Plan F which involves a baseline survey of both undergraduate and graduate students and subsequent follow up surveys of a sub-sample of students from each undergraduate cohort. Third, it is recommended that cultural indicators covering the faculty and staff be collected using Plan B. That is, annual surveys of a sample of faculty and staff members should be conducted so as to measure changes in their levels of awareness, degree of commitment, and their pro-environment behaviors. Finally, it is recommended no further action on collecting indicators from alumni until the current marketing study is completed and university officials decide how this important part of the university community should become engaged in UM's sustainability efforts.

Next Steps

Assuming the above recommendations are accepted by the IA Steering Committee, detailed planning for launching the program of cultural indicators should begin. First, a committee should be formed to plan the collection of the generic indicators. Another committee should be established to plan for the surveys of students and faculty staff. Finally, OCS and the Graham Sustainability Institute should initiate discussions with the Director of Marketing in the Office of the Vice-President for Communications, the Alumni Association, and U-M's Development Office concerning the collection of cultural indicators covering alumni.

INTRODUCTION

During Phase 1 of the Campus Integrated Assessment (IA), the Culture Team's charge was to develop a set of recommendations aimed at promoting a "culture of sustainability" on the University of Michigan (U-M) campus. A *culture of sustainability* is one where members of the university community are:

- Aware of environmental issues and the consequences of not behaving in an environmentally sustainable manner,
- Committed to a life-long life-style of sustainable practices and serving as role models for peer and future generations, and
- Acting or behaving in sustainable ways while on and off campus.

Our Phase 1 recommendations were designed to enhance awareness and promote environmentally responsible behaviors among students, faculty, staff and U-M administrators. Furthermore, a number of recommendations were intended to measure and demonstrate how well the university is doing in achieving the goal of establishing a culture of sustainability on campus[1]. Recommendations proffered were intended to fulfill three purposes: *engagement*, *educating/training*, and *assessment/monitoring* sustainability initiatives.[2]

Two of the five prioritized recommendations dealing with *assessment/monitoring* were identified by the IA Integration Team and Steering IA Steering Committee as important and were combined to define tasks for the Culture Team during Phase 2. These dealt with establishing a set of cultural metrics indicating the University's progress in moving toward a culture of sustainability (Recommendation 4) and launching a program of research aimed at learning about the thoughts and activities of members of the university community vis-à-vis sustainability to inform the Office of Campus Sustainability (OCS) and other U-M officials in their deliberations (Recommendation 5). The specific tasks identified by the Integration Team and Steering Committee were to:

1. Develop a comprehensive set of cultural metrics to assess sustainability awareness and behavior among U-M students, faculty, and staff;
2. Develop a detailed action plan outlining resource requirements and responsibilities for collecting, interpreting and reporting these metrics.

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[1] The recommendations were based on an examination of (1) relevant research from environmental psychology and consumer behavior, (2) sustainability initiatives on other campuses, (3) suggestions/comments gleaned from the IA CTools site, town hall meetings, and meetings with U-M officials, and (4) current practices at the U-M.

[2] See Phase 1 Report of the IA Culture Team (Marans, R., Levy, B., Haven, C., Bennett, J., Bush, K., Doman, C., Holdstein, B., Janiski, J., & Smith, R. *Campus Sustainability Integrated Assessment: Culture Team Phase 1 Report*. Ann Arbor, MI: Graham Sustainability Institute, University of Michigan, May 2010. Available from: http://www.graham.umich.edu/pdf/culture-phase1.pdf.

3. Launch a pilot study to assess current perceptions of campus sustainability[3].

There are many reasons for focusing on cultural metrics or indicators. First, if U-M wants to create a culture of sustainability on campus, it is important to assess our progress as we move toward this laudable goal. Tracking cultural indicators over time (annually or bi-annually) is a way of assessing that progress. Second, an analysis of changes in cultural indicators from year to year can be helpful in informing policies regarding specific campus sustainability initiatives (i.e. Planet Blue) or in modifying or creating new educational/training and engagement programs. Third, collecting cultural indicators over time provides a useful complement to the "hard" indicators currently presented in U-M's annual Environmental Report prepared by OCS. Having both hard indicators and cultural indicators (i.e. levels of awareness, degrees of engagement, behaviors, etc.) provides an opportunity to assess the degree to which changes in people's actions and thoughts are associated with changes in energy consumption, recycling, water use, course offerings, extracurricular programs, and other developments on campus. Fourth, the presentation of cultural indicators would be a unique contribution to sustainability in institutions of higher education.

From our Phase 1 assessment of sustainability activities on other campuses, we were unable to find schools that systematically monitored or reported sustainability-related behaviors of their students, faculty, and staff. The development and publicizing of a set of cultural indicators at the U-M would enhance our image and reputation as "leaders and best" and would likely improve U-M's ranking among Green schools[4]. Finally, publicizing changes in our cultural indicators over time (along with our hard indicators) could be effective in attracting interest and demonstrating the importance of U-M's Sustainability Initiative to our alumni and prospective students, faculty, and staff.

APPROACH

The work of the Culture Team was organized in three phases. A *Background and Conceptual Phase* involved readings, a review of the IA Phase 1 report, the 2007 ISR pilot study and OCS's metrics, liaison meetings with other IA teams, and, most important, brainstorming sessions on indicators that UM might adopt. Our initial search for literature covering cultural or social indicators in institutions of higher education confirmed what was determined in Phase 1:Cultural indicators or any metric documenting people's behavior are absent from sustainability programs at other schools. Subsequently, we examined literature on sustainability education in general to determine if programs had been evaluated and if so, what measures were used in the evaluations , (e.g., Shepherd, 2008; Segalas, Ferrer-Ballas, & Mulder[5]). Surprisingly, there was little information transferable to our project.

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[3] Early in the Phase 2 process, it was recognized that the time constraints of Tasks 1 & 2 would preclude the launching of a pilot study. Consequently, the Culture Team's efforts focused on the first two tasks recognizing that an assessment of perceptions of campus sustainability could be carried out as part of surveys proposed in the action plans.

[4] In fall 2010, the Sierra Club publication ranked U-M 47th among institutions of higher education in terms of their sustainability activities. (Sierra, Cool Schools: The Top 100. September/October 2010. Available from: http://www.sierraclub.org/sierra/201009/coolschools/top100.aspx.)

[5] Shephard, Kerry. Higher Education for Sustainability: Seeking Affective Learning Outcomes. International Journal of Sustainability in Higher Education 2008, v9n1: 87-98; Segalas, J. & D. Ferrer-Balas & K.F. Mulder. 2008. Conceptual

The social indicator movement that began in the 1970's was also discussed (Parke & Seidman,, 1978; Campbell, Converse, and Rodgers, 1976) and several social indicator reports were reviewed (Klutznick & Slater, 1980; Nissel, 1971). It was learned that two type of indicators were used but rarely simultaneously; one covering "hard" or objective measures (i. e. birth rates, crime statistics, school attendance records, etc.) and the other covering subjective and behavioral information gleaned from individuals through social surveys (i.e. life satisfaction, ratings of life domains, use of public transportation, etc.).

We also examined sustainability metrics prepared by organizations such as Sustainable Seattle, Ann Arbor Environmental Indicators, The Princeton Review's Green Ratings, Sierra Club's Cool Cities, and B-Sustainable. This background work informed our brainstorming sessions where all possible cultural indicators that might be used at U-M were identified and prioritized.

The *Developmental Phase* of our work considered members of the university community from whom measures would be obtained, how they might be reached, and with what frequency.

Finally, the *Proposal Phase* focused on alternative implementation strategies for measuring the indicators and is discussed in detail later in this report.

Types of Cultural Indicators

Two categories of cultural indicators were identified; one covers individual metrics or indicators that would be derived from surveys while the other indicators are generic in nature or aggregate metrics that are non-survey based[6]. The individual or survey-based metrics are those dealing with:

- People's levels of *awareness* and extent of *knowledge* about sustainability issues and procedures for dealing with them

- People's degree of *commitment* to dealing with sustainability issues and the extent of their collective *engagement* in environmental activities

- People's individual *behaviors* with respect to sustainability issues.

Brainstorming

When considering possible indicators, we found it helpful to not only think about general sustainability indicators but also indicators associated with themes addressed by other IA teams- Transportation; Buildings; Food; Purchasing and Recycling; and Land and Water. Furthermore, we identified a number of topics that were worthy of tracking over time but were not appropriate as cultural indicators. For instance, we posed questions dealing with perceived barriers to environmentally appropriate behaviors, the rating of peers on their commitment to sustainability, the

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Maps: Measuring Learning Processes of Engineering Students Concerning Sustainable Development. European Journal of Engineering Education 2008, v33n3: 297-306.
[6] Non-survey based metrics could be compiled from data available within or outside the university or though other data gathering techniques such as observations or content analysis of existing documents.

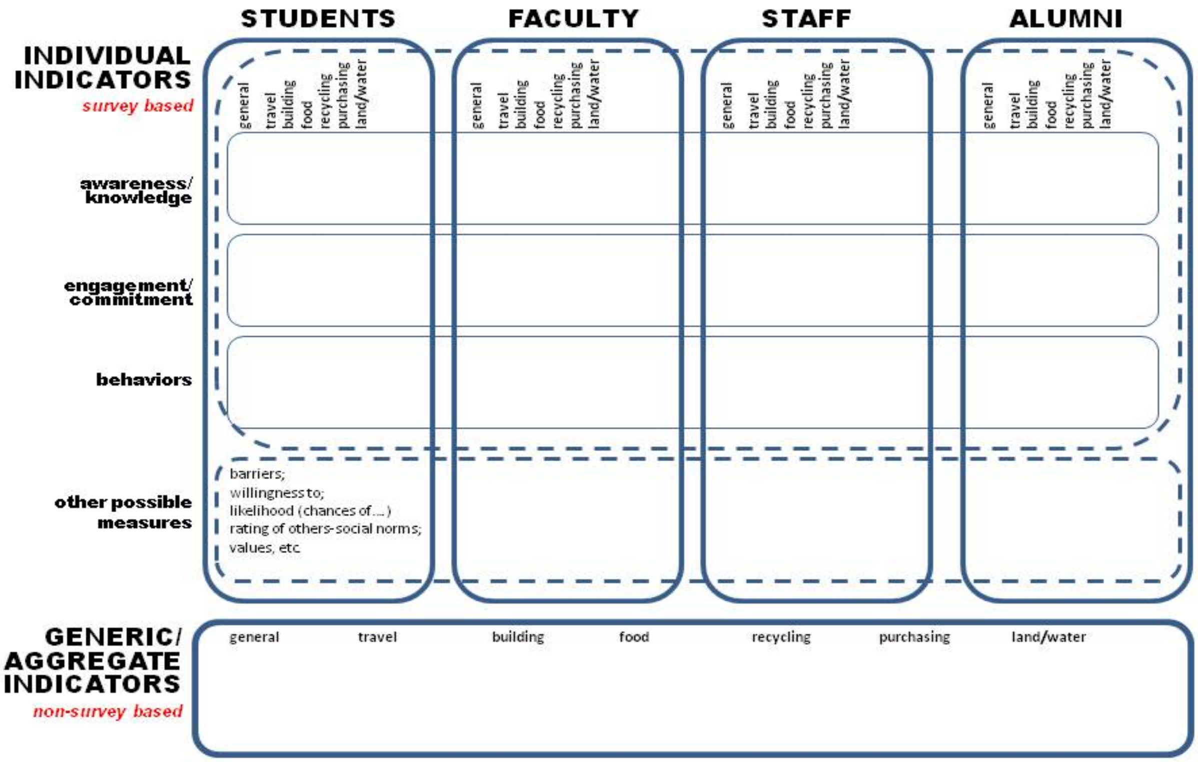
willingness of members of the university community to act in an environmentally responsible manner, and values. We also recognized that many indicators were not applicable to all populations representing the University community while others may have greater salience for one population than for another. Accordingly, we identified four populations that make up the university community--students, faculty, staff, and alumni[7].

Operational Framework

Figure 1 shows the operational framework that was used for organizing our indicators by both indicator type and target population. The framework also guided the development of our recommendations during the proposal phase of our work. That is, within the survey-based individual indicators for each population, there would be indicators that could tap awareness/knowledge, engagement/commitment, and behaviors. Since surveys offer an opportunity to collect other kinds of information besides cultural metric data, the figure shows that other possible topics could be measured as part of a questionnaire (i.e. barriers, willingness to…ratings of others, etc). Finally, the figure shows that the generic/aggregate indicators are not applicable to any single population but can reach across all members of the university community.

[7] Although the Steering Committee did not include the development of indicators for alumni in their assignment, the Culture Team believes that this population is a critical part of the U-M community. Collecting indicators covering alumni will become increasingly important as current and future students graduate. Tracking alumni indicators over time will be a way of demonstrating the impact of U-M Sustainability Initiative. That is, if we want to demonstrate that the alumni surveyed in say, 2020 are more knowledgeable and more committed to environmentally sustainable practices that the alumni queried during the early years of the cultural metric program, surveys of this population are critical.

Figure 1
Cultural Indicator Operational Framework



Cultural Indicators

Our brainstorming resulted in a list of over 60 possible cultural indicators that U-M could use to monitor its progress in moving toward a culture of sustainability. Since the team considered every suggested indicator, the challenge was to prioritize the list in terms of relative importance. Table 1 presents a list of the prioritized metrics determined by Culture Team members.[8]

It is important to note that many of these indicators reflect concepts rather than precise measures and will require further development. That is, individual indicators are likely to consist of multiple-questions asked as part of a survey. For example, assessing people's understanding of climate change and resource depletion will require several questions, the responses of which could be combined into a single indicator measuring one dimension of sustainability awareness. Similarly, multiple questions would be needed to determine whether or not and how often members of the campus community use different modes of transportation (AATA, bike, walk, etc.) to travel to and from campus. These could be treated as individual indicators or combined into a metric that reflects sustainable travel behavior. We recognize that the priority rankings shown in the table do not preclude the addition of new cultural indicators deemed important by others involved in the IA process.

[8] Each team member independently rated each suggested indicator as either "high", "medium", or "low" priority. Table 1 shows only those indicators that received 4 or more "high" priority scores. Other suggested indicators receiving a fewer than 4 high priority rankings are shown in Appendix Table 1.

INDIVIDUAL	Team Score	Type	Team	Themes	Target Population
Knowledge of climate change, resource depletion, etc.	9	knowledge	general	community awareness	students, faculty, staff
Involvement in environmental organizations (on-campus/off-campus)	9	behavior	general	community awareness	students, faculty, staff
Frequency of alternate travel modes—(e.g. walking, biking, AATA, Nite Owl)	9	behavior	travel	human health	students, faculty, staff
Discussions of environmental issues in class	7	behavior	general	community awareness	students, faculty
Knowledge of what can be recycled on campus	7	knowledge	recycling	ecosystem health	students, faculty, staff
Importance of--conserving energy, reducing consumption, organic food, etc.	6	commitment	general	Energy	students, faculty, staff
Use of reusable bags	6	behavior	recycling	ecosystem health	students, faculty, staff
Car ownership and use	6	behavior	travel	human health, ecosystem health	students
Trade-offs -- priority of environment/sustainability compared to other local, world issues	5	commitment	general	ecosystem health	students, faculty, staff
Use of campus & community green spaces—Arboretum, Botanical Gardens, Gallup Park, Hudson Mills, etc.	5	behavior	land/water	human health, community awaren3ss	students
Participation in EarthFest	4	behavior	general	community awareness	students, faculty, staff
Awareness of public transportation options	4	knowledge	travel	community awareness	students
Awareness of impacts of drinking bottled water	4	knowledge	recycling	community awareness	students, faculty, staff
Bike ownership & use during warm weather & cold weather months	4	behavior	travel	human health	students, faculty
Unplug appliances when leaving office/home	4	behavior	purchasing	community awareness	students, faculty, staff
Drink bottled water; # bottles/week	4	behavior	Food	ecosystem health	students, faculty, staff
Printing habits (e.g. 2-sided printing)	4	behavior	purchasing	materials footprint	students, faculty, staff
Eco-friendly alternatives for cleaning products and grounds keeping products	4	behavior	purchasing	ecosystem health	staff
Amount of time spent outdoors	4	behavior	land/water	human health	students
GENERIC/AGGREGATE					
# of students active in U-M sustainability groups	7		general	community awareness	
# of sustainability-related courses offered	6		general	community awareness	
# of parking permits sold to students/faculty/staff	6		travel	human health, ecosystem health	
% of buildings retrofitted with energy-saving devices	6		building	materials footprint, energy	
% of occupied bike racks (2-3 times/yr)	5		travel	human health, ecosystem health	
% of U-M parking spaces occupied	5		travel	human health, ecosystem health	
Do emissions (pollution) influence travel mode?	5		general	community awareness	
# of student/faculty/staff bus riders	4		travel	human health	
# of LEED buildings	4		building	ecosystem health, materials footprint	

Note: Orange represents those indicators receiving 5 or more high priority rankings; yellow represents indicators receiving 4 high priority rankings

Table 1. Prioritized Cultural Indicators

IMPLEMENTATION

The conceptual framework discussed above presents a roadmap for the third phase our work dealing with proposals for collecting cultural indicators. That is, we used the framework to prepare alternative plans for developing and collecting survey-based indicators covering students, faculty, staff, and alumni and for the generic/aggregate metrics.

For each alternative plan, we discuss the research design (i.e. sampling strategies, mode of data collection); the benefits (advantages) and barriers (disadvantages) to the approach; and cost estimates. Where appropriate, we also discuss issues of timing and collaborating partners. In the plans for collecting indicators on students and faculty and staff, key indicators drawn mainly from the list of priority indicators (Table 1) are also presented.

The plans (and subsets of them) can be viewed as a menu from which the Integration Team (and Steering Committee) can make selections as it determines when and how a program of cultural indicators should be launched. Ideally, it would be good to initiate the program by collecting indicators representing all university groups (students, faculty/staff, and alumni) simultaneously and do so while generic/aggregate measures are being collected. However, it is recognized that while some plans will be relatively easy to launch, most will require further development. Moreover, cost considerations will also influence which plan is implemented and when. The following sections cover plans for students, faculty/staff, and alumni and for the generic/aggregate metrics[9].

Plans for Collecting Student Indicators

In terms of creating a culture of sustainability on the U-M campus, the largest and perhaps the most important group is the student body. Students also present the greatest challenge in that their campus life is relatively short lived, their interests and activities vary widely, and for many, there is little commitment to a sustainable life-style. The importance of students lies in the fact that they represent future generations (and future alumni) and for administrators and faculty, their challenge is making sustainability and integral part of the students' educational experience while at the university.

Six alternative plans for building a set of cultural indicators based on surveys of U-M students are presented. The different plans cover different student cohorts and may be used independently or in combination with one another. The first two plans are relatively inexpensive but have limitations in terms of being representative of the U-M student body. The next plan (Plan C) covers graduates and focuses on sustainability as part of their educational experience. Plan D is incremental in that it builds toward full representation of the student body over a four year period while allowing the university to track individuals, their changes , and factors contributing to those changes. The next

[9] In the planning of the 2007 ISR pilot study, it was recognized that questions asked of UM staff were applicable to faculty and vice versa. Therefore, we assume that the same set of cultural indicators would be used to represent both populations. Accordingly, alternative plans for each of the three target populations (students, faculty/staff, and alumni) `were developed by two Culture Team members while two others developed plans for the generic/aggregate indicators. In developing the plans, the Culture Team received input from the Survey Research Center's Statistical Design Group (SDG) and in particular, Dr. Sunghee Lee. Cost estimates for selected plans to be carried out by ISR were prepared by the Center's Survey Research Operations (SRO) group.

plan (Plan E) is designed to be representative of all students while Plan F combines elements of the other plans.

*Common Assumptions among Plans***.** Common to all plans except Plans A and B is the use of web-based surveys to query students. Since all students either own or have easy access to computers and have public email addresses, it should be easy to inform them about the survey and how to access it. Emails can also be used to send reminders to those who have not responded. Similarly, incentives should be used to elicit responses to the surveys and increase response rates in all plans except Plans A and B[10]. Incentives might include iTunes gift cards, lottery tickets, or some monetary value added to student MCards. Finally, common to all plans is the set of priority indicators mentioned earlier. However, depending on the plan, the number of indicators that will be measured will vary. For instance, Plan A recommends a supplemental set of questions added to an existing survey that is administered annually to incoming freshmen. If this plan were implemented, a limited number of questions would be allowed.

Indicators Covering Students. There are several important indicators that capture knowledge/awareness, commitment, and behaviors of students. One of the most important is student awareness of or knowledge about environmental problems such as climate change. With the increasing emphasis on incorporating sustainability into the educational experience of students, this indicator would be important to track and would measure the university's progress over time. Another important cultural indicator related to awareness is student understanding of sustainability groups on campus and for those who are aware, the extent of their involvement. These and other indicators are drawn from the priority list in Table 1 are shown below.

- Knowledge of climate change, resource depletion, etc.
- Involvement in environmental organizations (on-campus/off-campus)
- Frequency of alternate travel modes (e.g. walking, biking, AATA, Nite Owl)
- Bike ownership & use during warm weather & cold weather months
- Car ownership and use
- Awareness of public transportation options
- Discussions of environmental issues in class
- Knowledge of what can be recycled on campus
- Use of reusable bags
- Importance of--conserving energy, reducing consumption, organic food, etc
- Use of campus & community green spaces—Arboretum, Botanical Gardens, Gallup Park, Hudson Mills, etc.
- Participation in EarthFest
- Awareness of impacts of drinking bottled water
- Drink bottled water; # bottles/week

*Survey Expertise***.** With the exception of the first two plans, it is recommended that expertise from ISR's Survey Research Center (SRC) be called upon to administer the data collection or be

[10] Students in Plans A and B represent a captive audience. That is, their participation in the survey will be seen as a requirement for new students (Plan A) or as a requirement for the course (Plan B)

consulted on plan details. This would ensure the collection of data of the highest quality and facilitate (and ease) their analysis and subsequent reporting. SRC's Survey Research Operations (SRO) has had extensive experience in developing data collection tools and processes via its web survey management system. As part of that system, targeted e-mails are sent to prospective survey participants, responses are tracked on a regular basis, e-mail reminders are sent to non-respondents, and completed questionnaires are coded and compiled into databases suitable for statistical analysis. Cost estimates from SRO for its administration of the surveys or for consulting are included.

Student Plan A: Incoming Freshmen: Supplemental Questions as Part of the CIRP Survey.

This plan is designed to collect data from incoming U-M freshmen through the annual Cooperative Institutional Research Program (CIRP) survey. The CIRP national survey of entering freshmen at universities and colleges is sponsored by UCLA and is administered by each participating school. Each fall,U-M's survey is administered by the Division of Student Affairs (DSA) which periodically adds questions for their own use[11]. Dr. Malinda Matney from DSA is responsible for administering the CIRP questionnaire and has agreed to work with OCS and the Graham Sustainability Institute is designing a sustainability supplement. Follow-up would be needed to determine the actual number of questions that could be added. The process of collecting indicators would be repeated every year.

<u>Costs</u>. The costs to collect indicator data from incoming students will be relatively low and mostly cover personnel who will work with DSA in determining the number and types of questions that could be added to the CIRP survey, deciding which of the priority metrics to collect, writing the questions that measure those indicators, and analyzing questionnaire responses and compiling the indicators. This work would involve OCS staff and SRC personnel with expertise in questionnaire design and statistical data analysis. The estimated cost of carrying out this plan is $15K to launch it for the first year and approximately $71K to execute the plan over a 6-year period.

<u>Benefits</u>. There are several benefits to collecting cultural indicators for students using Plan A. First, the administrative structure for conducting the CIRP survey is already in place and the time to prepare the sustainability supplement will be relatively short. Consequently, the costs associated with this approach will be relatively low. A related benefit is that indicators could be collected and reported as early as late 2011, particularly if the supplemental sustainability questions could be developed and incorporated into the questionnaire by March or April. Still another benefit is that the entire body of entering students would be participating and there would be a substantial amount of data to analyze covering the sustainability items and other subject matter gathered in the questionnaire. For example, relationships between sustainability questions (i.e. environmental awareness, commitment, and behaviors) and students' background, expectations, and plans for the future could be examined. Finally, the relatively high response rate for the CIRP survey[12] creates an opportunity to gather a large pool of students who might participate in a longer questionnaire dealing with sustainability during their freshmen year and possibly at some future time during their stay at U-M.

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[11] Information about CIRP at the U-M can be found on the Division of Student Affair's website at: www.umich.edu/~rsa/CIRP.html. .

[12] In 2009, 4,750 incoming students at Michigan responded to the survey representing a 78.1% response rate. See the 2009 University of Michigan Entering Student Fact book. http://www.umich.edu/~rsa/factbook.html

Barriers. The major disadvantage of this approach is that it captures only one segment of the student body. Upper-classmen and graduate students would not be represented in the reporting of cultural indicators. Another significant drawback to this approach is limited number of questions that could be added to the CIRP questionnaire. The questionnaire is fairly long and there would be limited tolerance for students to answer a full battery of questions dealing with sustainability.

Student Plan B: Surveys of Students in Large Classes Using "iClickers" to ask Questions.

This plan would target students who are enrolled in large, mainly introductory courses. As in Plan 1, participation in these courses will be primarily freshmen although sophomores and other upper class students may register for these courses[13]. "iClickers" are becoming increasingly popular in large, lecture classes to facilitate student participation and elicit responses to questions posed by the instructor. In Fall 2010, iClickers became the official Audience Response System used in many LSA classes. Other schools and colleges are adopting iClickers as well, including Engineering, Public Health and Public Policy.[14] Most 100- and 200-level classes, and even some 300-level classes, require each student to purchase an iClicker. During Fall 2010, 30 courses in LSA alone required the iClicker, these were comprised of 10,157 students (not taking into account the possibility of multiple enrollments).[14] The iClicker is used to answer in-class quizzes and surveys, which can then be tracked and used to measure class participation and learning. The accumulated data covering the entire class can also be displayed for evaluation and analysis. Because many classes already have the capability to use iClickers for quizzes and surveys, a short survey to measure cultural indicators on the U-M's campus could quickly and easily be given to mass amounts of students in classes with the iClicker. This approach would require cooperation from instructors and their departments because they would facilitate the survey in classes. This process would be repeated annually.

Costs The costs to collect indicator data from students using Plan B are estimated at $20K. The funds will pay advanced graduate students who would (1) work under OCS supervision in identifying indicators that require measurement,(2) write the questions that would capture those indicators in a format suitable for the iClicker, (3) work with identified departments and instructors in determining when and how the questions should be administered, and (4) analyze the responses. Time will also be needed to identify which classes using the iClicker should be targeted and contact their instructors and departments regarding participation. This work would involve OCS staff and SRC personnel as needed.

Benefits. A major benefit of this approach is that the indicator data can be collected quickly and easily and fed back to participating students. The approach also brings sustainability into the classroom, irrespective of the subject matter of the course. Finally, the approach can be a vehicle for engaging faculty and departments in U-M's Sustainability Initiative.

Barriers. As in the case of Plan A, Plan B does not capture the thoughts and behaviors of the entire student body and therefore is non-representative. Another disadvantage or potential barrier related to the academic requirements of the instructors and their departments. If the time allocated to measuring cultural indicators takes away from core learning objectives, instructors and their

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[13] Determination as to what is considered a "large" class needed to be made. Often, there are 200-300 students is some introductory courses.

[14]See http://www.iclicker.com/dnn/

departments may be unwilling to participate in the data collection. Therefore, time would be required to identify the large courses being taught each year, when they are being taught, and enlisting the departmental and instructor cooperation. Once there is agreement to participate, it will take time to work with each instructor for administering the questionnaire. Finally, there is the potential that the iClicker and its software will become obsolete, go out of business, or be discontinued by U-M. If this were to occur, the process of collecting indicators form student in large classes would have to be re-designed.

Student Plan C: Surveys of Graduating Students

This plan targets undergraduate and graduate students who are in their final semester at U-M. Since the number of graduates is large, it is proposed that a sample be selected from list of all those who will receive a degree so as to generate responses from approximately 1500 students. A stratified sample of both undergraduate and graduate students would be selected and contacted during their final semester prior to graduation. This process would be repeated annually.

<u>Costs</u>. In order to ensure the collection of data of the highest quality and facilitate (and ease) their analysis and subsequent reporting by OCS, the Survey Research Center (SRC) estimates that it perform all tasks for the first year of the program for approximately $45K. This work would entail working with OCS in designing the questionnaire to capture all indicators; selecting and contacting participants with targeted e-mails; tracking responses and sending e-mail reminders to non-respondents; compiling responses into databases suitable for statistical analysis; and providing OCS with raw indicator data. If the program continued for six years, SRC's cost would be $238K.

If OCS were to take on responsibility for executing the plan with SRC acting in a consulting capacity, the first year SRC costs would be approximately $12K. Assuming OCS administrative costs and the hiring of additional skilled student labor totaled about $20K, the minimum costs of administering Plan C would be $32K. These figures are summarized in Appendix Table 2.

<u>Benefits</u>. In addition to producing a set of cultural indicators, this plan has the potential to convey to U-M officials a cohesive view of the culture of sustainability as represented by students who have experienced campus life over an extended period. It would also demonstrate what U-M graduates would be bringing to the world following their U-M experience.

<u>Barriers</u>. As with Plans A and B, this plan does not represent the entire student body. At the same time, the findings from the survey cannot be used to change the culture of this group. Still another barrier will be the challenge of eliciting responses from graduating students. Most will be thinking about life after graduation, moving from Ann Arbor, and other future challenges and will be less inclined than other students to respond to the survey. This can be overcome in part by offering an incentive such as free membership to the Alumni Association. There are costs associated with the use of incentives, and personnel will be needed to design the sample and execute the survey.

Student Plan D: Surveys that Follow Incoming Students over Time

This plan is incremental in that it begins to collect indicator data from a sample of each incoming class and for a subset of this class (a panel), it continues to collect data during its next 3 years on campus. In the first year of the indicator program, a sample targeting 1500 freshmen would be selected and a questionnaire measuring indicators would be administered. The initial sample would be drawn from all freshmen registered during the first semester. In the second year of the program, a subset of these students (say, 750) would be selected and the same questionnaire would be administered. Concurrently, a sample targeting 1500 new freshmen would be selected for measuring the indicators.This process would be repeated until the fourth year of the program when the indicators from freshmen, sophomores, juniors, and seniors would represent all UM undergraduates.[15] This plan is illustrated in Table 2, which shows the number of targeted students from each cohort who would be queried over time. It assumes the cultural indicator program is launched in 2012. The arrows indicate students as they are move from year to year.

	2012	2013	2014	2015	2016	2017
Freshmen	1500	1500	1500	1500	1500	1500
Sophmores		750	750	750	750	750
Juniors			750	750	750	750
Seniors				750	750	750
Total Sample	**1500**	**2250**	**3000**	**3750**	**3750**	**3750**

Table 2. Student Plan D – Sample Design

Costs. SRC's estimated cost for administering the work during the first year of the program ($46K) is nearly comparable to their costs for administering Plan C. However because this plan involves tracking students over four years and soliciting new students, the estimated costs for administering the program for 6 years is higher at $257K. If the work were to be conducted by OCS with consultation from SRC, the first year costs would be $32K and running the program for six years would be about $209K. Again, we assumed OCS's additional costs (administrative, student labor, etc.) would be approximately $20K per year. These figures along with comparable figures for other plans are shown in Appendix Table 2.

Benefits. This plan offers a number of benefits to U-M. First, it starts small and evolves as the number of students who are queried grows over time. Since the initial year covers only freshmen, it can be considered as pilot study to test the questionnaire and data collection procedures. This allows for modifications to both in subsequent years. Second, the panels allow for tracking changes in awareness, commitment, and behaviors of students over time. The panel data could also be examined so as to determine factors contributing to greater awareness, commitment, or sustainable behaviors. That is, we would be able to see why some students are more in tune to a sustainable life style while others are not. Factors that may contribute to student differences include their academic concentration, their housing, their social network, and so forth. Finally, Plan 4 by the fourth year of operation would be representative of all undergraduates.

Barriers. The most significant barrier to executing this plan is the cost. Whereas initial startup costs (sample selection, questionnaire design and administration, incentives, etc.) would be relatively low, the cost of tracking the sub-sample of students and maintaining them in the panel would increase

[15] In order to obtain a representation of the entire student body, the plan could be supplemented with a sample of Rackham graduate students and students in the professional schools.

substantially. That is, over a period of six years, U-M would spend a maximum of $357K to gather cultural indicators from new and existing students.

Student Plan E: Students Using Cross-Sectional Surveys

This plan proposes a survey of a representative sample of all students enrolled during each fall semester. A sample size of about 1500 students drawn from lists maintained in the Registrar's Office would provide data measuring awareness, commitment, and behaviors, each year.

Costs. The costs to collect indicator data during the initial year under this plan are nearly comparable to the costs of Plans C and D ($45K). Since the approach does not involve following the same sample of students over time, the 6-year program would cost about $238K. This assumes SRC administration of the surveys. If SRC serves as a general consultant to OCS, the first year cost and the 6-year program costs will be $32K and $180K, respectively.

Benefits. This is a fairly straightforward approach to gathering indicator data that would be truly representative of all U-M students. The annual sustainability surveys have the potential of covering other topics deemed important to university officials. That is, additional questions to sustainability issues might be added as needed.

Barriers. A disadvantage of this plan would be the inability to make significant comparisons in indicators for major sub-groups of the sample. For instance, the sample size would allow for the comparison of metrics between say, undergraduate and graduate students but comparisons between students in various colleges and schools would not be possible unless the sample size was substantially increased and a stratified sampling design was used. This would affect the budget for administering the survey, which would include the use of incentives to generate interest and participation in the questionnaire.

Student Plan F: Surveys of All Students Using a Combined Panel and Cross Sectional Design

Plan F combines elements of Plan D and Plan E and is intended to produce indicators that reflect the entire student body while generating data that will enable OCS to track changes in these metrics for individual students. It is best explained by Table 3, which shows that during the first year of the cultural indicators program (assume 2012), samples of students would be selected from each undergraduate class and from students enrolled in graduate programs and professional schools. That is, the sample design would result in selections that would yield 1000 freshmen, 400 from each of the sophomore, junior, and senior classes; and 400 graduate and professional students[16]. In the second year, half of each undergraduate class would be followed and queried and new samples of freshmen and graduate/professional students would be selected. This process would continue in each subsequent year.

[16] Data generated by each cohort of students would need to be weighted to reflect the cohort's actual proportion of the entire student body. For example, of the 41,674 students are enrolled at the Ann Arbor campus in 2008, 31.6 percent were in graduate or professional schools. See U-M Facts and Figures. http://mmd.umich.edu/forum/michigan.php

	2012	2013	2014	2015	2016	2017
Freshmen	1000	1000	1000	1000	1000	1000
Sophmores	400	500	500	500	500	500
Juniors	400	200	200	200	200	200
Seniors	400	200	200	200	200	200
Grad/Professional	400	400	400	400	400	400
Total Sample	2600	2300	2300	2300	2300	2300

Table 3. Student Plan F- Sample Design

Costs. This comprehensive plan for collecting indicator data from a sample of all U-M students is the most expensive, costing $55K to launch to data collection using SRC and $36K using OCS staff with SRC consultation. Since each cohort of undergrads is followed throughout their time at U-M, tracking accounts for the higher costs of running the program for six years ($320K and $200K, respectively).

Benefits. This plan has the advantage of immediately launching the indicators program and covering the entire student body. It also would generate sufficient data to allow for comparisons within any year between different student cohorts and between students associated with sizeable academic programs or units[17]. Besides being able to track changes in individual levels of awareness, degrees of commitment, and behaviors, the panel data can be analyzed to find factors contributing to changes (or no changes) in awareness, commitment, or sustainable behaviors. As noted, earlier, factors that may contribute to student differences include their academic concentration, their housing, their social network, and so forth.

Barriers. Although this approach to collecting indicators that represent culture from the students' perspective, it will take time to fully develop the details of the plan and to administer it. Besides questionnaire development, time and resources will be required for sample design, data collection procedures, tracking or maintaining contact with the panel, providing incentives for panel members remain engaged in the data collection, and analysis.

Plans for Collecting Faculty/Staff Indicators

Although students represent the largest population on the Ann Arbor campus and reflect the culture of the university, faculty and staff are also significant in defining U-M's culture of sustainability. Both faculty and staff have a long-term commitment to the university and can be directly impacted by rising costs associated with building energy use and non-sustainable practices of the university, its students, and its employees. Faculty and staff also can be role models for students in terms of their sustainable practices. Accordingly, we offer three plans for collecting indicator data from faculty and staff.

[17] By sizeable programs or units, we mean those with large numbers of students such as LSA or Engineering. Smaller units such as department or small schools and colleges (i.e. Pharmacy, Information, Music, Theater, and Dance, etc.) within U-M may not have a large number of students who would fall in the sample. If there were particular interest in making comparisons between all or a subset of academic units, this could be accommodated in several ways such as increasing sample sizes, stratified sampling designs, and/weighting of the data.

Common Assumptions among Plans. As in the case of the alternative plans covering students, we propose collecting indicator data for faculty and staff through web-based surveys. In instances where staff or faculty members do not have and office or computer access, paper-based questionnaires will be used with distribution and collection through campus mail. In order to improve response rates to the surveys, incentives should be used in each plan. Hopefully, faculty and staff will see the intrinsic value of the information being sought and will be prompted to participate, even with a modest incentive such as a well-designed Planet Blue pencil; a raffle ticket with a chance to an iPod or video camera; or membership to a health club. Finally, common to all plans is the set of priority indicators mentioned earlier.

Indicators Covering Faculty/Staff. Many but not all of the indicators covering students would be appropriate for faculty and staff. At the same time, there are indicators measuring faculty/staff behaviors that are not appropriate for students. The indicators drawn from the priority list in Table 1 are shown below.

- Knowledge of climate change, resource depletion, etc.
- Involvement in environmental organizations (on-campus/off-campus)
- Frequency of alternate travel modes—(e.g. driving, car/van pooling, walking, biking, AATA,)
- Awareness of public transportation options
- Discussions of environmental issues in classes taught
- Knowledge of what can be recycled on campus
- Use of reusable bags
- Importance of conserving energy, reducing consumption, organic food, etc
- Use of campus & community green spaces—Arboretum, Botanical Gardens, Gallup Park, Hudson Mills, etc.
- Participation in EarthFest
- Awareness of impacts of drinking bottled water
- Drink bottled water; # bottles/week
- Eco-friendly alternatives for cleaning products and grounds keeping products (staff only)
- Discussions of environmental issues in class (faculty only)
- Unplug appliances when leaving office/home
- Printing habits (e. g. 2-sided printing)

*Survey Expertise***.** For each plan to collect indicators from faculty and staff, it is recommended that expertise from ISR's Survey Research Center (SRC) be called upon to administer the data collection or consult on its details. This would ensure the collection of data of the highest quality and facilitate (and ease) their analysis and subsequent reporting. SRC's Survey Research Operations (SRO) has had extensive experience in developing data collection tools and processes via its web survey management system. As part of that system, targeted e-mails are sent to prospective survey participants, responses are tracked on a regular basis, e-mail reminders are sent to non-respondents, and completed questionnaires are coded and compiled into databases suitable for statistical analysis. Cost estimates from SRO for its administration of the surveys outlined in the three plans are included below.

Faculty/Staff Plan A: Survey of Building Occupants

This plan is designed to produce data covering faculty and staff occupying selected university buildings each year. A stratified sample of buildings would be selected annually and its faculty and staff would be contacted to participate in a sustainability survey. Since there are over 360 buildings on the U-M campus, most of which house staff and faculty, a subset of for example, 45 buildings could be selected in each consecutive year. Building selection would be based on both the number of occupants and its level of energy consumption.

The plan also involves identifying a liaison person in each sampled building to assist with data collection. The liaison person might be the facility manager, a faculty member, or someone representing the unit's administrative office. This individual would serve as a link between survey administrators and the building occupants and be available to address questions about the survey and actively market it to building occupants.

As an initial step, a listing of all occupied campus buildings would be needed, including the number of occupants and their recent energy consumption. The data would be examined to determine those buildings that have large, medium and small numbers of occupants and buildings with high, medium, and low levels of energy consumption[18]. Table 4 presents the framework from which the buildings would be selected, assuming there were an equal number of buildings in each cell.

No. of Occupants	Energy Use Low	Energy Use Medium	Energy Use High	
Small	40	40	40	
Medium	40	40	40	
Large	40	40	40	
Total UM Buildings	120	120	120	360

Table 4. Sampling Framework for Faculty/Staff Plan A

Next, a sample of five buildings from each cell would be randomly selected. From within each sampled building, a sample of faculty and staff occupants would be contacted and asked to participate in a sustainability survey. If the average sample size per selected building were 50 occupants, this would result in a total sample of 2250 faculty and staff members and would be representative of all faculty and staff (occupying buildings) on campus. Tables 5 and 6 provide illustrations of the sampling approach. It is recognized that the number of buildings in each cell of the table will not be equal. Furthermore, the ratio of faculty members to staff in each building will vary. Consequently, adjustments to the number of buildings sampled will be required once the actual number of buildings in each cell is determined. Similarly, once the sampled buildings are identified, a stratified sample of occupants will be selected based on the ratio or faculty to staff.

[18] From examining the data, we would be able to define what are small, medium, and high occupancies and what are considered low medium, and high uses of energy.

No. of Occupants	Energy Use Low	Energy Use Medium	Energy Use High	
Small	5	5	5	
Medium	5	5	5	
Large	5	5	5	
Total Sample of UM Buildings	15	15	15	45

Table 5. Faculty/Staff Plan A - Sample Design for Selecting Buildings

No. of Occupants	Energy Use Low	Energy Use Medium	Energy Use High	
Small	250	250	250	
Medium	250	250	250	
Large	250	250	250	
Total Sample of Faculty/Staff	750	750	750	2250

Table 6. Faculty/Staff Plan A - Sample Design for Selecting Faculty/Staff

Costs. In this plan, a multi-stage sample is required in order to achieve the representativeness of both university buildings and their faculty and staff occupants. The selection of this sample requires expertise in sampling design that can be supplied through ISR's SRC. The SRC estimate of $55K for the initial year covers the cost of designing the sample, and setting up and administering the questionnaire to designated participants including follow up contacts, incentives, and record keeping. If OCS administers the survey with consultation from SRC on sampling and other technical matters, that cost is reduced to $34K. The corresponding costs for this plan running through 2018 are $302K and $195K, respectively.

Benefits. This plan would enable university officials to measure culture indicators for faculty and staff over time but it also has the advantage of comparing these indicators between individual buildings and building groups with different characteristics (occupancy rate and energy consumption). Since a number of these buildings have participated in Planet Blue, faculty/staff indicators for these building could be compared with comparable indicators covering faculty/staff in non-Planet Blue buildings. Such comparisons can be helpful in assessing the effectiveness of the behavioral component of the Planet Blue program. At the same time, the data can be helpful to Planet Blue and Plant Operations personnel to better target improvements to non-Planet Blue buildings. Another advantage of this plan is the opportunity to examine cultural indicator data within each sampled building vis-à-vis hard measures for that building. For example, looking at data across all buildings, we could determine if there is a relationship between the availability of light sensors and faculty/staff turning off lights and computers at the end of the day. Still another benefit is the use of a building liaison , one of the building occupants who would be instrumental in promoting survey participation. It is anticipated that this would significantly reduce the need for large incentives.

Barriers. Despite its significant advantages of generating indicator data on faculty/staff that can be analyzed to inform Plant Operations in the management of their non-Planet Blue buildings, there are barriers to the plan. First, there is the complexity of the design including decisions about frequency of data collection, whether buildings and its occupants are to be followed over time (i.e. a panel of building and/or a panel of occupants), and sampling details. A second barrier that needs to be

overcome is dealing with the coverage of university employers (i.e. primarily staff) who don't occupy a building or those who occupy more than one building (i.e. primarily faculty).
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Faculty/Staff Plan B: Faculty/Staff Using Cross Sectional Surveys

This plan is similar to Plan E covering students in that it produces cultural indicators reflecting faculty and staff through periodic cross sectional surveys. The surveys would cover a stratified sample of faculty and staff employed by U-M at the beginning of each calendar year. A sample that would yield about 1500 faculty and staff members would be drawn from employee lists maintained by U-M Office of Staff Benefits. Employee lists would be stratified by faculty and staff. As in Plan A, data would be collected primarily via web-based surveys, but if individuals do not typically use computers, paper questionnaires would be available and distributed and collected via campus mail. It is recommended that the surveys be conducted annually or semi-annually.

Costs. For SRC to administer this plan, the cost during the first year is $44K. If OCS were to assume responsibility for administering the plan with SRC assistance, the cost is reduced to $31K.For the 6-year program, this plan would cost approximately, $257K and $184K respectively.

Benefits. This plan would produce indicators reflecting the awareness, commitment, and behaviors of a representative sample of faculty and staff and would be comparatively easy to administer. Accessing lists and drawing the sample would be fairly straightforward. The timing of the survey at the beginning of the calendar year would likely produce reasonable response rates since it is early in the semester when people are less likely to experience demanding workloads.

Barriers. While the plan would produce indicators representative of the university's faculty and staff, indicator comparisons would not be possible between faculty and staff in different buildings and in different academic units. Given the proposed sample size, small units on campus would be unlikely to have many participants and therefore the estimates for faculty and staff in those units would be imprecise or subject to large sampling errors. This of course could be overcome by substantially increasing the overall sample size and/or assigning weights to the estimates.

Faculty/Staff Plan C: Panel Study of New Faculty and Staff Hires

This plan involves the collection of baseline indicator data from each cohort of new faculty and staff hires beginning in the fall 2012 and subsequently data collection from the same cohort in each of the following years for say, 10 years (through 2021). The process continues with new faculty and staff hires in 2013, 2014, and 2015. It begins with 500 new staff and faculty members and follows them through 2012. The process of administering the surveys could be handled through those academic units that offer special orientation program for new faculty and staff (i.e. CRLT, Rackham, Human Resources, etc.

Costs. To implement this plan, SRC estimates a cost of $35K for the first year. If OCS were to administer the plan with SRC consultation, the cost is reduced to $29K. These costs along with the associated costs covering a 6-year period are shown in Appendix Table 2.

<u>Benefits</u>. The primary advantage of this approach is that faculty and staff members who are new to the university know little about sustainability on campus and should show marked change in awareness, commitment, and behaviors over time. The plan allow for testing this hypothesis.

<u>Barriers</u>. The major disadvantage of the plan is that ignores faculty and staff who are currently on campus. It also requires the active participation of the units responsible for orienting new hires as well as the willingness of new hires to participate in the indicator measurement over

Plans for Collecting Alumni Indicators

The IA Steering Committee did not include the development of indicators for alumni in their assignment. Nonetheless, the Culture Team believes that this population is a critical part of the UM community and that collecting indicators covering alumni will become increasingly important as current and future students graduate. Tracking alumni indicators over time will be a way of determining the long-term impact of U-M's Sustainability Initiative. If we want to demonstrate that changing the culture of sustainability on campus has a long-term impact on society and that behavioral change among students is sustained over time, periodic surveys of this population are critical.

Still another reason for recommending the collection of cultural indicators from alumni is related to the university's goal of being recognized as a global leader in sustainability. As part of this goal, UM is in the process of launching a marketing study with an eye toward developing a communications plan aimed at its alumni and prospective students. It is expected that the marketing study will include a survey of alumni which could be seen as a pilot effort toward reaching out to alumni on the sustainability topic. Finally, the Alumni Association is keenly interested in the topic as demonstrated by the selection of sustainability as the theme for their outreach program for 2010-2011. They have expressed willingness to sustain this interest by periodically asking sustainability indicator questions as part of their regular surveys sent to alumni.

Common Assumptions among Plans. As in the case of the alternative plans covering students, faculty, and staff, indicator data for alumni would be collected through web-based surveys. Sample sizes would need to be large to account for a probable low response rate unless incentives were used to generate and sustain interest. A modest incentive such as free membership to the Alumni Association for one year should generate interest in the topic and a reasonably high response rate.

Indicators Covering Alumni. While it would be nice to collect measures reflecting knowledge/awareness, commitment, and behaviors drawn from our priority indicators listed in Table 1, many would not be applicable to individuals who are no longer on campus. If an indicator program covering alumni were to move forward, representatives from UM's Alumni Association, Graham, and OCS should meet to determine what would be appropriate measures for this group. Finally, the indicator questions, once identified, would be comparable but Plan B would contain more of them.

Alumni Plan A: Adding to Current Surveys

The University of Michigan Alumni Association maintains regular contact with its members via email and periodically seeks feedback from them. Similarly, several of the schools and colleges at U-M are in contact with their graduates, many of whom do not belong to U-M's Alumni Association. It is proposed that Graham and OCS build on our initial discussions with Alumni Association personnel regarding a supplement to existing questionnaires. The supplement would include questions measuring sustainability indicators. Similar discussions could also occur with deans and directors of academic units to determine their interest in asking sustainability questions as part of their alumni surveys.

Benefits. The primary benefit of collecting indicator data using current alumni surveys is the limited cost. The mechanism for collecting data on-line is already in place and the only additional cost would be personnel time to (a) identify indicators and their respective questions, and (b) analyze and report the data. The latter would vary depending on the extent of the analysis. For instance, simple reporting of the indicating would be minimal. On the other hand, if there were interest in seeing how indicators varied depending on when alumni graduated, the school or college they attended, or where they live, this would take more time and be more costly.

Barriers. The main disadvantage of this approach is the limited number of indicators that can be measured. That is, the number of such metrics would need to be small since the Alumni Association surveys would have other purposes and therefore have predominantly non-sustainability questions.

Alumni Plan B: New Surveys of Alumni

This plan proposes periodic surveys that focus exclusively on sustainability issues including questions that measure cultural indicators. It would build on information gleaned for the survey planned as part of the market research study conducted in early 2011 and would be developed in collaboration with the Alumni Association. The plan suggests a sample of 2000 be drawn from Alumni Association members who received their degree in 2001 or later and a sample of 1000 members who graduated in 2000 or earlier. The initial survey would be conducted in 2012 and be repeated every 2-3 years with a new sample selection[19].

Benefits. The advantage of this plan is that it has the potential to collect a full battery of indicators representing alumni. It would also provide data that allows for comparisons between those who graduated during the previous decade and those who graduated from the university earlier. Furthermore, it has the potential of generating greater interest in sustainability among alumni and in particular U-M's Sustainability Initiative. This in turn might become a focal point for soliciting alumni contributions.

Barriers**.** The plan would need full endorsement of the Alumni Association and their support in generating the funds to carry out the surveys. The cost of conducting the surveys would be substantial in terms of the sample designs, data collection, incentives, and analyses.

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[19] In subsequent years, the sample would be drawn from a list of those who graduated during the previous decade and from those who graduated in earlier years.

Plans for Collecting Generic/Aggregate Indicators

In addition to using survey data to measure indicators, other types of aggregate information can be compiled that reflect the culture of sustainability on campus. U-M currently compiles information on many sustainability topics, much of which is reported in its annual Environmental Report. In addition to data on energy use, CO2 emissions, water use, and recycling, OCS compiles data on campus bus ridership, AATA, MRide ridership, van pool participation, the number of bike racks, enrollment in sustainability-related courses and other indicators that can be categorized as cultural.

In this section, we recommend ten additional generic indicators that can be added to the Environmental Report. For many of these indicators, the data are currently available but will need to be compiled in order to best understand their significance and potential reporting format. Other indicators are relatively easy to collect, such as counting the occupancy of bicycle racks, but will require resources to track them. We note that our recommended generic indicators are drawn in part from our list of prioritized cultural indicators (see Table 1). Others represent measures that are deemed important by other IA Teams and OCS. Finally, it could be argued that some may not directly measure U-M's culture with respect to sustainability. In these instances, we have attempted to justify their inclusion to the list. The recommended indicators are:

- Student Involvement in Sustainability Organizations (# of students)
- Pesticide Load (pounds used annually)
- Local Food (proportion of locally grown/processed food)
- Sustainability Grants (# of grants/contracts)
- Sustainability Projects (# of on-campus projects)
- Bicycle Ridership (# of parked bikes)
- Parking Permits (# of permits issued)
- Small Deliveries (# of delivery orders under $50)
- Sustainability Events (# of events promoted)
- Sustainability News Stories (# of stories published)

Student Involvement in Sustainability Organizations (# of students). An accurate count of student involvement in sustainability organizations would help to indicate both the depth and the breadth of student commitment to sustainability initiatives. Unlike student participation in courses related to sustainability, participation in student organizations is not an activity that provides academic credit and therefore demonstrates student commitment and altruism. This metric would involve indentifying all sustainability–related organizations on campus and then obtaining membership counts from each at a specified time each year, preferably at the end of the fall semester or the beginning of the winter semester, when the website has been updated for the year. If possible, counts with each organization would include a breakdown between undergraduate and graduate students. Lists of student groups related to sustainability are maintained by Maize Pages, a website that is maintained by the Office of Student Activities and Leadership (http://studentorgs.umich.edu/maize/environmental) and updated yearly. The information should be included in the annual Environmental Report. Because the sustainability groups and their membership are already listed on Maize Pages, this should be a relatively straightforward task and would take about five hours of work annually. Assuming student labor at $15 per hour, assembling these data would cost $75 annually.

Pesticide Load (pounds used annually). Chemical pesticides are not only damaging to ecosystem health but they also have adverse effects on human health, and the extent to which they are used indicates the types of behaviors practiced at the institution.. A reduction in the amount of pesticides U-M uses through more efficient application procedures, limiting areas covered, or new methods such as integrated pest management or an increase in native plant cover, would have positive benefits. Reductions would show a concern not only for the regional ecosystem, but also for the immediate area around campus. Having already been identified as an area for improvement by the Land and Water Team and because pesticide use is mainly an operations issue, any change in use would demonstrate a direct commitment by the administration to environmental health.

Data on the amount of pesticides and fertilizers used are available as part of the required records kept by the Plant Building and Ground Services (Groundskeeping). The data should be collected and tabulated annually at the beginning of a new fiscal year. OCS could be in charge of obtaining the information from the groundskeeping staff. Because there will need to be communication and data gathering involving OCS and Ground Services, this metric would require an estimated four hours per year. Assuming an annual salary of $85,000, this equates to $163 per year.

The advantages of using pesticide load as a metric are numerous. The data is already being recorded and will be relatively easy to obtain. It also assesses an area of sustainability–land and water quality – that may be difficult to measure in other ways. However, there are many types of pesticides, all of which have varying effects on the ecosystem. There do exist "eco-friendly" pesticide alternatives which when used, show a commitment to sustainable practices. Any switch to more environmentally sensitive products would need to be reflected in the Environmental Report, though it might not affect the overall number of pounds of pesticides used.

Local Food (proportion of total food purchases that are locally grown or locally processed). The IA Food Team has recommended that U-M purchase locally grown or locally processed food as an important step in making the university more sustainable. This will benefit the region economically while contributing to the physical health of those who eat food sold on campus. The Food Team has recommended an increase in locally grown and processed food to 20% and thus has already explored the feasibility of assessing the percentage of food bought by U-M that fits these standards.

The Food Team has recommended that information be tracked on purchases of local food. Sysco is already sourcing local food to U-M and if the Food Team's recommendation is adopted, then this number will need to be monitored to ensure the Food Team's goal is met. These data would be best obtained annually and should cover the calendar year. OCS would collect the information and the process could take eight hours among all the departments involved, once the method for data collection is set. The total estimated cost of collecting this indicator is $327.

Sustainability Grants (# of grants/contracts awarded annually). U-M is known as a world-class research institution and there are an increasing number of grants/contracts that address sustainability issues. Accordingly, funds obtained by U-M researchers would be an excellent indicator of the level of scholarship focused on sustainability efforts.

Sponsored Awards on the Web (http://cgi.research.umich.edu/saw) is a website where awards and proposals can be searched by date of award. This information should be collected annually and the amount of money awarded to projects having to do with any aspect of sustainability should be included in the metric. OCS would be the logical unit to compile the figures; the estimated time to compile the information is about eight hours and would cost approximately $327.

However, because the awards are not categorized according to subject matter or theme, it may be difficult to assess exactly which grants are in fact related to sustainability. With only the name of the proposal upon which to base a categorization, it may become necessary to develop a more comprehensive search plan. A list of keywords (e.g. efficiency, sustainable, environment, climate change) should be developed in order to ease the search. This search may also be eased if certain departments unlikely to be doing sustainability research (e.g. medical research) are not included in the search. Categorization may make this metric more difficult to collect than some of the others. However, because it is reflective of a part of U-M which little of the survey data or other metrics will measure, it becomes that much more important to include this metric in the Environmental Report.

Sustainability Projects (# on campus sustainability projects). While U-M is contributing to the broader base of knowledge about sustainability through research (see above metric), it is also taking on operational projects on campus. These projects are focused on a variety of issues (e.g. reducing energy consumption through Planet Blue). The number of such campus sustainability projects is a good indicator of how committed the university is to spending money in order to decrease its environmental impact.

The OCS already maintains a record of all sustainability projects on campus. The development of this program would simply involve summing the annual number of projects and reporting it in the Environmental Report. While there would be no differentiation between large and small projects, the sheer number of projects would indicate how widespread the commitment is on the part of the University. The estimated amount of additional time to report this metric is about 4 hours at a cost of approximately $163.

Bicycle Ridership (# of parked bikes). As of FY2009 U-M maintains approximately 4250 bicycle racks across its Ann Arbor campuses that can accommodate up to 8,500 bicycles. The need for additional racks is evaluated based on bicycle parking guidelines and visual assessments of rack utilization. These evaluations typically take place during the planning of construction projects and upon receipt of request submitted to Parking and Transportation Services (PTS). The current system of evaluation has been helpful in supporting an increase in the number of racks throughout the past decade and serves as an indicator of the University's commitment to sustainability. However, U-M may not be adequately meeting demand due to the evaluation of needs only when situations arise. This concern is detailed in a report titled "Building a Michigan Bicycle Blueprint - An Outline for the U-M Bicycle Master Plan," that was written in the summer of 2009, under the direction of the Executive Director of Parking and Transportation[i].

To more effectively evaluate demand, an annual assessment of the number of bicycles parked on campus is recommended. The Transportation Team undertook a preliminary study of this nature that could be used as a prototype. The count can be accomplished through a visual assessment performed by a student group (e.g. the Student Sustainability Initiative, EnAct, or the Environmental

Issues Commission).. PTS provides bike rack maps on its website (www.pts.umich.edu) that would help students locate racks and count the number of parked bicycles at each. Aggregate data from this process would be compiled by the OCS for inclusion in the annual Environmental Report. Detailed data on the utilization of individual bike racks could be provided to PTS.

The assessment presents several challenges. The size of the campus and quantity of bike racks make a point-in-time calculation implausible, absent a prohibitively large assessment team. Consequently, the assessment must be accomplished over a period of time. A prolonged assessment period increases the likelihood of variability due to uncontrollable factors that may influence bicycle ridership, such as academic schedules and weather conditions. To optimize accuracy and manage cost, a team of 25-30 students is recommended to simultaneously count the number of parked bicycles across U-M. It is recommended that the assessment take place during an early afternoon in mid-September, when maximum demand would be expected due to weather and U-M schedules. The OCS's management of this process is expected to take approximately twenty hours per year and cost about $817.

Parking Permits (# of permits Issued). U-M supports alternatives to single-occupancy vehicle use through many initiatives, including the MRide program enabling free rides on AATA buses and various ridesharing options. These initiatives are in place to improve air quality, decrease traffic congestion, reduce fuel consumption, and maximize the efficiency of the parking infrastructure by reducing the number of vehicles driven to and from U-M..

As of FY2009, there are over 23,000 parking spaces in lots and decks across the U-M's Ann Arbor campus. Students, faculty, and staff are required to obtain permits from PTS in order to park in these spaces. Traditionally, variability in daily demand has allowed the number of parking passes sold to exceed the number of spaces available. Consequently, the quantity of parking permits issued annually can be used as a proxy for parking demand – a reflection of the university's commitment to environmentally friendly transportation. In addition, by measuring parking demand, the university will be able to make more effective decisions regarding public transportation (e.g. number of buses) and the need for parking lots and decks.

The data required to report the quantity of parking permits issued is currently captured by PTS. In order to make the data more accessible, it is recommended that it be provided to OCS for inclusion in the annual Environmental Report. This process would take an estimated four hours per year at a cost of about $163. The new metric would complement existing parking statistics, including the total number of parking spaces available and the percentage of total parking spaces that are in decks.

It should be noted that this measure has a limitation regarding its use as an indicator of parking demand. In addition to permit parking, members of the university community can park in metered parking and on some residential streets. This demand would not be captured by the metric. Despite this drawback, the relative ease of collection and potential usefulness of this metric make it an ideal candidate for inclusion in the annual Environmental Report.

Small Deliveries (# of delivery orders under $50). U-M's Procurement Services (PS) encourages faculty, staff, and students to set a minimum order value of $50 when ordering products. As stated on PS's website, "by increasing the size of individual orders you reduce deliveries and limit packaging waste." Although a minimum order size is encouraged, it is not enforced or tracked. The annual tracking of the metric in the Environmental Report – along with the existing procurement metric, "total paper purchases" – would serve as an indicator of faculty/staff's' commitment to sustainable purchasing practices. It should be noted, however, that some situations require or otherwise make it difficult for purchasers to consolidate orders. Accordingly, the metric would be a useful, although not completely representative indicator of sustainable purchasing.

This collection of this metric would require participation of the reporting group of PS. A member of that group can create a business objects query of the M-Purchasing website. Coordination between PS and OCS will be required when compiling the annual Environmental Report. The process is estimated to take two hours of PS staff time and four hours of OCS time annually resulting in a cost of approximately $245. It is recommended that the OCS work closely with PS to assess the appropriateness of the $50 cutoff over time, as the value may need to be occasionally adjusted to account for inflation.

Sustainability Events (# of events promoted). Each year, U-M hosts events that focus on issues related to sustainability. By engaging and educating faculty, staff, and students, these events – conferences, speaker series, expositions, etc. – are able to influence the culture of sustainability on campus. Similarly, since events require motivation and participation from the University community, their existence is an indicator of the interests and values of U-M. Consequently, measuring the quantity of sustainability events is recommended.

Although this number is not formally tracked, a mechanism for its collection already exists. U-M's sustainability website (http://sustainability.umich.edu) currently compiles sustainability events. Counting the number of events published annually would require an estimated four hours of time per year at a cost of roughly $163. This activity would be managed by OCS.

Sustainability News Stories (# of stories published). As a world-class educational institution, U-M frequently engages in newsworthy activities, many of which are about, impact, or influence sustainability. The number of news stories on a topic can serve to demonstrate the significance and interest of the topic among its recipients. Accordingly, an annual count of the number of news stories related to sustainability is recommended as an indicator.

The number of news stories is not currently recorded, but the University's sustainability website (http://sustainability.umich.edu) provides all of the necessary data. As the compiler of sustainability news from U-M, the website publishes news stories that can be counted annually. The collection of this information is estimated to take four hours of time per year and cost approximately $163.

Summary Costs of Collecting Generic Indicators. Although there are costs associated with the collection of these indicators, many are opportunity costs rather than precise dollar expenditures. That is, they reflect workloads assigned to OCS staff and others currently employed by the university. The following summarizes all costs for collecting our recommended generic indicators.

GENERIC CULTURAL INDICATORS	EST. ANNUAL COST
Number of students involved in sustainability organizations	$ 75
Number of pounds of pesticides used annually	$163
Proportion of food purchases that are locally grown or processed	$327
Number of sustainability-related grants/contracts	$327
Number of campus sustainability projects	$163
Proportion of bike racks used	$817
Number of parking permits issued	$163
Number of delivery orders under $50	$245
Number of sustainability events promoted	$163
Number of sustainability new stories published	$163
TOTAL ANNUAL COST	$2,606

Table7. Summary of Costs of Generic Cultural Indicators

INTEGRATION AND RECOMMENDATIONS

The initial conceptual model for the Campus Integrated Assessment depicted culture as an overarching theme related to each of the other themes (i.e. transportation, buildings, food, etc.). Accordingly, one member of the Culture Team was assigned as a liaison to each of team, learn from their deliberations, share information, and regularly report back to our team. As we prioritized cultural indicators, we considered the data needs expressed by other analysis teams. The associated team for each selected indicator is noted in Table 1. In the future, as specific questions are developed to capture the indicator, it is recommended that the relevant team be consulted. For instance, the Transportation Team would be consulted in drafting questions about automobile use and alternative transportation modes. Table 1 also shows the higher lever sustainability themes associated with our recommended indicators.

Our recommended indicators (or metrics) fall into two categories: individual and generic. We have developed a number of plans for collecting individual indicators, most of which rely on surveys of students, faculty and staff, and alumni. We believe that surveys are the most effective and reliable approach to measuring indicators that reflect the culture of sustainability on campus. Moreover, surveys provide a mechanism for systematically tracking the changes in campus culture that we hope to achieve. Unlike other indicators such as energy use or bus ridership, there is currently no measure at UM that reflects the culture of sustainability on campus. Since we can only speculate as to where we are with respect to our culture, the initial set of surveys that we recommend will provide the baseline data on what members of the university know, their levels of commitment to sustainability, and their current behaviors. These initial surveys can help university officials establish specific goals about the campus culture we aspire to. The follow-up surveys that we propose are intended to measure our progress in moving toward those goals. At the same time, careful analysis of the data emanating from the surveys can guide university officials as they make policies regarding sustainability operations, education, and research. These actions are unprecedented in institutions of higher education and if initiated, would make the University of Michigan a global leader in sustainability.

Our recommendations on collecting indicators draw on the benefits and costs of the various plans we outlined. They also reflect data presented in Tables 8-10 and Appendix Table 3[20].

First, we recommend that efforts to collect and report environmental indicators be expanded to include indicators identified in our discussion of generic indicators. Collection of these indicators annually will be relatively inexpensive and easy to measure. Although some may be questionable as to their relevance to culture (i.e. pesticide load), most reflect either behaviors (i.e. bicycle rack occupancy) or commitment to sustainability (student involvement).

Second, we recommend that a program of cultural indicators reflecting students begin with the implementation of Plan F which involves a survey of both undergrad and graduate students and subsequent follow up surveys of a sub-sample of student from each undergraduate cohort.

Third, we recommend that cultural indicators reflecting the faculty and staff be collected using Plan B. That is, annual surveys of a sample of faculty and staff members should be conducted so as to measure changes in their levels of awareness, degree of commitment, and pro-environment behaviors.

Finally, we recommend no further action on collecting indicators from alumni until the current marketing study is completed and university officials decide how this important part of the university community should become engage in U-M's sustainability efforts.

[20] We have broken down the Prioritization Matrix offered as a guideline into 4 separate matrices or tables.

Individual Indicators	Environmental Aspects			Social Aspects		
	Climate	Ecosystem Health	Materials Footprint	Human Health	Community Awareness/ Reputational Benefit	Learning/Research Opportunities
Knowledge of climate change, resource depletion,etc.;	4	4	3	3	3	3
Involvement in environmental organizations (on campus/off campus)	4	4	4	3	4	3
Frequency of alternate travel modes(eg. walking, biking, AATA, Nite Owl)	3	4	4	4	4	3
Discussions of environmental issues in class	4	4	4	4	4	4
Knowledge of what can be recycled on campus	4	4	5	3	3	3
Importance of--conserving energy, reducing consumption, organic food, etc	4	4	4	4	4	4
Use of reusable bags	3	4	5	3	4	4
Car ownership and use	4	3	3	3	3	4
Trade-offs -- priority of environment/sustainability compared to other local, world issues	4	4	4	4	4	4
Use of campus & community green spaces-Arboretum,Botanical Gardens, Gallup Park, Hudson Mills,etc	3	4	4	5	4	3
Participation in EarthFest	4	4	4	4	5	4
Awareness of public transportation options	4	3	3	4	4	3
Awareness of impacts of drinking bottled water	3	5	4	4	4	3
Bike ownership & use during warm weather & cold weather months	4	3	3	4	4	3
Unplug appliances when leaving office/home	4	3	3	3	3	3
Drink bottled water?; # bottles/wk	3	4	4	4	4	3
Printing habits (eg. 2-sided printing)	3	3	4	3	3	3
Eco-friendly alternatives for cleaning products and grounds keeping products	3	5	4	4	3	3
time spent outdoors	3	4	4	5	4	3

The higher the number, the stronger the relationship

Table 8. Relationships between Individual Indicators and Sustainability Themes

Generic Indicators	Economic Aspects: Capital Costs	Economic Aspects: Operating Costs	Economic Aspects: Payback	Environmental Aspects: Climate	Environmental Aspects: Ecosystem Health	Environmental Aspects: Materials Footprint	Social Aspects: Human Health	Social Aspects: Community Awareness/ Reputational Benefit	Social Aspects: Learning/Research Opportunities
Student Involvement in Sustainability Organizations (# of students)	3	3	1	4	4	4	3	5	4
Pesticide Load (pounds used annually)	3	2	2	3	5	4	4	3	3
Local Food (proportion of locally grown/processed food)	4	3	1	4	4	5	4	4	4
Sustainability Grants (# of grants/contracts)	3	2	1	4	3	3	3	3	3
Sustainability Projects (# on campus projects)	2	2	1	4	4	4	4	4	4
Bicycle Ridership (# of parked bikes)	4	4	1	4	4	4	5	4	3
Parking Permits (# of permits issued)	3	2	1	4	3	3	4	3	4
Small Deliveries (# of delivery orders under $50)	3	2	1	5	4	5	3	3	3
Sustainability Events (# of events promoted)	2	1	1	3	3	3	3	4	3
Sustainability News Stories (# of stories published)	2	1	1	3	3	3	3	4	3

The higher the number, the stronger the relationship

Table 9. Relationships between Generic Indicators, Costs, and Sustainability Themes

	Survey Strategy Cost Comparison	Economic Aspects		
		Capital Costs (initial)	**Operating Costs (annual)**	**Payback**
Strategies for Surveying Students	Plan A: Incoming Freshmen: Supplemental Questions as Part of the CIRP Survey	**1**	**1**	**1**
	Plan B: Surveys of students in Large Classes Using iClickers to Ask Questions	**2**	**2**	**1**
	Plan C: Surveys of Graduating Students	**4**	**3**	**1**
	Plan D: Surveys that Follow Students Over Time	**4**	**5**	**1**
	Plan E: Students Using Cross Sectional Surveys	**4**	**3**	**1**
	Plan F: Surveys of all Students Using a Combined Panel and Cross Sectional Design	**5**	**5**	**1**
Strategies for Surveying Faculty/Staff	Plan A: Survey of Building Occupants	**5**	**4**	**2**
	Plan B: Faculty/Staff Using Cross Sectional Surveys	**4**	**3**	**2**
	Plan C: Panel Study of New Faculty and Staff Hires	**3**	**4**	**2**

The larger the number, the greater the costs. The scale is 1=< $20K,2=$20-29.9K, 3=$30-39.9K, 4=$40-49.9K, 5=$50K or more

Table 10. Comparative Costs of Alternative Survey Plans

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	General	Transportation	Building (use)	Food	Recycling/Purchasing	Land/Water
INDIVIDUAL						
Knowledge, awareness, understanding	Knowledge of specific UM environ. policies; Awarensss of annual UMs annual Environ. Report; Knowledge of environ. literacy requirement; Knowing how to get involved w/ sustainability groups at U-M; Knowing how to get involved w/ sustainability activities in community;	Knowledge of free AATA service; Awareness of bus schedules & bus stop locations	Awareness of environmental controls (lights, heat, A/C); Awareness of building features energy saving devices, recycled bldg material, etc.:;	Interest in gardening/campus farm/agriculture--why interested?; Knowledge or green/organic labeling on food products;	Awareness of EnergyStar certification when purchasing appliances/equipment at home (all) & at work (faculty & staff); Which of 3 Rs (reduce, reuse, recycle) has most impact?; Where e-waste recycling centers are located?;	Awarness of campus and community green spaces; Awareness of benefits of land/water/ecosystem services/biodiversity;
Engagement, Commitment	Degree of support of specific UM enviro policies; Made suggestions on how to be more sustainable; Involvement in "green" organizations (social and political activism);				Willingness to share equipment--faculty/staff; How far are you willing to travel to destination;	Self-defined as "outdoorsy" or as an environmentalist; Avg length of time in shower willingness to: conserve H2O
Behavior	Purchase or "organic"/eco clothing # discussions about sustainability; Sources of sustainability-related information/news (print, online, social media etc) tapped & frequency	Why not use alternate travel mode; Telecommuting (% of time per week work from home); Does transit system meet needs?; Mode of travel to Metro Airport; frequency of van pool use	Absenteeism, performance impacts of sick bldgs.;	Vegan or vegetarian? ; Own/use a reusable H2O bottle; When eating out, where?(sustainable kitchens, restaurants serving organic or locally-sourced food, etc); Buy farmer's market products? on-campus? elsewhere?; Access to food stores, etc; Satisfaction with access;	Communication mode--email vs. hard copy; Types of purchasing--packaging; Consolidated purchases--purchasing agents; % EnergyStar purchases by type; donations to thrift stores/charities; how deal with old/broken equipment?;	
GENERIC, AGGREGATE						

	Comparative national sustainability ranking; total $ spent on sustainability initiatives; % of UM investments in sustainable/responsible investments; %internal $ for enviro activities/research; % of donations/contributions to sustainability initiatives; # course field trips re: sustainability (Students, Faculty); # of schools w/ envir. literacy requirement; # places giving 'discounts' on campus for using reusable cup/bag etc wearing Planet Blue T-shirts mention of sustainability by tour guides;;	Times throughout year; van pool participation Average distance from residence to bus stop; Satisfaction with commute time; annual MSA-sponsored trips to Metro Airport; Campus bus ridership; AATA ridership	Amount (lbs) of recycling/person/bldg; % of bldgs with motion sensors, energy efficient lighting, daylight sensors, etc.; ISR pilot study questions	# water bottles in vending machines; # bottle filling stations % organic/local food purchases; % of dining hall meals w vegetarian options; % locally purchased foods (locally=within 100 miles); amount of "good" fish purchased; # of nearby food stores selling organic food	Paper (reams)/yr purchased, used; # OfficeMax orders/yr--$ spent annually/per capita (inflation adjusted); # of 0 waste events;	Incidence of campus recreation equipment rentals; # sales/$ spent-outdoors gear at local shops; Ratio of native to non-native plants on campus; % of recycled/reclaimed water used
Inferred and Observed Behaviors	Attendance at sustainability related events; Donations to charitable sustainability groups on campus,in AA, other; Sustainability related books read/heard of; checked out of library; # of events listed on Facebook; # hits - UM sustainability websites (Graham Inst.,etc.); # of likes- Facebook; pledge signitures at EarthFest; Acres of permeable paving; sustainability issues raised in professional training for faculty/staff?; enrollment in sustainability related courses; number of news stories on UM Sustainability website; # sustainability event promoted on UM Sustainability website; number of sustainability-related jobs posted on UM Sustainability website;# of sustainability projects on campus;					

Appendix Table 1. Additional Indicator Summary

Alternative Plans for Collecting Indicators from Students and Faculty/Staff	1st Year		6 Year Program	
	SRC Administration	**OCS Admin. + SRC Consulting**	**SRC Administration**	**OCS Admin. + SRC Consulting**
Student Plan A - CIRP Survey*	**-**	**15k**	**-**	**71k**
Student Plan B - iClicker Questions*	**-**	**20k**	**-**	**76k**
Student Plan C - Graduating Student Survey	**45k**	**32k**	**238k**	**180k**
Student Plan D - Incoming Student Panel	**46k**	**32k**	**357k**	**209k**
Student Plan E - Cross-Sectional Survey	**45k**	**32k**	**238k**	**180k**
Student Plan F - Panel & Cross-Sectional Survey	**55k**	**36k**	**320k**	**200k**
Faculty/Staff Plan A - Building Occupant Survey	**55k**	**33k**	**302k**	**195k**
Faculty/Staff Plan B - Cross-Sectional Survey	**44k**	**31k**	**257k**	**184k**
Faculty/Staff Plan C - Incoming Faculty Panel	**35K**	**29k**	**277k**	**190k**

*SRC assistance is not needed due to the relatively straightforward nature of these plans. Accordingly, costs for these options do not include SRC assistance.

Appendix Table 2. Cost Estimates for Collecting Culture Indicators for First Year and Over 6 Years

	Cost Estimate Summary	Capital Costs	Operating Costs
Generic Indicators	Student Involvement in Sustainability Organizations (# of students)	NA	$75
	Pesticide Load (pounds used annually)	NA	$163
	Local Food (proportion of locally grown/processed food)	NA	$327
	Sustainability Grants (# of grants/contracts)	NA	$327
	Sustainability Projects (# on campus projects)	NA	$163
	Bicycle Ridership (# of parked bikes)	NA	$817
	Parking Permits (# of permits issued)	NA	$163
	Small Deliveries (# of delivery orders under $50)	NA	$245
	Sustainability Events (# of events promoted)	NA	$163
	Sustainability News Stories (# of stories published)	NA	$163
Strategies for Surveying Students	Plan A: Incoming Freshmen: Supplemental Questions as Part of the CIRP Survey	$15,000	$15,000
	Plan B: Surveys of students in Large Classes Using iClickers to Ask Questions	$20,000	$20,000
	Plan C: Surveys of Graduating Students	$45,000	$35,000
	Plan D: Surveys that Follow Students Over Time	$46,000	$55,000
	Plan E: Students Using Cross Sectional Surveys	$45,000	$35,000
	Plan F: Surveys of all Students Using a Combined Panel and Cross Sectional Design	$55,000	$55,000
Strategies for Surveying Faculty/Staff	Plan A: Survey of Building Occupants	$55,000	$50,000
	Plan B: Faculty/Staff Using Cross Sectional Surveys	$44,000	$40,000
	Plan C: Panel Study of New Faculty and Staff Hires	$35,000	$45,000

Survey cost estimates represent full Institute for Social Research Survey Research Center participation.

Cost savings of @ 30% would be expected if survey were to be conducted by OCS staff with ISR consultation.

Appendix Table 3. Summary of Cost Estimates

Appendix F: Listing of Faculty, Staff, Students and External Contacts Involved

ENVIRONMENTAL SUSTAINABILITY EXECUTIVE COUNCIL	
Name	**Title**
Mary Sue Coleman	U-M President
Stephen R. Forrest	Vice President for Research
Philip J. Hanlon	Provost and Executive Vice President for Academic Affairs
E. Royster Harper	Vice President for Student Affairs
Jerry A. May	Vice President for Development
Lisa Rudgers	Vice President for Global Communications and Strategic Initiatives
Ora Hirsch Pescovitz	Executive Vice President for Medical Affairs
Timothy P. Slottow	Executive Vice President and Chief Financial Officer

CAMPUS SUSTAINABILITY INTEGRATED ASSESSMENT STEERING COMMITTEE		
Name	**Title**	**Unit**
Tony Denton	Executive Director of University Hospitals and Chief Operating Officer	Health System
Loren Rullman	Associate Vice President for Student Affairs	Student Affairs
Rob Rademacher	Assistant Athletic Director	Athletics
Brad Canale	Executive Director of Advancement	College of Engineering
Knute Nadelhoffer	Biological Station Director	College of Literature, Science, and the Arts
Phil Hanlon/Martha Pollack	Vice Provost for Academic & Budgetary Affairs	Office of the Provost
Hank Baier	Associate Vice President for Facilities and Operations	Facilities and Operations
Don Scavia	Director and Special Counsel to the U-M President for Sustainability	Graham Sustainability Institute
Terry Alexander	Executive Director	Office of Campus Sustainability

CAMPUS SUSTAINABILITY INTEGRATED ASSESSMENT INTEGRATION TEAM	
Name	**Unit**
Andy Berki	Office of Campus Sustainability
Graham Brown	Student Sustainability Initiative
John Callewaert	Graham Sustainability Institute
Bill Canning	Student Affairs
Sarah Crawford	Graham Sustainability Institute
Poonam Dagli	Student Sustainability Initiative
Matt Gacioch	Student Sustainability Initiative
Devi Glick	Student Sustainability Initiative
Sue Gott	Architecture, Engineering and Construction
Drew Horning	Graham Sustainability Institute
Barb Hagan	Office of Campus Sustainability
Ken Keeler	Office of Campus Sustainability
Megan Loll	Office of Campus Sustainability
Katie Lund	Graham Sustainability Institute
Lydia McMullen-Laird	Student Sustainability Initiative
Jim Michels	Office of Campus Sustainability
Samantha Schiebold	Student Sustainability Initiative
Ryan Smith	Student Sustainability Initiative

CAMPUS SUSTAINABILITY INTEGRATED ASSESSMENT ANALYSIS TEAMS			
Team	**Name**	**Role**	**Unit / Program**
Buildings			
	Geoffrey Thun	Faculty Lead, Phase 1 & 2	Taubman College of Architecture and Urban Planning
	Zain Abuseir	Student Lead, Phase 1 & 2	Architecture
	Mary O'Malley	Student Lead, Phase 1 & 2	Architecture
	Anthony Ambroselli	Research Assistant, Phase 2	Business Administration
	Thao Do	Research Assistant, Phase 1	Architecture
	Julie Janiski	Research Assistant, Phase 2	Architecture
	Tarlton Long	Research Assistant, Phase 1 & 2	Architecture
	Katie Miller	Research Assistant, Phase 1	Architecture & Business Administration
	Nagapooja Seeba Om Prakash	Research Assistant, Phase 2	Natural Resources & Environment
	Chelsea Snodgrass	Research Assistant, Phase 2	Civil Engineering
	Dan Weissman	Research Assistant, Phase 1	Architecture

Energy			
	Greg Keoleian	Faculty Lead, Phase 1 & 2	School of Natural Resources and Environment
	Alphonse Anderson	Research Specialist, Phase 1	Center for Sustainable Systems
	Robb De Kleine	Research Specialist, Phase 2	Center for Sustainable Systems
	Mike Anderson	Research Assistant, Phase 1	Astronomy & Astrophysics
	Jarett Diamond	Research Assistant, Phase 1 & 2	Mechanical Engineering
	Tammy Dorje	Research Assistant, Phase 2	Business Administration
	Patty Liao	Research Assistant, Phase 1 & 2	Natural Resources & Environment
	Claire Santoro	Research Assistant, Phase 1 & 2	Natural Resources & Environment
	Matt Seagraves	Research Assistant, Phase 2	Natural Resources & Environment
	Gaurang Sethi	Research Assistant, Phase 2	Natural Resources & Environment
	Dave Thoman	Research Assistant, Phase 1	Public Policy
	Ajay Varadharajan	Research Assistant, Phase 1	Engineering and Natural Resources & Environment
	Dan Wilson	Research Assistant, Phase 2	Energy Systems Engineering
Transportation			
	Jonathan Levine	Faculty Lead, Phase 1 & 2	Taubman College of Architecture and Urban Planning
	Brennan Madden	Student Lead, Phase 1 & 2	Natural Resources & Environment
	Joel Batterman	Research Assistant, Phase 2	Urban & Regional Planning
	Anika Fassia	Research Assistant, Phase 1	Social Work
	Regan Fox	Research Assistant, Phase 2	Business Administration
	Te-Ping Kang	Research Assistant, Phase 2	Urban & Regional Planning
	Christopher Machielse	Research Assistant, Phase 1 & 2	Business Administration
	Evan Mallen	Research Assistant, Phase 2	Urban & Regional Planning
	Sarah Mandlebaum	Research Assistant, Phase 1	Public Health
	Gretchen Miller	Research Assistant, Phase 1	Urban & Regional Planning
	Julia Roberts	Research Assistant, Phase 2	Urban & Regional Planning
	Elias Schewel	Research Assistant, Phase 2	Urban & Regional Planning
Land & Water			
	Stan Jones	Faculty Lead, Phase 1 & 2	School of Natural Resources and Environment
	Jessica Neafsey	Student Lead, Phase 1	Landscape Architecture
	Robin Burke	Research Assistant, Phase 2	Landscape Architecture
	Jennifer Casler	Research Assistant, Phase 1	Business Administration
	Sander Dolder	Research Assistant, Phase 2	Business Administration
	Jeffrey Dube	Research Assistant, Phase 2	Landscape Architecture
	Elizabeth Durfee	Research Assistant, Phase 2	Natural Resources & Environment
	Amy Fingerle	Research Assistant, Phase 1	Program in the Environment

	Tina Fix	Research Assistant, Phase 1	Landscape Architecture
	Caitlin Harren	Research Assistant, Phase 2	Natural Resources & Environment
	Mary Henja	Research Assistant, Phase 2	Landscape Architecture
	Kevin Li	Research Assistant, Phase 2	Landscape Architecture
	Virgilio Sklar	Research Assistant, Phase 1	Urban & Regional Planning and Law
Food			
	Larissa Larsen	Faculty Lead, Phase 1 & 2	Taubman College of Architecture and Urban Planning
	Kevin McCoy	Student Lead, Phase 1 & 2	Urban & Regional Planning
	Bradley Detjen	Research Assistant, Phase 1	Chemical Engineering
	Kathleen Elmquist	Research Assistant, Phase 2	Program in the Environment
	Alysia Giatas	Research Assistant, Phase 1 & 2	Urban & Regional Planning
	Peter Grella	Research Assistant, Phase 2	Natural Resources & Environment
	Jing Huang	Research Assistant, Phase 2	Urban and Regional Planning and Business Administration
	Susan Johnson	Research Assistant, Phase 1	Urban & Regional Planning
	Noam Kimelman	Research Assistant, Phase 2	Public Health and Urban & Regional Planning
	Margo Ludmer	Research Assistant, Phase 1	Program in the Environment
	Breanna Shell	Research Assistant, Phase 1 & 2	Urban & Regional Planning
	Gregory Walz-Chojnacki	Research Assistant, Phase 2	Public Policy
Purchasing & Recycling			
	Olivier Jolliet	Faculty Lead, Phase 1	School of Public Health
	Brian Talbot	Faculty Lead, Phase 2	Ross School of Business
	Julian Dautremont-Smith	Student Lead, Phase 1	Business Administration and Natural Resources & Environment
	Kate Harris	Student Lead, Phase 2	Natural Resources & Environment
	Amy Braun	Research Assistant, Phase 1 & 2	Natural Resources & Environment
	Catherine Dennis	Research Assistant, Phase 2	Landscape Architecture
	Nicole Flores	Research Assistant, Phase 1	Economics and Program in the Environment
	Andrew Henderson	Research Assistant, Phase 1	Public Health
	Dingsheng Li	Research Assistant, Phase 1 & 2	Public Health
	Rachana Patel	Research Assistant, Phase 2	Business Administration and Natural Resources & Environ
	Jessica Ruff	Research Assistant, Phase 1	Spanish and Program in the Environment
	Edward Schexnayder	Research Assistant, Phase 1	Public Policy and Law
	Mary Sell	Research Assistant, Phase 2	Natural Resources & Environment
	Kathryn Thudium	Research Assistant, Phase 2	Political Science and Program in the Environment
	Ashish Vatsal	Research Assistant, Phase 2	Business Administration

Culture			
	Robert Marans	Faculty Lead, Phase 1 & 2	Institute for Social Research
	Brett Levy	Student Lead, Phase 1 & 2	Educational Studies
	Tal Avrahami	Research Assistant, Phase 2	Natural Resources & Environment
	Jazmine Bennett	Research Assistant, Phase 1 & 2	Natural Resources & Environment
	Brett Bridges	Research Assistant, Phase 2	Business Administration
	Kevin Bush	Research Assistant, Phase 1	Urban & Regional Planning
	Kara Davidson	Research Assistant, Phase 2	Natural Resources & Environment
	Courtney Doman	Research Assistant, Phase 1	Program in the Environment
	Lael Goodman	Research Assistant, Phase 2	Natural Resources & Environment
	Celia Haven	Research Assistant, Phase 1	Program in the Environment
	Beatrice Holdstein	Research Assistant, Phase 1 & 2	Program in the Environment
	Julie Janiski	Research Assistant, Phase 1	Architecture
	Ryan Smith	Research Assistant, Phase 1 & 2	Mechanical Engineering
8 Faculty Leads representing 5 units			
2 Research Specialists			
77 students total representing 18 programs			
	Phase 1: 43 students (34 graduate students, 9 undergraduates)		
	Phase 2: 52 students (48 graduate students, 4 undergraduates; includes 7 MBAs who conducted financial analyses for Phase 2 recommendations and 3 students who completed a special bicycle parking audit for the transportation team)		
	17 students contributed to both Phase 1 and Phase 2 (most students continued with the same team, one student joined a different team in Phase 2)		

STAFF CONSULTED/ENGAGED	
Name	**Unit**
Tracy Artley	Grounds & Waste Management
Randall Burns	University Hospitals& Health Centers
Christopher Carr	University Unions
Tony Catchot	Architecture, Engineering and Construction
Nancy Connell	Strategic Communications
Steve Dolan	Parking & Transportation Services
Mark Eboch	Architecture, Engineering and Construction
Michelle Eleby	University Hospitals & Health Centers
Eric Farrell	University Hospitals& Health Centers
Bob Grese	Matthaei Botanical Gardens and Nichols Arboretum
Elizabeth Halloran	Development
Yoshiko Hill	Utilities & Plant Engineering

Keith Johnson	Transportation Services
Renee Jordan	Transportation Services
Pam Koczman	Occupational Safety & Environmental Health
Kris Kolevar	Plant Operations
Dennis Krieg	Maintenance Services
David Lampe	Communications
Mike Lee	Residential Dining Services
Sandra Lowry	Residential Dining Services
Mary Ellen Lyon	Property Disposition
Deanna Mabry	Architecture, Engineering and Construction
Kallie Michels	Communications
Merrill Mullis	Procurement Services
Jennifer Nord	Occupational Safety & Environmental Health
Stefanie Nurmi	Procurement Services
Lisa Pappas	Graham Sustainability Institute
Frances Mueller	U-M Space Utilization Initiative
Tom Peterson	University Hospitals & Health Centers
Jeffrey Rabbit	Procurement Services
Kenn Rapp	Grounds & Waste Management
Heather Rice	Occupational Safety & Environmental Health
Stephanie Riegle	Office of the Provost
Richard Robben	Plant Operations
Marina Roelofs	Architecture, Engineering and Construction
Susan Shields	Business Engagement Center
Mike Shriberg	Graham Sustainability Institute
Steve Sinelli	Office of Financial Analysis
Keith Soster	University Unions-Food Service
Bill Verge	Utilities & Plant Engineering
Robert Yecke	University Unions
Virginia Wait	Resource Planning and Management
Bonny Webber	Strategic Contract Management
Cythia Wilbanks	Government Relations
Steve Woldt	Utilities & Plant Engineering
Greg Wright	Housing Planning and Design

EXTERNAL CONTACTS		
Name	**Title**	**Organization**
Jennifer Battle	Assistant Director Campus Sustainability	Michigan State University
Terry Black	Maintenance Manager	Ann Arbor Transit Authority
Skiles Boyd	Vice President, Environmental Management & Resources	DTE Energy
Kate Brass	Ecomagination Program Manager	GE Energy
Hilary Davidson	Director, Sustainability & Community Affairs	Duke Energy
Laura Drabczyk	Director of Environmental Health Safety & Emergency Management	University of Michigan- Dearborn
Lisa Drake	Natural Resources Director	Stonyfield Farm, Inc.
John Erb	President	Erb Family Foundation
Mike Garfield	Director	Ecology Center
Jan Hallberg	Information Technology Manager	Ann Arbor Transit Authority
Neil Hawkins	Vice President of Sustainability and Environment	The Dow Chemical Company
Mike Lane	Environmental Health & Safety Manager	University of Michigan-Flint
Sue McCormick	Public Services Area Administrator	City of Ann Arbor
Verna McDaniel	County Administrator	Washtenaw County
Carol Miller	Professor & Chair, Civil Engineering	Wayne State University
Jay Miller	Chief, Facilities	VA Ann Arbor Healthcare System
Steven Moore	Energy & Sustainability Manager	Eastern Michigan University
Matthew Naud	Environmental Coordinator	City of Ann Arbor
Dale Petty	Professional Faculty	Washtenaw Community College
Dave Raymond	Service Delivery Leader for Planning	St. Joseph Mercy Hospital
Lisa Reynolds	Multi-Unit Accounts Manager	Sysco Detroit
Laura Rubin	Executive Director	Huron River Watershed Council
Cindy Shea	Director, Sustainability Office	University of North Carolina - Chapel Hill
Amy Short	Director of Sustainability	University of Minnesota
Tony VanDerworp	Director, Economic Development & Energy	Washtenaw County, Planning & Environment
Anne Wallin	Director, Sustainable Chemistry	The Dow Chemical Company
Craig Westcott	Director, Samson Environmental Center	The Darrow School

CAMPUS COMMUNITY IDEAS/COMMENTS AND TOWN HALL PARTICIPANTS				
Ideas and Comments	**Number**		**Town Halls**	**Registrants**
			January 2010	311
Submitted by Staff	96		April 2010	170
Submitted by Students	55		July 2010	92
Submitted by External Contacts	12		October 2010	117
Total	**163**		**Total**	**690**
Total Ideas and Comments	**189**		**Total Unique Participants**	**292** (many attended more than one event)
(some individuals submitted more than one comment or idea)			Staff	147
			Students	126
			External	19
Staff Units Represented: 101				
Student Programs Represented: 27				

Please direct additions/corrections to: GrahamInstitute-IA@umich.edu

Appendix G: Comments and Ideas Summary

Throughout the course of the IA, 189 comments and ideas were received via the project website. Comments and ideas were batched each week and sent to the appropriate teams for consideration and response. Comments and ideas below have been summarized by topic and ranked in order of frequency. Everyone who submitted a comment or idea received an initial thank you and explanation of how their submission would be processed. At the end of the project they will also receive information on how their submission was utilized.

		Commenting Team							
Proposal ID	Sustainability Topic	Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	Response
417, 435, 479, 486, 496, 498, 511, 516, 530, 532, 533, 535, 538, 556, 557, 558, 569, 572, 574, 582, 598, 724	Upgrading recycling containers on campus (make more clear what is able to be recycled & have more of them)						x		P&R- In July 2010, the City of Ann Arbor is changing its recycling system, which means that U-M will be changing as well. We hope that the new labeling will be understandable. We will work with Waste Management Services to ensure that sufficient recycling receptacles are available.
411, 412, 467, 508, 532, 547, 562, 585, 609, 813	Native Landscapes					x			L&W- In our Phase 1 report, we are promoting a strict native plant policy to enhance campus biodiversity.
503, 517, 520, 524, 534, 548, 555, 565, 638	Change default font for email to century gothic & default printers on all computers to 2-sided						x		P&R- We are hoping to work with ITCS on double-sided printing (see http://www.itd.umich.edu/sites/printing/duplex.php). Changing email font is something that many users may be resistant towards.
416, 426, 512, 519, 526, 532, 569, 622, 632	Composting leftover food or sell as animal feed				x		x		Food- Addressed in Phase I report - Recommendation #4: Reducing Campus Food Waste. P&R- In Phase I, this was addressed by the Food team; in Phase II, we hope to include a study of composting as part of a U-M Life Cycle Analysis.
468, 475, 483, 489, 518, 535, 537, 538, 596	Use only recycled and biodegradable food packaging, or use washable utensils				x		x		Food- Addressed in Phase I report - Recommendation #4: Reducing Campus Food Waste. P&R- This was beyond the scope of the Purchasing & Recycling team's analysis for Phase I. In Phase II, we will work with the Food team to address this suggestion.
414, 477, 480, 575, 605, 621, 629, 630, 840	Create conditions that favor public transportation like walking & biking			x					Transportation- The Transportation team recommends that conditions that favor walking and biking be implemented into all future master plans for the University.
448, 472, 474, 487, 497, 510, 527, 551	Motion-activated lights & power strips at work stations		x						Energy- This comment should be redirected to Buildings team. This type of technology is being implemented as part of the Planet Blue Operations Teams.

Proposal ID	Sustainability Topic	Commenting Team							Response
		Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	
410, 470, 484, 493, 502, 567, 609, 618	On-campus farm	x			x	x			Culture- The Food Team has suggested this as one of their major recommendations, and the Culture Team envisions the possibility of integrating this into sustainability courses (recommendation #3) and studies of how this farm might influence various stakeholders' perceptions of our campus (recommendation #5, additional recommendation # 11). Food- Addressed in Phase I report - Recommendation #3: Establish a farm on-campus. L&W- The food team is addressing this, though we will likely collaborate with them on choosing a location in Phase 2.
469, 488, 544, 595, 627, 629, 630, 840	Bus system changes: routing, solar powered transit system/rapid transit			x					Transportation- The Transportation team researched the implementation of streamlining the city bus system with that of the campus bus line as demonstrated by Michigan State University. The team has also recommended increases in both transit speed and inter-modal connections.
450, 487, 499, 540, 562, 619, 624	Reduction/elimination of bottled water	x			x		x		Culture- "Eco-reps" and RAs could help to prepare students to accept this policy and its rationale (recommendation #2), and through sustainability training, faculty and staff could learn the same (additional recommendation #2). In this way, these stakeholders would also be encouraged to reduce or eliminate their own use of bottled water beyond the campus community. Food- Addressed in Phase I report - Recommendation #1: Elimination of bottled water from campus. P&R- In Phase I, the Food team addressed bottled water. In Phase II, we hope to look into the possibility of setting a U-M policy to reduce (or eliminate) its use.

Proposal ID	Sustainability Topic	Commenting Team: Culture	Energy	Transportation	Food	Land and Water	Purchasing and Recycling	Buildings	Response
434, 449, 529, 531, 625, 631	Use new technologies to reduce waste & increase energy (BigBelly Solar compactors, Plasma gasification tool to convert trash into electricity, recirculating)		x				x	x	Energy- Thank you. We have discussed waste-to-energy at the power plant. The feasibility of this idea needs further analysis. Re: PropID 625 - We agree that moving toward a standardized and transparent GHG reporting framework is the way to go. We already have a good start on this effort. GHGs, among other indicators, are currently reported in the publicly accessible Environmental Data Repository (click on "Raw Data Overview" http://www.oseh.umich.edu/reporting.html). We will recommend expanding the boundaries of this GHG accounting framework and advocate that this data be used more effectively as drivers for renewable energy implementation on campus. P&R- This is beyond the scope of the Purchasing & Recycling team's analysis. However, Waste Management Services would be interested in such technologies, provided they are cost-effective. Buildings- Our Phase I recommendations include a requirement to evaluate the feasibility of installing on-site renewable energy production whenever there is a new construction or major renovation project. We also recommend strategies to encourage building material salvaging and reuse.
454, 546, 553, 564, 620, 628	Curriculum changes to encourage sustainability in students	x							Culture- Our report's third recommendation incorporates this by encouraging the development of a "global awareness" or "ecological literacy" requirement for all undergrads
514, 545, 568, 610, 617, 840	Bike rentals - bike sharing program & better parking			x					Transportation- The Transportation team conducted an analysis featuring photographs and tables of unsafe cycling zones and insufficient and uncovered bike parking on campus as reported by the campus community. Additionally, a group of SNRE students created a detailed report on the feasibility of implementing a bike-sharing program at UM.
472, 521, 551, 563, 584	No air conditioning in dorms & reduce it & heat in other buildings by limiting access to thermostats		x					x	Energy- Suggest comment be redirected to Buildings team and Culture team. Buildings- Our Phase 1 recommendations address energy reduction goals established according to building type and occupation schedules. Some specific implementation strategies to achieve these goals are discussed, but there are many more we have yet to incorporate. This approach would most likely require integration with the culture teams recommendation so incoming students would understand the decision to limit indoor climate control.

Proposal ID	Sustainability Topic	Commenting Team: Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	Response
515, 561, 584, 616, 623	Mandatory training for staff & monetary incentives for Dept's	x					x		Culture- This is addressed in three of our recommendations: the "cultural liaison" (first recommendation) could explore means of doing this; or it could be addressed through our additional recommendations #1 & #2, which suggest respectively that there are department sustainability plans & that all staff learn about sustainability issues. P&R- A Phase I recommendation - to be followed up in Phase II - is to have an enforced purchasing policy, which will require training for all U-M staff that procure goods for their departments.
538, 564, 566, 571, 609	Wind/solar power for buildings		x						Energy- Thank you for your suggestions. We have initiated and will continue analyzing the potential for new solar and wind power projects, among other feasible technologies, at UM. Currently, a 33kW solar PV array is on the Dana Building roof, a large solar water heating system is on the central power plant roof, and UM recently announced an agreement to purchase significant amounts of wind energy from wind turbines in northern MI (please see: http://www.ns.umich.edu/htdocs/releases/story.php?id=7589)
470, 613, 624, 635	Local food purchasing				x				Food- Addressed in Phase I report - Recommendation #2: 20% local food by 2020.
509, 528, 554, 727	Encourage electronic communication over paper/encourage faculty to use Ctools for paper submissions 7 handouts rather than paper	x							Culture- This could be addressed by the "cultural liaison (our first recommendation) or our recommendation that each academic unit develop a sustainability plan for its own operations (additional recommendation #1).
471, 579, 580	Repair/repurpose rather than replace equipment. Donate rather than trash/recycle when able	x					x		Culture- The cultural liaison (recommendation #1) could initiate efforts to help staff and faculty use fewer resources, and department sustainability plans and requirements (recommendations #1 and #2) would likely lead to this, as well. Furthermore, OCS and Procurement Services could train administrative staff members in methods of office resource reduction and reuse (additional recommendation #5). P&R- This is one of the Purchasing & Recycling team recommendation for Phase I. In Phase II, we will continue to explore this idea.
473, 583, 609	Conservation & use of rain water					x			L&W- In our Phase 1 report, we are promoting on-site infiltration of stormwater across all campus landscapes.
427, 436, 682	Use of landscaping tools that are manual or electric instead of gas					x			L&W- In our Phase 1 report, we emphasize hand weeding and use of two-stroke (vs four stroke) engines. We also call for a reduction in mowing practices.

Proposal ID	Sustainability Topic	Commenting Team							Response
		Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	
481, 539, 723	Work-from-home options for non-supervisory staff	x		x					Culture- This suggestion could be incorporated into each department's sustainability plan (additional recommendation #1), and the cultural liaison could work with departments to encourage and facilitate this option (recommendation #1). Transportation- The team recommends establishing one or two unified campus teleconferencing systems that would end the differing technology and fragmented resources plaguing the University's various departmental systems.
549, 564, 837	Use more efficiently designed lighting fixtures such as light tubes		x						Energy- Suggest the comment be redirected to Buildings Team. Also, please see: http://www.planetblue.umich.edu/home.php
485, 637	"Green advocate" employee for each building/dorm or group of buildings							x	Buildings- This seems like a possible area for collaboration between the Buildings and Culture Teams for Phase II. Culture has already recommended instituting Eco-Reps for all facilities and educating RA's for sustainability outreach.
422, 433	Use of IT to reduce energy costs		x						Energy- Suggest comment be redirected to Buildings team.
613, 633	Food labeling systems to show how local/sustainable menus options are				x				Food- Addressed in Phase I report - Recommendation #5: Comprehensive Food Labeling System.
614, 626	Encouraging students to be conscious about the amount of food they take	x							Culture- This could be part of what "eco-reps" address, and in Phase 2, we can be more specific about the issues eco-reps will emphasize.
476, 597	Elevators should idle when not in use (rather than returning to ground floor automatically), encourage stair use		x					x	Energy- Suggest comment be redirected to Buildings team. Buildings- Our Phase 1 recommendations include establishing targets for energy reduction based on dynamic building occupation and typology. This strategy could be incorporated into our Phase 2 suggestions for reaching energy targets in buildings where it is most appropriate.
490, 559	Eliminate mailed appointment reminders from health system	x							Culture- This could be addressed by the "cultural liaison (our first recommendation) or our recommendation that each academic unit develop a sustainability plan for its own operations (additional recommendation #1).
560, 578	Empty trash less frequently	x							Culture- This could be addressed by the "cultural liaison (our first recommendation) or our recommendation that each academic unit develop a sustainability plan for its own operations (additional recommendation #1).
570, 408	Encourage train transportation rather than air for travel &/or purchasing carbon offsets			x					Transportation- The Transportation team has benchmarked peer institutions efforts around off-campus travel, including unfruitful attempts at purchasing carbon offsets, but have found optimal methods to increase public transit access to popular destinations like the airport and Detroit. Regarding air travel, the primary barrier to reforming these practices is political.

Proposal ID	Sustainability Topic	Commenting Team							Response
		Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	
478, 513	New buildings held to specified energy performance level		x					x	Energy- Addressed by Buildings team and new UM LEED Silver / Energy Performance policy for new construction. Please see: http://sustainability.umich.edu/news/u-m-makes-major-commitment-green-buildings-0. Buildings- Our Phase 1 recommendations include a suggestion to adopt LEED Silver Certification with a 30% improvement on energy consumption over ASHRAE 90.1 as the new buildings standard. The University has already adopted these measures.
427, 474	No-idling policy for vehicles at campus work sites	x		x					Culture- The cultural liaison (recommendation #1) could initiate efforts to educate drivers about the negative effects of idling, and the OCS could investigate the best methods for influencing drivers' behavior in this regard (additional recommendation #14). Transportation- UM Plant Ops has a no-idling policy. UM has also worked with the City of Ann Arbor to extend some kind of no-idling policy to private vehicles on our property, however there appears to be a lack of 'no idling' signs posted.
487, 802	Bathroom upgrades: hand dryers, double flush toilets, faucet aerators							x	Buildings- Our Phase 1 recommendations established targets for reducing water consumption and energy consumption. Efforts to achieve these goals will almost surely involve the installation of more efficient fixtures, as we have seen in many existing retrofits across campus.
447	Contact vendors/mass mailing houses to reduce bulk mail						x	x	P&R- Good idea; in Phase II, we will look into options to encourage departments and units to do this. Buildings- This seems like a recommendation that could be more effectively addressed by the purchasing team.
522	Don't print as many newspapers						x	x	P&R- We are working on making departments aware of their material use, but setting policies for individual departments (such as the Michigan Daily) is unfortunately outside the scope of our study. Buildings- This seems like a recommendation that could be more effectively addressed by the purchasing team.

Proposal ID	Sustainability Topic	Commenting Team: Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	Response
442	Geothermal Energy system/Green roofs		x					x	Energy- A member of the energy team is focusing on geothermal opportunities on campus as a summer intern with UM Utilities. The green roofs idea should be passed to the Buildings Team. Buildings- Our Phase I recommendations include a requirement to evaluate the feasibility of installing on-site renewable energy production whenever there is a new construction or major renovation project. We also recommend developing a campus-wide stormwater management strategy in collaboration with the Land and Water team, which may involve green roofs in appropriate locations.
593	Need strong top-down leadership to promote sustainability goals	x							Culture- This is addressed in five of our recommendations: The "cultural liaison" (our first recommendation) could use various methods to create top-down sustainability efforts. Recommendations #2 (training RAs for dorm leadership) could also create a group of leaders on campus who are committed to sustainability. Also, this could be addressed through our additional recommendations #1 and #2, which suggest respectively that there are department sustainability plans and that all staff learn about sustainability issues; also, our additional recommendation #7 would prepare teachers on campus to educate students about sustainability.
507	Reuse paper at computing sites on campus	x					x		Culture- We have not addressed this issue directly in our report, but it may be worth considering in Phase 2. The cultural liaison (recommendation #1) could initiate efforts to help staff, faculty, and students use fewer paper resources, and "eco-reps" and RAs could encourage this among students (recommendation #2). Furthermore, OCS can work with ITS towards reducing their use of paper resources (implied by additional recommendations #3 and #5). P&R- ITCS is resistant to this, because it requires allowing users to open printer paper trays. Instead, we will focus on encouraging users to recycle paper they do not need.
543	Stop building new buildings & work on greening current ones instead							x	Buildings- Our Phase 1 recommendations prioritize acquiring existing facilities wherever possible, either though retrofits or departmental swap, as opposed to constructing new buildings. Additionally, we have recommended prioritizing renovations based on need for improvement of environmental performance.

Proposal ID	Sustainability Topic	Commenting Team: Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	Response
418	Student kitchen for students who pack their own lunches	x			x			x	Culture- If individuals (faculty, staff, and students) learn about the potential benefits of preparing their own food (recommendations #2, #3, additional recommendations #2, #7), they will be more likely to demand such facilities and incorporate such development into their units' sustainability plans (additional recommendation #1). This is an inquiry that might best be considered further by the buildings team. Noted the importance of this issue and may incorporate within a larger recommendation during Phase II. Buildings- Our Phase 1 recommendations did not include any specific suggestions for space uses or programs within buildings. However, this suggestion seems like it could be incorporated into 'Michiganized' LEED standards. LEED guidelines already include building facilities that encourage sustainable behavior. Additional guidelines could be incorporated by the University to promote sustainable food choices.
413	University land stewardship					x			L&W- In our Phase 1 report, we make many recommendations for better stewardship of land and water, including reducing/eliminating use of pesticides, etc.
536	Use new metric for measuring building performance		x					x	Energy- One of our recommendations will be to develop a new, building-specific GHG footprint metric, determined by electricity and steam use of each building. This metric may also factor in building occupancy and other characteristics and can support occupant awareness efforts. Buildings- Our Phase I recommendations encourage the use of LEED as a design guideline for building design because it is the most widely recognized and is updated to incorporate environmental improvements on a regular basis. However, we have also included specific recommendations for water consumption, indoor air quality, and resource consumption. Additionally, we are proposing a more refined metric for quantifying energy performance on a building by building basis.

Proposal ID	Sustainability Topic	Commenting Team: Culture	Energy	Transpor-tation	Food	Land and Water	Purchasing and Recycling	Buildings	Response
619	New policy at stadium for water bottles	x			x				Culture- We have not addressed this specifically, but it is yet another issue that could be handled by the cultural liaison (recommendation #1) if there is sufficient support for such action. Such a change might also be part of the sustainability plan of the Athletic Department. (Although the Athletic Department is not explicitly mentioned in additional recommendation #1, it would make good sense to include them as one of the groups that would create a sustainability plan.) Food- Noted the importance of this issue and will address further as part of Recommendation #1 during Phase II.
634	Reduce meat consumption (meatless Mondays)				x				Food- Noted the importance of this issue and may embed within Recommendation #4 (Reducing campus food waste) during Phase II.
636	Contract with a shredding company for university-wide shredding						x		P&R- The U-M already has a contract with a shredding company. Individual departments, however, may contract with other companies. In Phase I (and continuing to Phase II), we recommend that all contracts, including for paper-shredding, be university-wide.
803	Tax/charge for plastic bags						x		P&R- This was beyond the scope of the Purchasing & Recycling team's analysis. If economically feasible, the University could continue to explore this idea.
838	Office sharing of parking passes			x					Transportation - Phase II report cites that some units have purchased a blue parking pass for their department to encourage pass sharing among their faculty and staff. This is one way the team recommends providing greater non-price parking incentives, especially for selecting remote parking .

Appendix H: Links to Additional U-M Sustainability Resources

U-M Sustainability	http://sustainability.umich.edu/
Undergraduate Programs	http://sustainability.umich.edu/education/undergraduate
Graduate Programs	http://sustainability.umich.edu/education/graduate
Sustainability Courses and Experts	http://sustainability.umich.edu/education/courses-faculty
Centers, Institutes and Learning Labs	http://sustainability.umich.edu/research/centers
Reports	http://sustainability.umich.edu/research/reports
Operations	http://www.ocs.umich.edu/
Planet Blue Operations Team	http://opsteams.plantops.umich.edu/
Planet Blue Student Ambassador Program	http://sustainability.umich.edu/content/planet-blue-student-ambassador-program
Sustainable Computing	http://sustainability.umich.edu/content/sustainable-computing
Student Opportunities	http://sustainability.umich.edu/involved/students
Faculty and Staff Opportunities	http://sustainability.umich.edu/involved/faculty-staff
News	http://sustainability.umich.edu/news
Planet Blue eNewsletter	http://sustainability.umich.edu/news/enewsletter
Events	http://sustainability.umich.edu/events
Multimedia	http://sustainability.umich.edu/multimedia