WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

GREEN INFRASTRUCTURE & STORMWATER MANAGEMENT MASTER PLAN

2015 CAMPUS MASTER PLAN UPDATE

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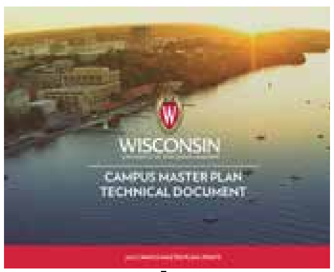
Document Composition

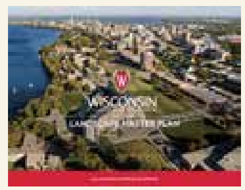
The “2015 Campus Master Plan Update” is comprised of the Executive Summary, the Technical Document, which includes the four (4) supporting appendix documents; Landscape Master Plan, Utility Master Plan, Long Range Transportation Master Plan, and Green Infrastructure & Stormwater Management Master Plan, and the Campus Design Guidelines. It is important for planners, architects, designers, and engineers to familiarize themselves with the pieces of the plan to understand how they relate and inform each other in the physical development of the University of Wisconsin–Madison.

Big Picture

Executive Summary

Technical Document





Landscape Master Plan

Utility Master Plan

Long Range Transportation Plan

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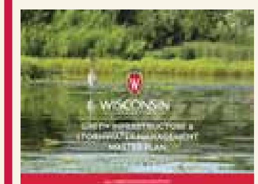
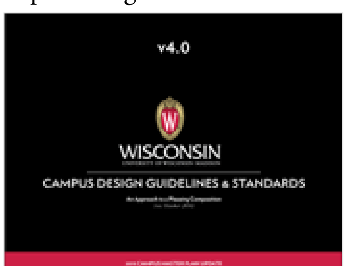


Green Infrastructure & Stormwater Management Master Plan

Campus Design Guidelines & Standards



Technical Specifications

More Detail

2015 Campus Master Plan Executive Summary

A full color 24-page report that summarizes the major goals and guiding principles for the Master Plan. The document includes the Chancellor's vision and the major goals and initiatives for each of the identified focus topics (appendices to the Technical Document). Welcomes and sets the tone for users and viewers of the master plan document. It is both a marketing piece for future development and a summary of the planning process.

2015 Campus Master Plan Technical Document

The unabridged thought and support behind the goals and guiding principles for the Master Plan. This more than 250-page document presents a roadmap for campus development over the next 30-50 years by referencing what has come previously and embracing what the future holds. Together with the Campus Design Guidelines, the Technical Document strives to give physical form to the university's mission, vision, and programs through the effective use of human, environmental and fiscal resources.

UW–Madison Campus Design Guidelines

The site specific framework that has been established to create the ground rules for a fruitful dialogue between planners, architects, engineers, campus community, and city/state authorities. Divided into nine Campus Design Neighborhoods, the goal of the guidelines is to enhance the university's sense of place by creating well-defined, functional, sustainable, beautiful and coherent campus environments that promote intellectual and social exchange.

Appendices:

Landscape Master Plan Establishes a 'sense of place' where phased growth and future development can occur while maintaining a cohesive environment.

Utility Master Plan: Confirms status of the 2005 recommendations, acknowledges completed projects, and makes recommendations to meet the 2015 plan revisions.

Long Range Transportation Plan: Updated from the previous LRTP, the plan is the university's transportation vision and describes baseline conditions, travel behaviors, and trends all modes.

Green Infrastructure & Stormwater Management Master Plan: A campuswide plan that recommends solutions to meet stormwater management regulations as well as existing campus stormwater policy.

Executive Summary

University of Wisconsin–Madison is already a leader in sustainable stormwater practices, having implemented dozens of progressive practices from green roofs to wetlands throughout the 936-acre campus. However, increased sustainability awareness by students, faculty, and staff as well as a more stringent regulatory climate offer opportunities for UW–Madison to be even more progressive in greening its facilities. The 2015 Campus Master Plan Update offers both opportunities for enhancing green infrastructure and challenges as the campus continues to densify and space for stormwater management is balanced with other programmatic needs.

Within the context of green infrastructure and stormwater management planning, the primary purpose of this document is to identify green infrastructure opportunities so that they can be appropriately budgeted and accommodated during site planning. A secondary purpose is to identify and quantify possible impacts (both positive and negative) of Master Plan implementation on stormwater runoff so that appropriate land use decisions can be made or measures incorporated to address potential adverse impacts.

Through this planning process, there were three primary goals identified for green infrastructure on campus:

1. Implement stormwater practices and policies that contribute to healthy Yahara Lakes.
2. Integrate research and learning into the campus stormwater management approach.
3. Connect campus stormwater management to the wider Yahara Lakes watershed community.

This report suggests structural and non-structural approaches to achieving these goals and estimates potential numeric progress toward achieving regulatory objectives offered by major structural practices. While the specific policies and practices recommended in this report should not be considered mandates, it is important to recognize that there are specific regulatory mandates driving many of the recommendations. Therefore, the decision to implement, not implement, or modify each of the identified practices will impact progress toward meeting regulatory mandates.

Recommendations in this report were developed following a multi-tiered approach. First, practices were identified which could be implemented in areas receiving stormwater runoff from relatively large tributary areas covering multiple "sites" (i.e., more than one block, building, or facility). Second, a menu of site-specific best management practices (or BMPs) and the intended outcomes (such as volume reduction, total suspended solids capture, groundwater recharge, etc.) for consideration as redevelopment occurs block by block was developed. Third, updates to campus stormwater standards are suggested so that new campus redevelopment projects contribute in a positive way towards overall sustainability and green infrastructure goals. In addition to these recommendations, UW–Madison should continue following good housekeeping practices on campus including street sweeping, snow and leaf litter collection, and diversion and isolation of waste areas to keep runoff from campus as clean as possible.

Implementation of recommendations in this report will help UW–Madison advance a culture of green infrastructure and work towards achieving permit compliance and related sustainability goals such as ecological awareness of the community and serving as a living laboratory. In addition, UW–Madison is participating in water quality initiatives outside of campus which contribute to a healthy watershed. Adaptive Management in the Yahara Lakes watershed is a program that includes dozens of municipalities and other governmental agencies to target urban and non-urban sources of sediment and phosphorus in the watershed. The long term goal is to achieve water quality standards in the Yahara Lakes for fishable and swimmable lakes, which will ultimately benefit the university as a major landholder along Lake Mendota.

Report recommendations are based on technical analysis of existing and future campus conditions and alternative green infrastructure practices. This appendix to the 2015 Campus Master Plan Update contains the technical background and detailed recommendations regarding green infrastructure and stormwater management on campus.

1. INTRODUCTION

1.1 Introduction

This stormwater/green infrastructure master plan is being completed as part of the 2015 update to the 2005 Campus Master Plan. The Campus Master Plan is intended to direct campus development and reinvestment to meet the academic and campus needs and trends anticipated in the next 20 years. The Campus Master Plan includes a framework for development and redevelopment of campus buildings and open spaces and suggests areas for increased density, improved pedestrian circulation, edge enhancement, and expanded open space network. The Campus Master Plan does not identify specific building or site designs and is not overly prescriptive but does provide guidance for defining initiatives and conceptual directions.

Implementation of Campus Master Plan initiatives offers both opportunities for enhancing green infrastructure and challenges associated with modification of long established land use and drainage patterns. Within the context of green infrastructure and stormwater management planning, the primary purpose of this document is to identify green infrastructure opportunities so that they can be appropriately budgeted and accommodated during site planning. A secondary purpose is to identify and quantify possible impacts (both positive and negative) of master plan implementation on stormwater runoff so that appropriate land use decisions can be made or measures incorporated to address potential adverse impacts. Understanding and documenting these potential impacts will identify UW–Madison's current WPDES permit compliance status and inform the creation of a strategy for meeting future compliance milestones.

This report suggests structural and non-structural approaches to achieving stormwater management/green infrastructure goals and estimates potential numeric progress toward achieving regulatory objectives offered by major structural practices. While the specific policies and practices recommended in this report are not mandates, it is important to recognize that there are specific regulatory requirements driving many of the recommendations. Therefore, the decision to implement, not implement, or modify each of the identified practices will impact progress toward meeting regulatory requirements.

Figure 1-1 Native Prairie Plantings and Permeable Patio, Carson Gulley Commons

1.2 Context

The existing campus stormwater management system reflects natural and built features and the evolution in stormwater management planning philosophy over the past century and a half. The oldest portions of campus, notably Bascom Hall and adjacent buildings were built on a hilltop so surface drainage effectively protected early buildings. As the campus grew and spread, storm sewers were installed for the purpose of "disposing" of excess stormwater runoff. Given the proximity of Lake Mendota and Willow Creek, the simplest and most cost effective solution was to drain storm sewers directly to individual outfalls along the lakeshore. This pattern was prominent throughout most of the 19th and 20th centuries, resulting in an extensive network of storm sewers and multiple outfalls along the Lake Mendota and Willow Creek Shorelines. Stormwater controls such as ponds and chambers were occasionally constructed as part of the stormwater management system. However, these were typically designed for peak discharge control and did not usually address water quality issues.

In the 1970's and 1980's public consciousness about the adverse impacts of urbanization on lakes and streams began to shape accepted approaches to stormwater management on campus and throughout the country. The National Pollutant Discharge Elimination System (NPDES) Storm Water Program, enacted by the U.S. Environmental Protection Agency (USEPA) in 1990, and administered locally by the Wisconsin Department of Natural Resources (WDNR) required municipalities with populations greater than 100,000, including the City of Madison and surrounding areas, to prepare stormwater management plans to reduce nonpoint source pollutants associated with stormwater runoff. This was reinforced by the adoption of Wisconsin Storm Water Management Performance Standards requiring nonpoint source runoff controls for construction sites, new developments, redevelopments, and municipal separate storm sewer systems (MS4's).

Campus stormwater management planning over the past 15 years has largely been shaped by several documents prepared at both an administrative and academic level. These documents are described below:

2005 Master Plan Goals

The University of Wisconsin–Madison, Storm Water Runoff Management, Facilities Planning and Management, December 2005.

This report, funded primarily by an Urban Nonpoint source and Stormwater Management Planning Grant from DNR, was prepared by a group of UW–Madison professors, graduate students, and Facilities Planning & Management (FP&M) staff. The report described on-campus physical conditions impacting stormwater runoff, provided a "menu" of BMPs, and identified potential BMPs for implementation at various campus locations.

Stormwater Quality Management Plan (2008 Plan)

Stormwater Quality Management Plan, Wisconsin DOA/DSF Project No. 06A1B, University of Wisconsin–Madison, Strand Associates Inc., September 2008.

The Stormwater Quality Management Plan (referred to in this report as the "2008 Plan" was prepared in response to requirements mandated by the Wisconsin Pollutant Discharge Elimination System (WPDES) Permit issued by the Wisconsin Department of Natural Resources (DNR). The report estimated pollutant loads from on-campus nonpoint source pollution source areas (such as roads, parking lots, rooftops, etc.) and identified alternative strategies for reducing pollutant loads for conformance to DNR permit requirements. In addition, the report summarized UW–Madison operations and maintenance protocols impacting nonpoint source runoff from campus.

Stormwater Quality Management Plan, West Campus Technical Revision (2011 Update)

Stormwater Quality Management Plan, West Campus Technical Revision, University of Wisconsin, Madison Campus (DSF #10I3D), Mead & Hunt, June 29, 2011.

The West Campus Technical Revision, referred to in this report as the "2011 Update" updated the 2008 Plan to reflect updates to DNR permit compliance requirements and modeling protocols. The report updated pollutant loading calculations for portions of campus west of Willow Creek and refined the analysis of recommended BMPs in the Eagle Heights neighborhood, along University Bay Drive, and north of Lot 60.

Other Significant Documents

Wisconsin Pollutant Discharge Elimination System (WPDES) Permit

Wisconsin Pollutant Discharge Elimination System (WPDES) Permit requires biennial reports to DNR on activities completed under the UW–Madison permit during the reporting period. UW–Madison submitted annual reports in 2008 and 2009 then biennial reports in 2011, 2013, and 2015. Reports summarize campus stormwater management activities such as illicit discharge detection and elimination screening, construction site and post-construction site compliance progress and issues, stormwater pollution prevention efforts and outcomes, and other related data.

Figure 1-2 Permeable Pavement, Carson Gulley Commons

Green Infrastructure for Stormwater Management, Toward a Model Campus by 2025

This report authored by James LaGro et al in 2014 and funded by a "Sustainability in Research and Education (SIRE)" grant from the UW–Madison Office of Sustainability, explores opportunities for UW–Madison to "leverage its intellectual capacity and creativity while presenting new opportunities for students to experience the cutting edge of a greener future". Included are policy recommendations addressing issues for consideration during the master planning process, including the following:

- Design: incorporate green infrastructure early in the contract process (currently, designers and engineers are hired THEN informed of campus policy); evaluate, in every project, the potential for BMPs – especially expanded canopy coverage.
- Communication: increase interpretive signage/transparency of current policies; improve collaboration between FP&M, faculty, and students – faculty and students could play a more substantive role in both big process (i.e. campus master planning) and individual project design decisions.
- Education: increase opportunities to engage multidisciplinary advisory committees and interdisciplinary student workshops in advancing the concept of campus as "learning lab"; systematically incorporate learning opportunities in new projects.
- Accountability: implement a monitoring program for new infrastructure vis a vis campus stormwater policy; enforce offset requirement on new buildings/renovations that cannot meet policy goals; monitor indicators/metrics with the assistance of academic programs and/or faculty, to gain a more complete understanding of water quality and quantity issues, and to establish clearly defined targets; we can take lessons from Lakeshore Nature Preserve – priority starts with implementing a preserve and through research develops incrementally into a well-researched and well understood system.
- Planning: evaluate opportunities to incrementally advance water sustainability through campus infrastructure/landscape changes (e.g., street reconstruction) – not only through major building projects.
- Funding: consider potential co-benefits (in addition to costs) when assessing the financial viability of green infrastructure investments.

Other

Other related plans include the following (see full list in References section):

- UW–Madison Lakeshore Nature Preserve Master Plan, Ken Saiki and Conservation Design Forum, February, 2006.
- West Campus Stormwater Management Plan, Strand Associates, Inc., July, 2004.
- Innovating Stormwater Management on the University of Wisconsin–Madison Campus, 2004 and Water Resources Management Workshop 2003 Gaylord Nelson Institute for Environmental Studies, UW–Madison.
- The State of the Rock River Basin, April, 2002, Publ # WT-668-2002, DNR.
- Evaluation of Stormwater Facilities, DOA/DSF and University of Wisconsin–Madison, Strand Associates, Inc., May 2001.
- Rock River TMDL Plan, Wisconsin Department of Natural Resources.

Figure 1-3 Rain Garden, Smith Residence Hall

1.3 Goals and Objectives

The Stormwater and Green Infrastructure Master Plan intends to prepare campus to integrate campus stormwater management responsibilities into the campus landscape through green infrastructure first and gray infrastructure second, as needed. As a component of the 2015 Campus Master Plan (CMP) this plan contributes to the CMP vision of managing our resources, celebrating our resources, revitalizing outdoor spaces, and being good neighbors.

This report builds on conclusions of the previously described 2008 and 2011 studies and offers a framework for advancing progressive campus stormwater management and green infrastructure on the UW–Madison campus. Goals and objectives were developed through review of current state and local regulatory requirements, meetings with state and local staff, discussions with campus staff, and collaboration with the Green Infrastructure Technical Coordinating Committee (GITCC). The GITCC was comprised of faculty, Facilities Planning & Management staff, and the consultant team and met on six occasions through the course of the project to offer direction on the course of stormwater management and green infrastructure planning efforts. The following long term stormwater management and green infrastructure goals and objectives for campus were collaboratively developed through this process:

Goal #1: Implement stormwater practices and policies that contribute to healthy Yahara Lakes.

Objectives

- Revisit existing campus stormwater policy to encourage green infrastructure and re-evaluate campus stormwater management standards in light of the campus physical setting and the stormwater analysis included in this plan.
- Promote practices in key locations to maximize as many of the following benefits as possible: reduce runoff volumes, reduce erosion, capture pollutants, contribute to groundwater recharge, and be cost effective.
- Incorporate ecosystems services into stormwater practices constructed on campus, and to the extent possible, utilize practices that incorporate or mimic natural processes, provide habitat opportunities, and enhance quality of life.
- Consider strategies which maximize the beneficial reuse of rain water.
- Remove redundant or unnecessary impervious areas or disconnect impervious areas to minimize direct pollutant runoff to outfalls.
- Implement, when possible, multi-site practices that serve a watershed-scale area.
- Recommend innovative green practices that should be implemented on block or district scales as master plan construction projects are implemented.
- Enforce/encourage/assist site redevelopment projects to achieve set campus stormwater standards.
- Implement, when possible, the strategy created in this plan that shows how UW–Madison will achieve compliance with the applicable Rock River Total Maximum Daily Load (TMDL) waste load allocations (WLAs) The selection of practices implemented should be made through an evaluation of construction and maintenance costs as well as campus land use considerations.

Goal #2: Integrate research and learning into the campus stormwater management approach.

Objectives

- Leverage the University's intellectual and creative capacity and support the evaluation and use of cutting-edge practices in a "learning laboratory" fashion to help advance theory and practice of designing and implementing the green infrastructure.
- Promote the use of practices that are creative, visible, and accessible to both the campus community and the public at large for the benefit of sustainability education and awareness.
- Monitor campus green infrastructure performance to inform future green infrastructure design decisions. The monitoring program should be developed with the goal of improving future green infrastructure cost-effectiveness and performance.

Goal #3: Connect campus stormwater management to the wider Yahara Lakes watershed community.

Objectives

- Identify opportunities to work collaboratively with others (e.g. watershed adaptive management project) in the region to achieve the ultimate goal of a healthy Yahara Lakes ecosystem.
- Support ways to engage the UW–Madison community around stewardship efforts including clean-up events, informational and interpretive signage, involvement of clubs and recreational organizations, etc.
- Emphasize the importance of good public relations outreach and communication tools that promote UW–Madison's sustainability efforts to the community.

2. REGULATORY REQUIREMENTS

2.1 Municipal Stormwater Permit

Permit Coverage Area

While the goals and objectives presented in this report are intended to apply to the entire campus, the stormwater discharge from a portion of the campus is subject to a Wisconsin Discharge Elimination System (WPDES) Municipal Storm Water Discharge Permit issued by the Department of Natural Resources (DNR). This permit authorizes discharge of stormwater runoff through separate storm sewer systems (MS4s) in the campus permit area to waters of the state. The UW–Madison permit area is that portion of the campus located north of University Avenue, west of Park Street , and east of University Bay Drive (Figure 2-1). The City of Madison is responsible for stormwater discharges south of University Avenue and east of Park Street while the Village of Shorewood Hills is responsible for discharges from lands west of University Bay Drive.

WPDES MS4 Permit Requirements

The WPDES MS4 Group Permit mandates UW–Madison to meet specific stormwater quality goals within the permit's 5-year compliance schedule. These goals include reduction of non-point source pollution including reduction in Total Suspended Solids (TSS) and Phosphorus (TP). Meeting these permit requirements is one of the primary drivers in UW–Madison's efforts to plan future stormwater management and green infrastructure practices.

Current permit requirements include participating in public education and outreach activities, conducting outfall inspections and other activities to detect and eliminate illicit discharges to the storm sewer system, controlling erosion and sediment from construction sites, new development, and redevelopment, implementing "good housekeeping" practices for operation and maintenance activities such as material storage, roadway maintenance, and deicing, and maintaining mapping of the campus-owned storm sewer system. In addition, UW–Madison must report progress in meeting permit requirements to WDNR on a biennial basis and demonstrate compliance with developed urban area and TMDL performance standards through pollutant loading calculations.

UW–Madison has achieved some of the MS4 permit requirements through collaborative engagement in the Madison Area Municipal Stormwater Partnership (MAMSWaP), a group of 21 municipalities in the Madison area included in the MS4 Group Permit. Joint activities by MAMSWaP members include permit preparation and submittal, public information education and outreach, and participation in research. Individual UW–Madison responsibilities within the MS4 permit include mapping existing storm sewers and of state construction and site erosion and sediment controls, implementation of best management practice to achieve TSS and TP reduction goals, and Stormwater Pollution Prevention Planning for maintenance and other related facilities.

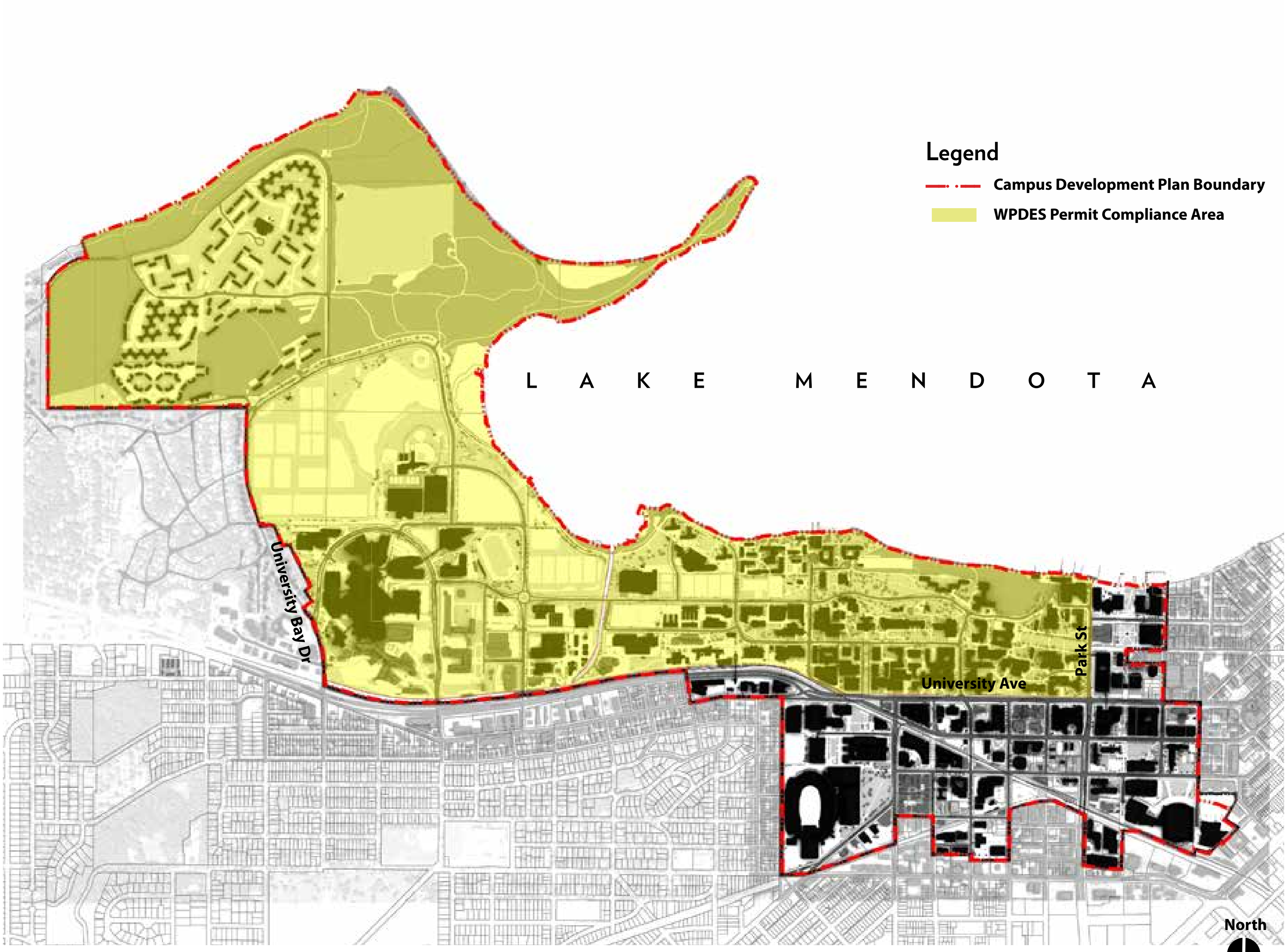


Figure 2-1 Campus Development Plan Boundary and Permit Coverage

2.2 Rock River TMDL

Background

A major focus of UW–Madison's stormwater management efforts will be reducing contribution of TSS and TP from the Yahara River, Six Mile Creek, and Rock River watersheds. The Clean Water Act defined impaired waters as rivers, lakes, or streams not meeting water quality standards for intended uses such as fishing or swimming. Each state is required to prepare a listing (known as the "303(d) list") of water bodies not meeting water quality standards and identifying the cause of the water quality impairment. For each water body listed, the state must prepare a calculation known as a "Total Maximum Daily Load" (TMDL) that estimates the maximum amount of the pollutants causing the impairment that can be discharged to the water body such that the water body can achieve its intended use. The calculated reduction necessary is then allocated to various pollutant sources such as wastewater effluent, agricultural discharge, stormwater discharge, etc.

The Rock River watershed, which includes Lake Mendota, Lake Monona, the UW–Madison campus, and much of the City of Madison (Figure 2-2), is included on the USEPA and DNR list of impaired waters. Phosphorus caused in part by nonpoint source runoff is a primary cause of Lake Mendota and Lake Monona impairment resulting in excessive algae growth and other water quality use restrictions.

In September, 2011, the USEPA approved the Rock River TMDL submitted by the DNR. The approved TMDL allocated phosphorus discharge limits (waste load allocations) among various point and nonpoint pollutant sources and municipalities with the goal of achieving water quality standards in the Rock River watershed within the next several decades (the specific time frame is currently undefined). For Reach 64, which includes the Six Mile Creek and Yahara River Watersheds, including Lakes Mendota and Monona, the TMDL mandates a 73% TSS reduction and 61% TP reduction compared to the "no controls" condition. This means, for example, that for every 100 pounds of sediment generated on a campus surface, 73 pounds must be reduced through either implementation of a stormwater management practice, land use change, or related measure.

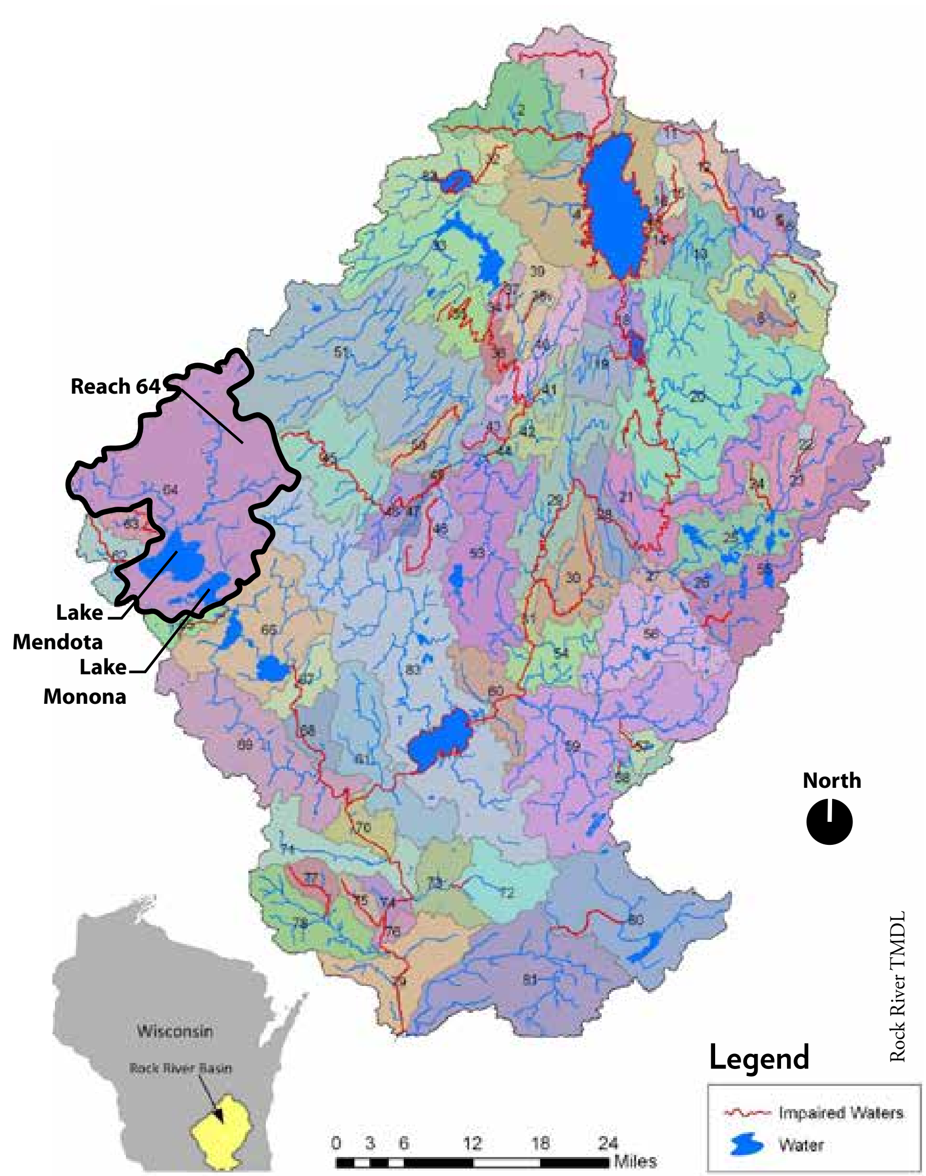


Figure 2-2 Rock River Watershed TMDL Reaches

UW–Madison Responsibilities and Implementation

Provisions in the Clean Water Act allow USEPA (and DNR through its delegated administrative authority) to implement nonpoint source "end of pipe" discharge restrictions into stormwater discharge permits for owners and operators of certain storm sewer systems in areas where TMDL's have been approved. Consequently, UW–Madison is mandated to implement a plan for compliance with the reduction targets listed above over its future stormwater permit cycles. Guidance published by DNR ("TMDL Guidance for MS4 Permits, Planning, Implementation, and Modeling Guidance", Guidance # 3800-2014-04, published October 20, 2014) lists the following responsibilities:

Ordinance Review and Updates: Due to the UW–Madison's unique administrative structure (compared to other regulated municipalities), this requirement does not specifically apply. However, as discussed in Section 5.4, UW–Madison should consider revisions to campus stormwater management requirements for new development and redevelopment to comply with TMDL standards.

Quantifiable Reductions: Implement green infrastructure practices such as wet detention ponds, infiltration basins, bioretention, sump cleaning, street cleaning, vegetated swales, and land use modifications where TSS and Phosphorus reductions can be quantified through modeling.

Non-Quantifiable Reductions: Implement or enhance practices such as leaf and brush collection, nutrient application reductions, and related activities whose impacts are difficult to measure through modeling but are beneficial to the overall health of the lakes and Rock River Watershed.

Bank Stabilization: DNR is encouraging permittees to explore opportunities to stabilize shorelines. In UW–Madison's case, this would include Willow Creek and eroding portions of the Lake Mendota shoreline. However, resulting reductions to sediment and phosphorus loading are not considered "quantifiable" and do not count toward mandated pollutant reductions because the DNR model upon which the TMDL calculation is based considers all shorelines to be stable in the baseline condition.

WPDES Permit Implications

UW–Madison's current stormwater permit requires submittal of the following to DNR either individually or through MAMSWP

- By March 31, 2016, an updated storm sewer map identifying the current municipal (i.e., campus) boundary and/or permitted area, TMDL reach boundaries, and the MS4 drainage boundary. Mapping should also be provided showing the permittees excluded areas.
- By March 31, 2018, a tabular summary identifying the following:
  1. The permittee's percent TSS and phosphorus reductions needed to comply with the TMDL allocation from the "no-controls" modeling condition.
  2. The "no-controls" condition average annual pollutant load (i.e., the average annual pollutant load without any stormwater control measures in place).
  3. The modeled average annual pollutant load with existing stormwater control practices in place.
  4. The percent reduction under the existing stormwater controls condition.
  5. A summary of existing stormwater control measures including the practice type, area treated, pollutant load reduction efficiency, and confirmation of the permittee's authority for long-term maintenance.
  6. A written plan describing how the permittee will make progress toward achieving compliance. The plan should include recommendations and alternatives for stormwater management and green infrastructure practices for pollutants of concern. In addition, the plan should establish a preliminary schedule for compliance "benchmarks" (i.e., progress increments) expected to be achieved during subsequent 5-year permit terms.

2.3 Relationship to Regional Initiatives (Adaptive Management)

Over 30 municipalities and stakeholders in the Madison area, led by the Madison Metropolitan Sewerage District, have partnered to reduce phosphorus in the Yahara River (and ultimately Rock River) watershed through a group known as the Yahara Watershed Improvement Network or “Yahara WINS”. The goal of Yahara WINS is to reduce phosphorus by an “adaptive management” approach. The goal of adaptive management is to achieve overall phosphorus reductions by implementing jointly-funded large-scale projects at various locations in the watershed to reduce both point and nonpoint sediment and phosphorus sources. Studies by MMSD suggest that this collaborative approach has the potential to be more cost effective for participating stakeholders than attempting to achieve mandated reductions individually.

UW–Madison is an active participant in the Yahara WINS program as a signatory of the intergovernmental agreement and through the participation of academic staff development and operation of pilot projects. By signing the intergovernmental agreement, UW–Madison has agreed to review and comment on the Adaptive Management Plan, coordinate or contract with DNR and other pertinent entities to achieve adaptive management goals, participate in program funding based on cost allocations specified in the agreement, and achieve compliance with the permit requirements related to the Rock River TMDL.

As discussed in greater detail in this report, it is anticipated that UW–Madison compliance with TMDL requirements will be achieved through a combination of additional green infrastructure and stormwater management practices on campus and participation in various off-campus projects intended to reduce phosphorus levels to the benefit of the entire watershed community.

The adaptive management work being done by Yahara WINS is the first of its kind in the state and likely the nation and is setting a precedent for how different agencies and municipalities can work together to produce positive results in a watershed. UW–Madison should continue to play an active role in participating and leading through academic research and education.

Figure 2-3 Campus Relationship to Rock River Watershed

3. PHYSICAL SETTING

3.1 Existing Land Use and Drainage

This section describes physical characteristics of the UW–Madison campus that impact the amount of stormwater runoff and associated pollutants draining to adjacent waters.

The study limits for this analysis encompass the entire area within the Campus Development Plan Boundary shown in Figure 2-1. While this is defined as the "campus", it should be noted that this area also includes non-campus properties such as the VA Hospital and the USDA Forest Products Laboratory in the west campus areas, as well as numerous privately owned properties and city-owned rights-of-way in the west and south campus areas. For stormwater management and green infrastructure planning purposes, land use and drainage descriptions include both campus and non-campus properties within the Campus Development Plan Boundary unless otherwise noted.

Figure 3-1 Campus Watershed Divide

Drainage Patterns and Planning Areas

The last glaciation period formed much of the topography present on the UW–Madison campus. Observatory Hill and Bascom Hill are glacial drumlins characterized by steep slopes rising rapidly from flatter areas to the east, west and south. Drumlin slopes exceeding 20 percent are prominent in this area resulting in high erosion potential and limiting efficacy of large scale stormwater management practices (Figure 3-2).

The Observatory Hill/Bascom Hill drumlin generally splits the campus into two major drainage subwatersheds (Figure 3-1). Areas north and west of the ridgelines draining to Lake Mendota are considered to be in the Six Mile and Pheasant Branch Creeks Watershed (USEPA HUC 070900020604) and areas to the south and east draining to Lake Monona lie within the Yahara River and Lake Monona Watershed (USEPA HUC 070900020702). The entire campus is located in Reach 64 of the Rock River Watershed which, as noted previously, is considered impaired due to excess phosphorus.

Overall, approximately 802 acres within the Campus Development Plan Boundary drain to Lake Mendota, and 238 acres to Lake Monona via campus and city-owned storm sewers (Figure 3-3). Of the area draining to Lake Mendota, approximately 134 acres drains via discharge to Willow Creek.

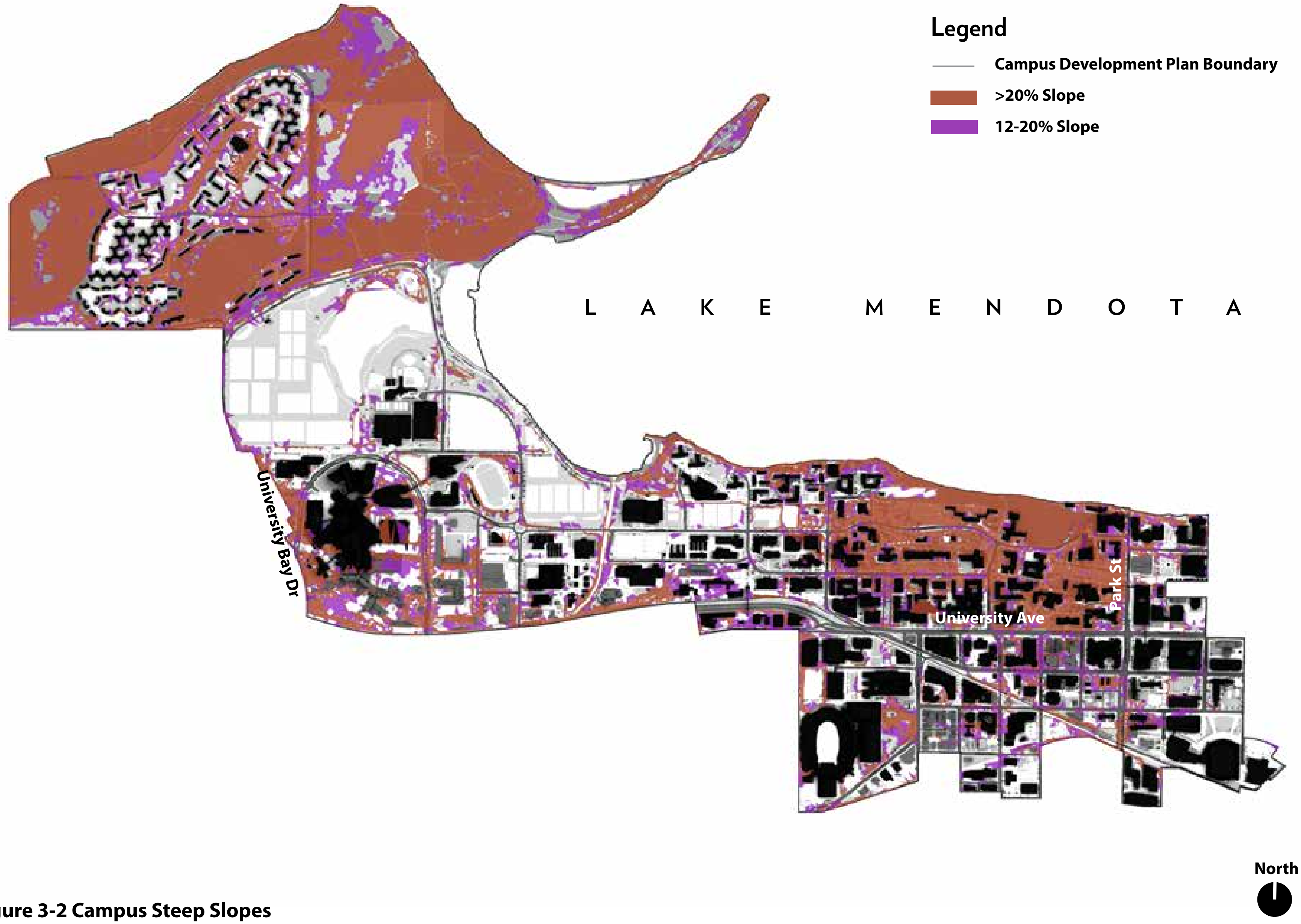


Figure 3-2 Campus Steep Slopes

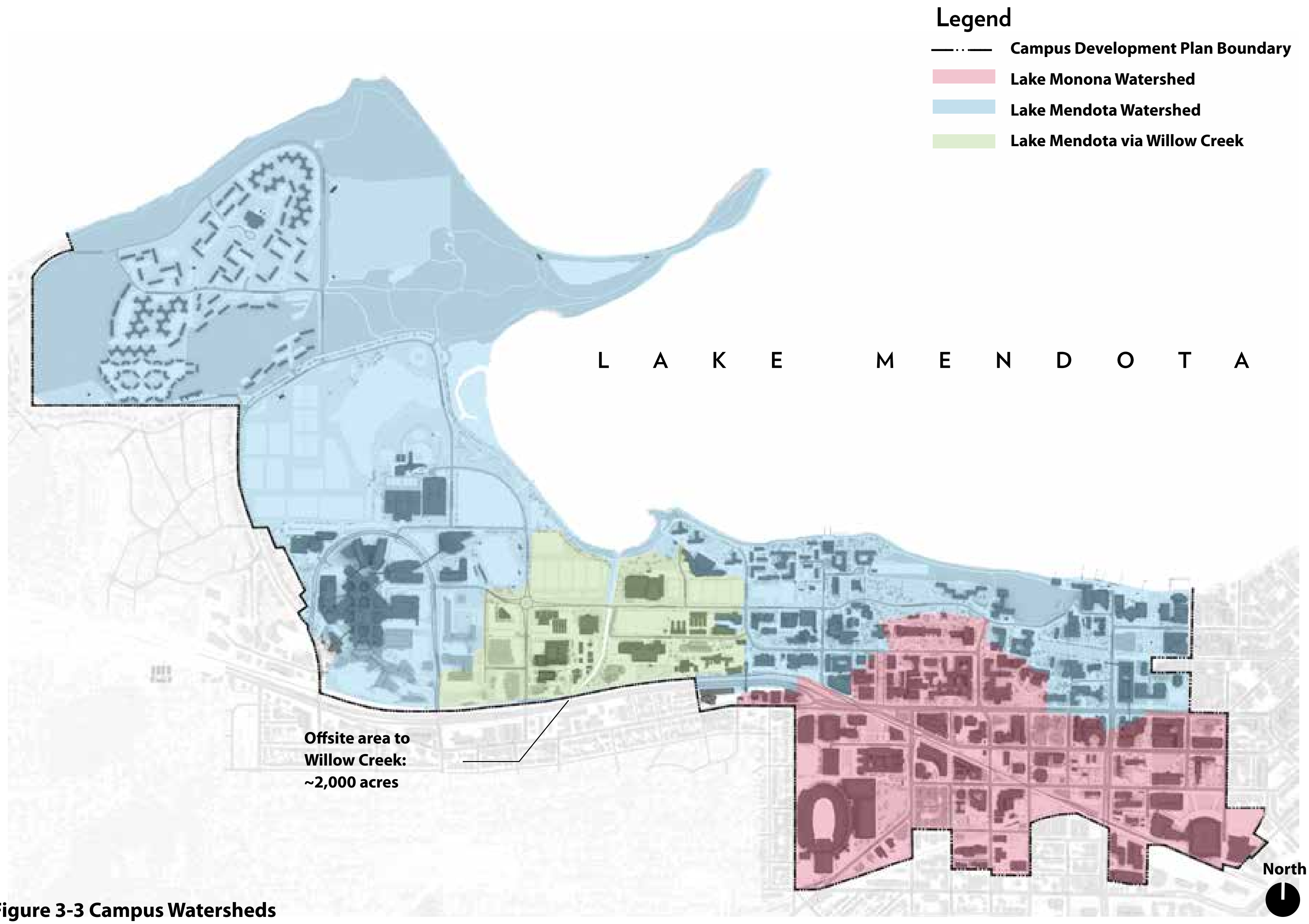


Figure 3-3 Campus Watersheds

Impervious and Pervious Surfaces

UW–Madison is located near the central core of the City of Madison on the shore of Lake Mendota. Over 1,000 acres of land exist within UW–Madison Campus Development Plan Boundary, including 936 acres owned by UW–Madison (Figure 2-1). Of this, approximately 300 acres are Lakeshore Nature Preserve and protected from future development. Since its founding in 1848, the campus has grown from three buildings located on what would become Bascom Hill to include over 180 acres of building "footprints" supported by over 320 acres of supporting impervious areas such as roadways, parking lots, walkways, plazas, and driveways. Currently, approximately 504 acres of the 1,040 acres of land within the Campus Development Plan Boundary is impervious (approximately 48%). Of the impervious area, it is estimated that approximately 190 acres supports traffic (e.g., streets, parking lots, driveways, etc.) The proportion of area supporting traffic is important because these are typically the highest sources of pollutant loads of the pertinent land uses.

Campus impervious areas are shown in Figure 3-4. Figure 3-5 shows locations of driveable impervious surfaces.

Table 3-1 Impervious and Pervious Areas

Surface Type	2015 Impervious Area (acres)
Impervious Traffic Areas	**184.9**
Impervious Non-Traffic Areas	**319.6**
Overall Impervious Area	**504.4**
Pervious Area	**536.1**
Total Area	**1040.6**
Impervious %	**48%**

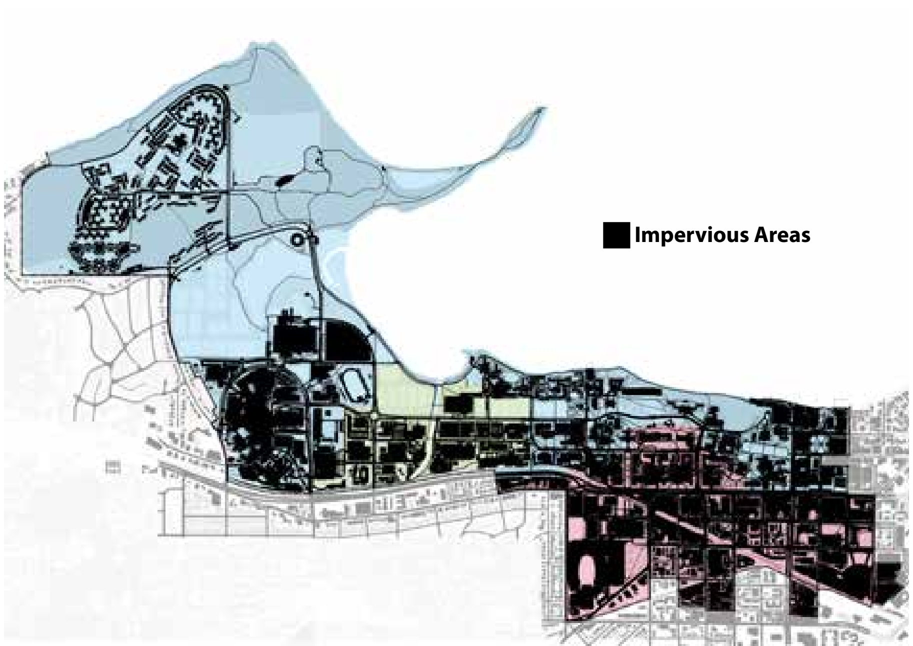


Figure 3-4 Campus Impervious Areas

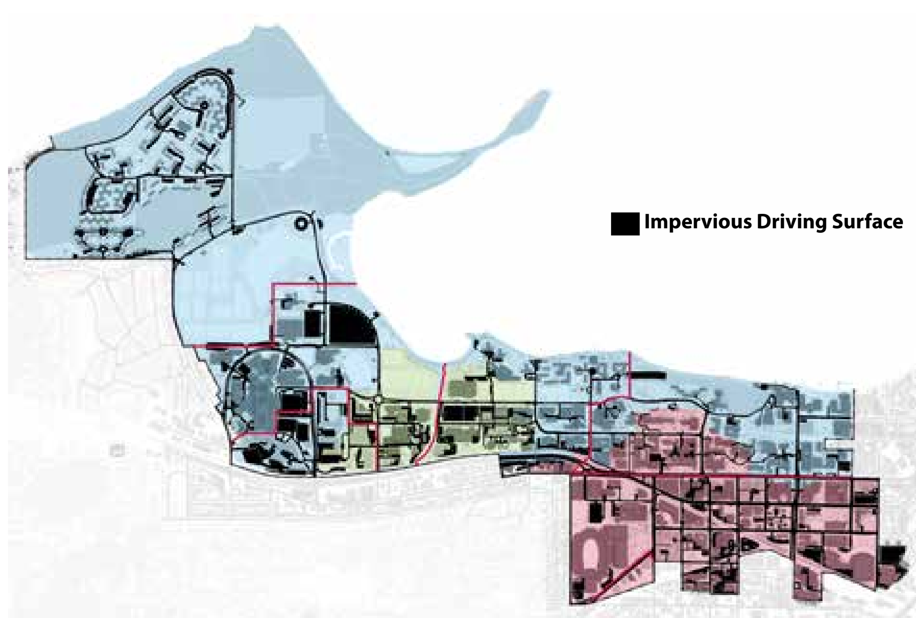


Figure 3-5 Campus Impervious Traffic Areas

3.2 Natural Features

Natural Areas and Subsurface Conditions

The land upon which UW–Madison is now located was once a savanna-like landscape, with prairies and wetlands intermingled with open forests (University of Wisconsin–Madison Lakeshore Nature Preserve, 2006 Master Plan). While most of the campus has been significantly urbanized, over 300 acres of land including the Lake Mendota shoreline and areas such as Muir Woods, Picnic Point, Frautschi Point, and the University Bay Marsh have been maintained in a natural or only slightly altered state (See Figure 3-7).

Other natural features include the restored 1918 Marsh and Willow Creek. The 1918 Marsh is an enclosed depression that has been restored to a natural wetland. However, it receives runoff from a portion of the west campus and is maintained by pumping excess runoff and groundwater to Lake Mendota. Willow Creek was once a marshy, meandering waterway that was artificially straightened in order to facilitate campus development ("University of Wisconsin–Madison Lakeshore Nature Preserve Master Plan" – March 2006). Stormwater runoff from over 2,000 acres of urbanized lands in the City of Madison as well as approximately 130 acres of the UW–Madison campus drains to Willow Creek. The modification of the channel in addition to the volume of untreated stormwater runoff to the creek has resulted in impairments such as streambank erosion, introduction of invasive species, and the formation of a delta of sediment at the confluence of Willow Creek and Lake Mendota. The City of Madison intends to install a sediment trap in the summer of 2016 to capture pollutants near the outlet of the city-owned culvert discharging to the creek just north of Campus Drive. Additional measures will be necessary to remove the "delta" of sediment that has accumulated near the Willow Creek confluence and to restore the Willow Creek corridor itself.

Stormwater management issues are present at a number of locations in the Lakeshore Nature Preserve. While these are not the specific focus of this report, these areas have been extensively documented in the report titled "University of Wisconsin–Madison Lakeshore Nature Preserve Master Plan" (March 2006).

Figure 3-6 Aerial Photograph of Lake Mendota Shoreline and Picnic Point in the Lakeshore Nature Preserve

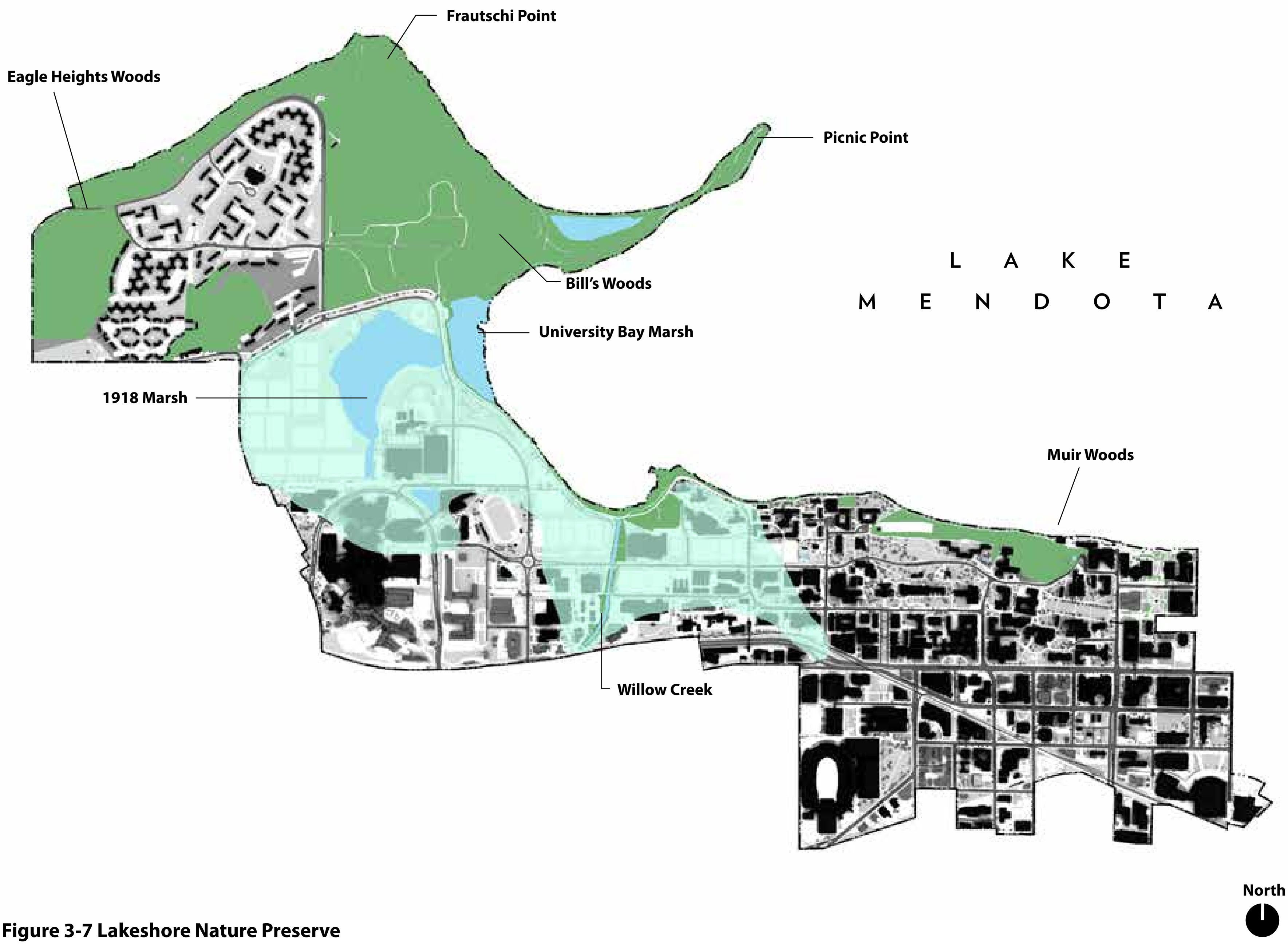


Figure 3-7 Lakeshore Nature Preserve

Soils

Campus soils also reflect the glacial history of campus with upland areas largely underlain by glacial till and low lying areas featuring poorly drained outwash soils such as Houghton Muck and Colwood Silt Loams. (Figure 3-9) Upland surface soils are typically silt loams and loams in the Batavia, Dodge, Kegonsa, McHenry, Whalan, and Virgil classes classified in Hydrologic Soils Group (HSG B). Soils mapping and anecdotal observations suggest that except for the Dodge series, soils 3 to 5 feet below the surface in these groups may contain sand and gravel seams possibly conducive to infiltration. Low lying portions of the west and near west campus are underlain by Houghton Muck and Colwood Silt Loams, both of which are poorly drained and classified as hydric soils typically in HSG C. Soil borings in Colwood Silt Loam areas suggest that there may be deeper sand layers conducive to infiltration where not otherwise limited by high groundwater or presence of non-native fill material. UW–Madison campus soils characteristics are summarized in Table 3-2.

An investigation of historical soil borings in the near west campus area suggests that groundwater is typically 6 feet or more below the ground surface except near Willow Creek and approaching the lake shore. (Figure 3-8). Groundwater in this area is expected to rise and fall with lake levels.

Bedrock is not typically encountered on campus construction projects and is not expected to be a limiting factor in the selection and location of green infrastructure features. However, campus staff reports some bedrock has been encountered in the Eagle Heights neighborhood and near Breese Terrace during construction of the Engineering Centers and Wisconsin Energy Institute Buildings. In addition, bedrock has been encountered during construction projects near 1810 Linden Drive and in the vicinity of the Veterinary Medicine Building.

Figure 3-8 Groundwater Depths Per Soil Borings – Near East and Near West Campus

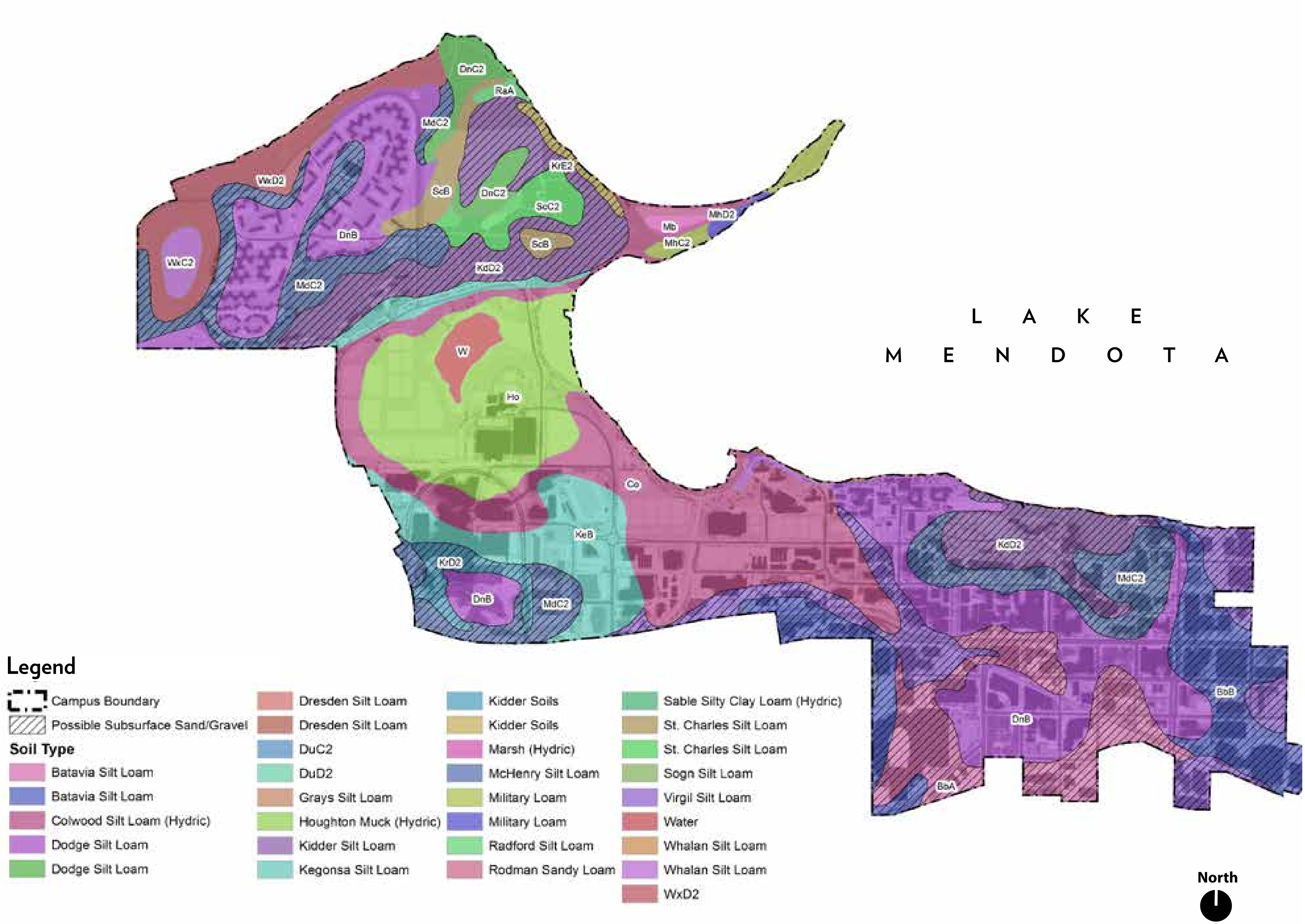


Figure 3-9 Campus Soil Types

Table 3-2 Campus Soils Characteristics

Soil Series	Symbol	Hydrologic Soils Group	Soil Texture	Surface Soil Permeability (in/hr)	Depth (in)	Reported Subsurface Permeability (Below Depth) (in/hr)	Surface Infiltration Potential	Subsurface Infiltration Potential	Hydric?
Batavia	BbA	B	Silt Loam	0.63-2.0	>40	>20	Poor	Very Good	
	BbB	B	Silt Loam	0.63-2.0	>40	>20	Poor	Very Good	
Colwood	Co	C/D	Silt Loam	0.63-2.0			Poor		Hydric
Dodge	DnB	B	Silt Loam	0.63-2.0	>40	2.0-6.3	Poor	Fair	
	DnC2	B	Silt Loam	0.63-2.0	>40	2.0-6.3	Poor	Fair	
Dresden	DrD2	B	Loam	0.63-2.0	>31	6.3-20	Poor	Good	
	DsC2	B	Silt Loam	0.63-2.0	>31	6.3-20	Poor	Good	
Dunbarton	DuC2	D	Silt Loam	0.63-2.0	>18	0.2-0.63	Poor	Poor	
	DuD2	D	Silt Loam	0.63-2.0	>18	0.2-0.63	Poor	Poor	
Grays	GsB	B	Silt Loam	2.0-6.3	>33	0.2-0.63	Poor	Poor	
Houghton	Ho	A/D	Muck	2.0-6.3			Poor	Poor	Hydric
Kidder	KdD2	B	Loam	0.63-2.0	>38	2.0-6.3	Poor	Fair	
Kegonsa	KeB	B	Silt Loam	0.63-2.0	>33	>20	Poor	Very Good	
Kidder	KrD2	B	Loam	0.63-2.0	>38	2.0-6.3	Poor	Fair	
Kidder	KrE2	B	Loam	0.63-2.0	>38	2.0-6.3	Poor	Fair	
Marsh	Mb	D	Muck				Poor	Poor	Hydric
McHenry	MdC2	B	Silt Loam	0.63-2.0	>33	2.0-6.3	Poor	Fair	
Military	MhC2	C	Loam	0.63-2.0	>28	2.0-6.3	Poor	Fair	
	MhD2	C	Loam	0.63-2.0	>33	Sandstone	Poor	Poor	
Radford	RaA	C	Silt Loam	0.63-2.0			Poor		
Rodman	RpE	A	Sandy Loam	2.0-6.3	>13	>20	Fair	Very Good	
Sable	SaA	B/D	Silty Clay Loam	0.63-2.0	>13	0.2-0.63	Poor	Poor	Hydric
St. Charles	ScB	B	Silt Loam	0.63-2.0	>50	2.0-6.3	Poor	Fair	
St. Charles	ScC2	B	Silt Loam	0.63-2.0	>50	2.0-6.3	Poor	Fair	
Sogn	SoE	D	Silt Loam	0.63-2.0			Poor	Poor	
Virgil	VwA	C	Silt Loam	0.63-2.0	>13	0.2-0.63	Poor	Poor	
Water	W	W	Water				Poor		
Whalan	WxB	C	Silt Loam	0.63-2.0			Poor	Poor	
Whalan	WxC2	C	Silt Loam	0.63-2.0			Poor	Poor	
Whalan	WxD2	C	Silt Loam	0.63-2.0			Poor	Poor	

Floodplains, Wetlands and Hydric Soils

Portions of the near west and west campus are impacted by the presence of wetlands, floodplains, and hydric soils(Figure 3-9). Hydric soils, generally in the Colwood and Houghton Muck groups, are prominent from just south of University Bay Drive, extending southeasterly across the far west athletic fields, Lot 60, then crossing Willow Creek and much of the Agriculture Campus. The Wisconsin Wetland Inventory indicates that wetland areas are limited to shoreline and low areas such as near Picnic Point and the 1918 Marsh. While not shown on the Wisconsin Wetland Inventory, the "triangle" marsh located east of Lot 60 is also a wetland. The Lake Mendota 100-year flood zone encroaches westerly from the shoreline to the 1918 Marsh, extending partially onto the far west athletic fields (see Figure 3-11). In addition, mapping indicates the floodplain encroaching on the near west fields. However, these fields have been filled and are now above the 100-year flood elevation. FP&M is currently discussing map revisions with FEMA, DNR, and the City of Madison to remove this designation. The floodplain also extends southerly through the Willow Creek corridor but does not exceed the Willow Creek banks.

In general wetland and floodplain issues do not significantly impact infrastructure and building development or green infrastructure potential on the UW–Madison campus. However, wetland and floodplain issues should be addressed thoroughly when shoreline activities such as Willow Creek restoration are undertaken. Also, hydric soils may be indicative of periodic inundation so green infrastructure measures proposed in these areas may require underdrains and/or plantings selected to survive anticipated wet conditions.

Figure 3-10 Marsh Along Lake Mendota Shoreline

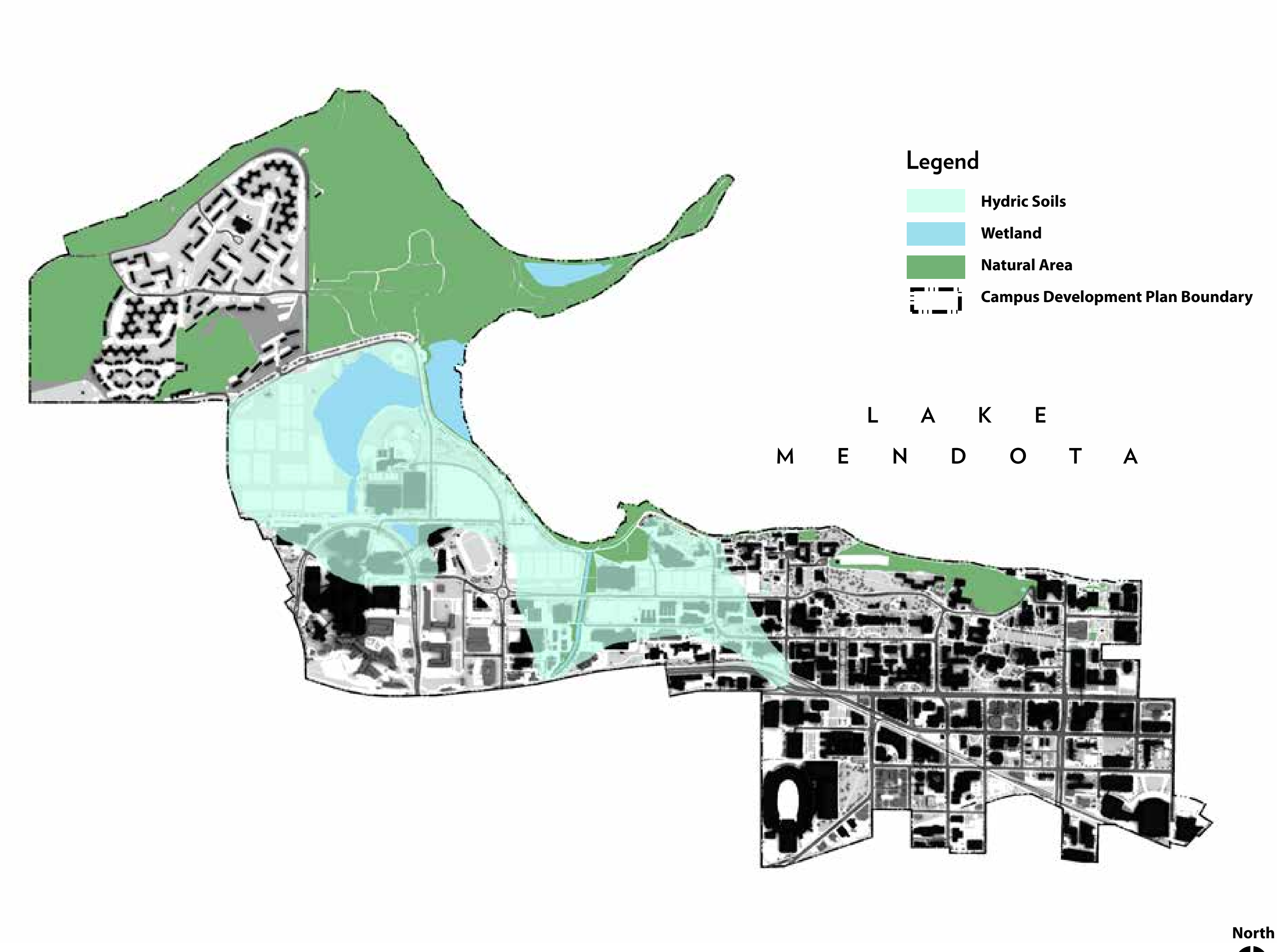


Figure 3-11 Locations of Floodplains, Wetlands, and Hydric Soils

3.3 Existing Stormwater Infrastructure

Storm Sewer System and Outfalls

UW–Madison owns and maintains an extensive network of storm sewers, inlets, catch basins (Figures 3-13 through 3-16). North and west of the Bascom and Observatory Hill ridges, storm sewers were historically designed to follow the shortest route feasible to Lake Mendota or Willow Creek. This development pattern has resulted in the presence of over 45 relatively small storm sewer outfalls along the Willow Creek and Lake Mendota shoreline. Exceptions to this pattern include a 68-inch by 43-inch elliptical pipe serving a 92 acre portion of the west campus via Nielsen Pond (ME-8) and a 36-inch storm sewer draining westerly along Observatory Drive discharging to Willow Creek just southwest of the Natatorium serving over 70 acres of the west campus (WIL-2).

Campus areas lying south and east of the Bascom and Observatory Hill ridges typically drain through UW–Madison-owned storm sewers that discharge to city-owned storm sewers located in city right-of-ways. The city-owned system in this area typically drains southerly and easterly, eventually discharging to a series of large box culverts draining to Lake Monona.

For purposes of this report, a stormwater outfall is defined as a point where campus stormwater runoff discharges to either the existing public storm sewer, Lake Mendota, or Willow Creek. On this basis, over 80 stormwater outfalls are present within the project limits. The DNR, however, defines a major outfall as a MS4 outfall if it meets one of the following criteria:

1. A single pipe with an inside diameter of 36 inches or more, or from an equivalent conveyance (cross sectional area of 1,018 square inches) which is associated with a drainage area of more than 50 acres.
2. A municipal separate storm sewer system that receives stormwater runoff from lands zoned for industrial activity that is associated with a drainage area of more than 2 acres or from other lands with 2 or more acres of industrial activity, but not land zoned for industrial activity that does not have any industrial activity present is not classified as a major outfall under this paragraph.

By this definition only outfalls ME-8 and WIL-2 are considered “major outfalls”.

Figure 3-12 Nielsen Pond Stormwater Outfall

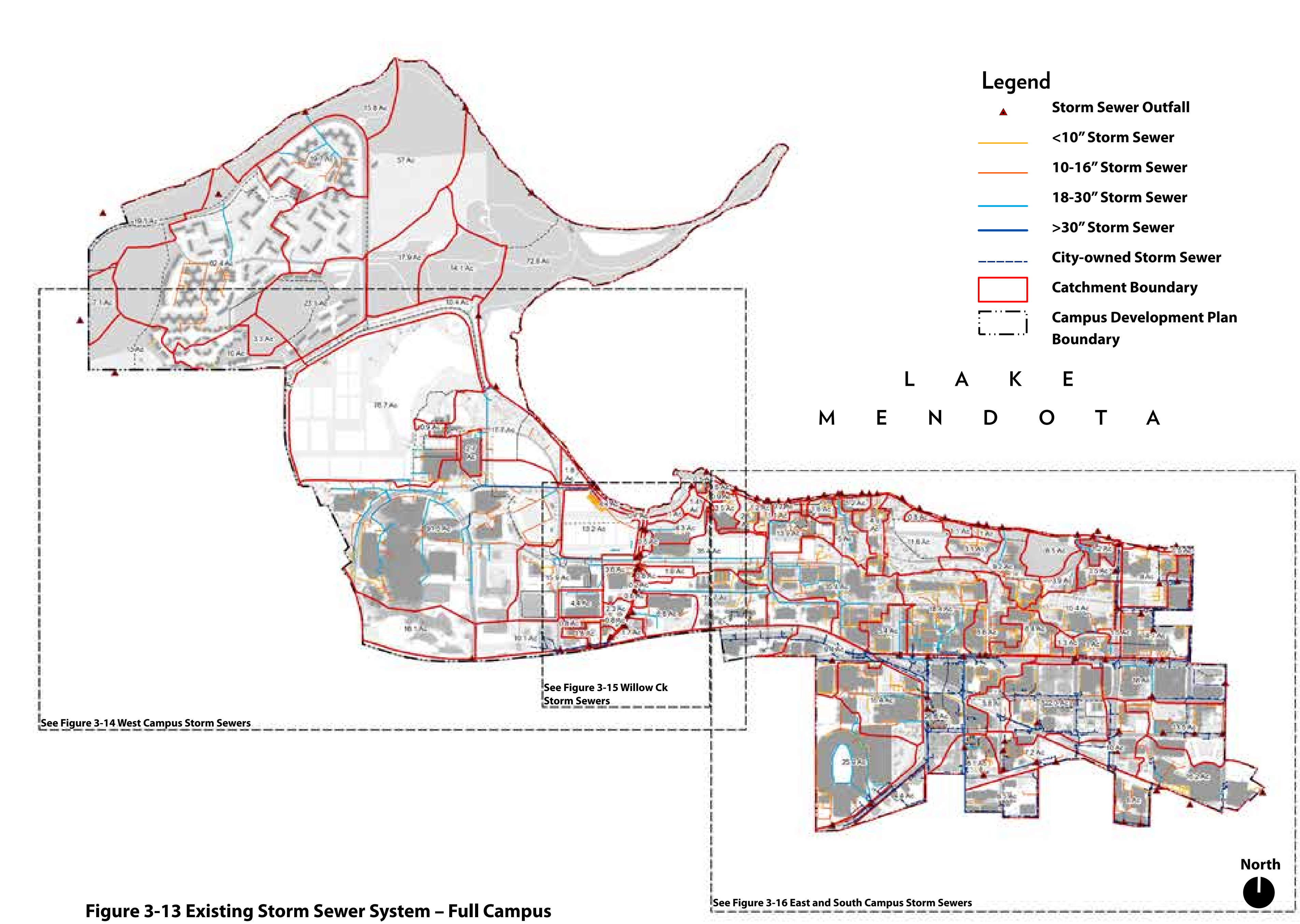


Figure 3-13 Existing Storm Sewer System – Full Campus

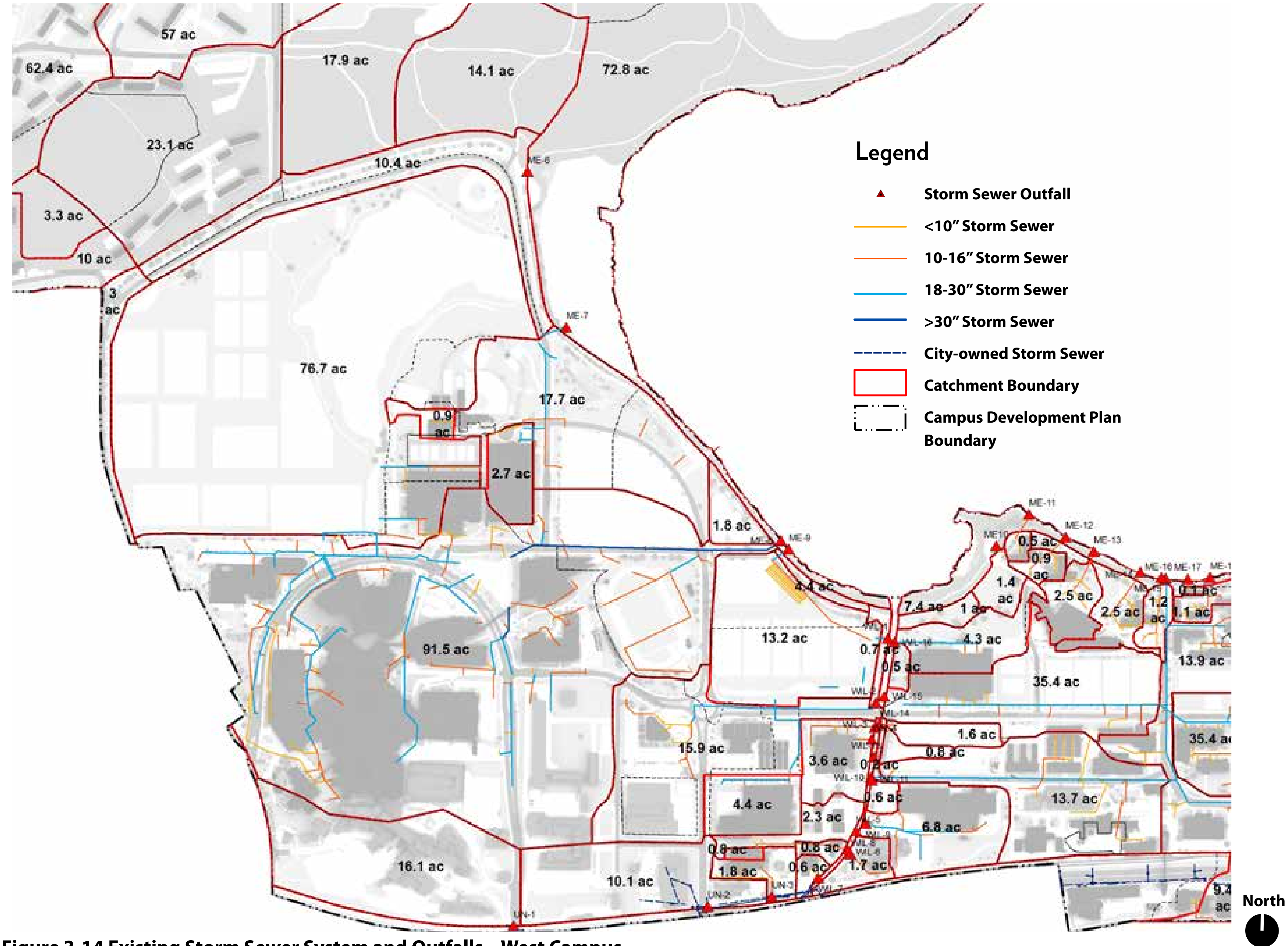


Figure 3-14 Existing Storm Sewer System and Outfalls – West Campus

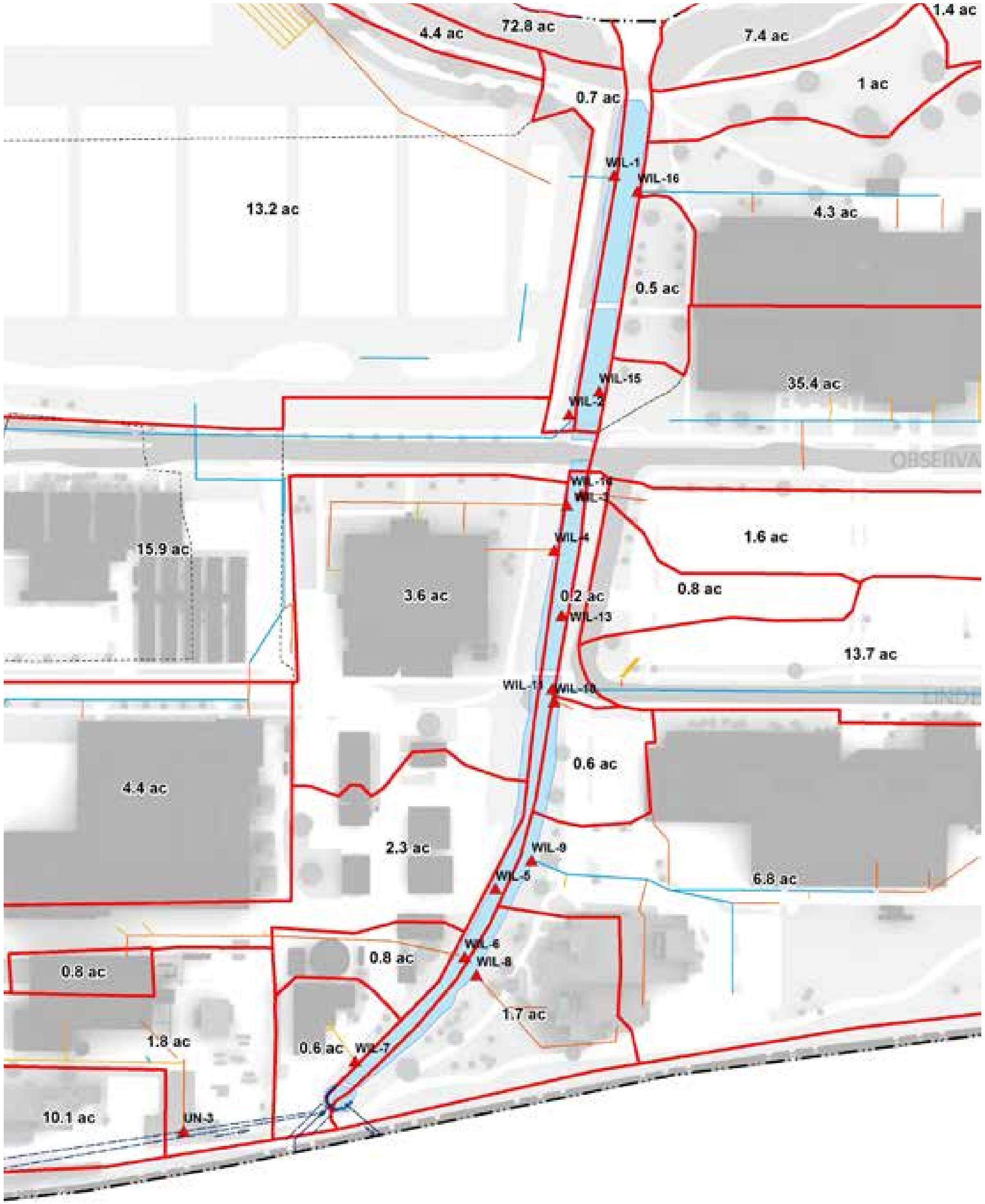
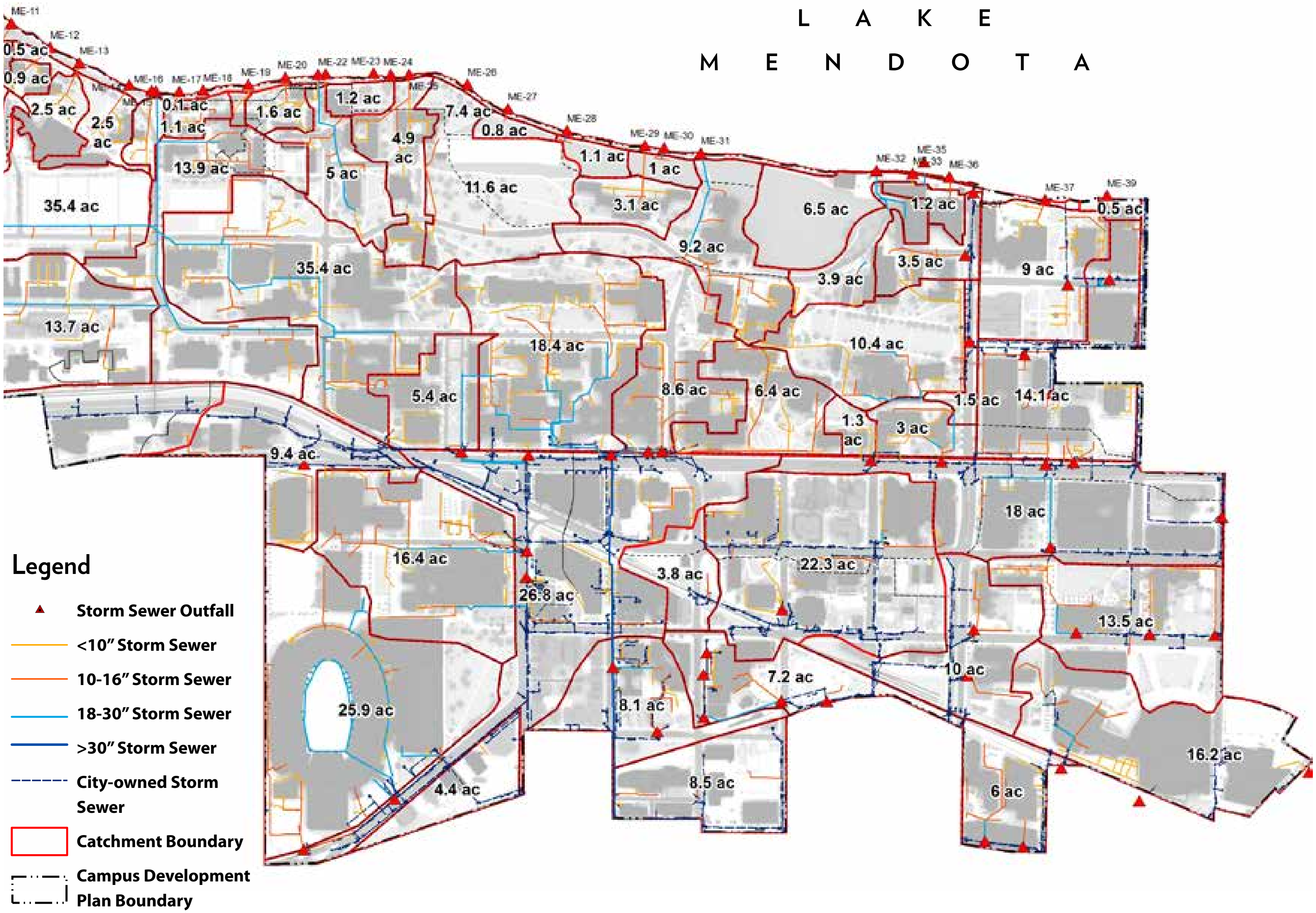


Figure 3-15 Existing Storm Sewer System and Outfalls – Willow Creek

Legend

- Storm Sewer Outfall
- <10" Storm Sewer
- 10-16" Storm Sewer
- 18-30" Storm Sewer
- >30" Storm Sewer
- City-owned Storm Sewer
- Catchment Boundary
- Campus Development Plan Boundary

North



North

Figure 3-16 Existing Storm Sewer System and Outfalls – East and South Campus

Best Management Practices and Stormwater Controls

The coverage and effectiveness of campus green infrastructure practices has increased substantially since completion of the 2008 Plan and initial DNR Stormwater Permit Submittal. In 2008, the primary stormwater BMPs employed within the permit area included street sweeping, the Nielsen Pond, the Cogen Ponds along the west athletic fields, vegetated swales located along University Bay Drive, porous pavement installations at the Biotron Laboratory, Lot 92, and Lot 34, an oil/sand separator at Lot 76, and the Lot 34 bioretention basin. In addition, the Microbial Sciences green roof had been constructed and catch basin inserts constructed in Lot 58 (Figure 3-18).

Many new BMPs have been constructed since 2008 in response to campus and state design guidelines, permit requirements, or the desire to improve campus sustainability (Figure 3-19). Some of these practices in the permit area include:

- Biofiltration areas in Eagle Heights, along University Bay Drive, the new Dejope Residence Hall, Wisconsin Institutes for Medical Research (WIMR), Carson Gulley Residence Hall, and other locations.
- A large Wet Detention Pond northeast of Lot 60.
- Underground chambers at Gordon Commons and the N. Charter Street Heating and Cooling Plant.
- Green Roofs at Gordon Commons, Education Building, Dejope Residence Hall, WIMR, and University Square.

Figures 3-18 and 3-19 show locations of BMPs present in 2008 and 2016, respectively. Table 3-3 provides a listing of known campus BMPs

Figure 3-17 Biofiltration area, Wisconsin Institute for Medical Research

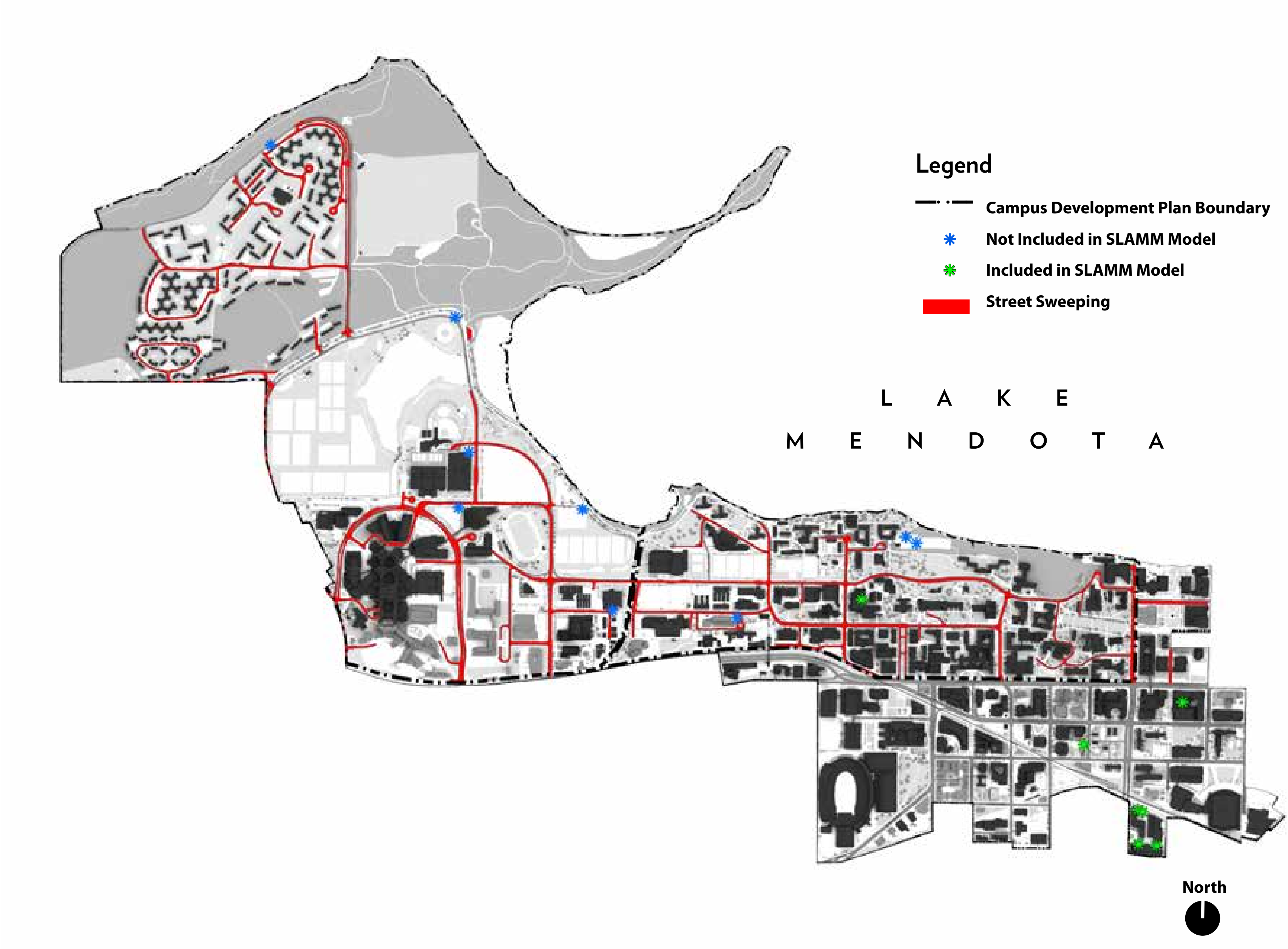


Figure 3-18 Campus BMPs Present in 2008

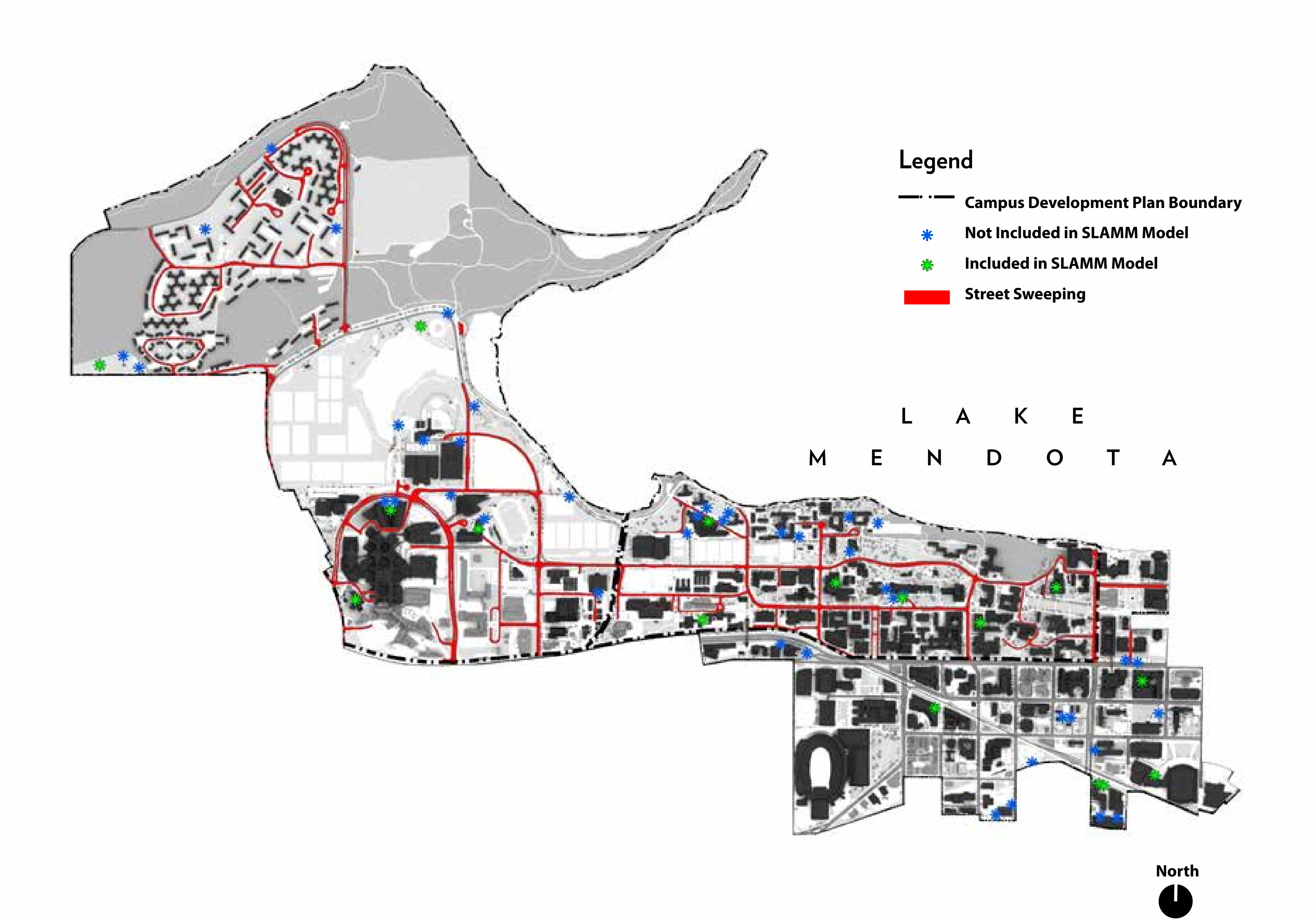


Figure 3-19 Campus BMPs Present in 2015

Table 3-3 Existing Campus BMPs (as of 2015)

Name	Year Constructed	BMP	Included in WinSLAMM Model?	BMP Type	Located in Campus Permit Area?
30 N. Mills Street	2010	55 sf x 2' Deep Sump	Y	Sump	N
30 N. Mills Street	2010	100 sf x 2' Deep Sump	Y	Sump	N
Biotron	2006	Porous Asphalt	Y	PP	Y
Carson Gully Biofiltration	2012	Biofiltration	Y	Bio	Y
Carson Gully Permeable Pavement	2012	Porous Pavement	Y	PP	Y
Centennial Gardens Pond		Wet Pond	N	WP	Y
Charter Street Plant	2012	StormTrap Chamber	Y	UG	N
Chazen	2009	Stormwater Treatment Unit	Y	Sep	N
Chazen	2009	Stormwater Treatment Unit	Y	Sep	N
Childrens Hospital Biofiltration	2008	Biofiltration/Rain Garden	N	BF	Y
Childrens Hospital Green Roof	2008	Green Roof	N	GR	Y
Cogen	2005	Wet Detention	Y	WP	Y
Cooper Hall	2013	Green Roof	N	GR	Y
Cooper Hall Biofiltration	2013	Biofiltration/Rain Garden	Y	BF	Y
Dairy Cattle Center	2012	Manure Runoff Management	N	Misc	Y
Dejope	2010	Green Roof	N	GR	Y
Dejope Hall	2010	Green Roof	N	GR	Y
Dejope Parking Lot	2010	Stormceptor	Y	Sep	Y
Dejope Rain Garden A	2010	Biofiltration	Y	Bio	Y
Dejope Rain Garden B	2010	Biofiltration	Y	Bio	Y
Dejope Rain Garden C	2010	Biofiltration	Y	Bio	Y
Dejope Rain Garden D	2010	Biofiltration	Y	Bio	Y
Eagle Heights (EH1a)	2013	Biofiltration	Y	Bio	Y
Eagle Heights (EH1b)	2013	Biofiltration	Y	Bio	Y
Eagle Heights (EH3)	2013	Biofiltration	Y	Bio	Y
Eagle Heights (EH6)	2013	Biofiltration	Y	Bio	Y
Education Building	2011	Green Roof	N	GR	Y
Engineering Building Green Roof		Green Roof	N	GR	Y
Gordon Commons Green Roof	2011	Green Roof	N	GR	N
Gordon Commons Underground Chamber	2013	Underground Treatment	Y	UG	N

Table 3-3 Existing Campus BMP's (as of 2015) (continued)

Name	Year Constructed	BMP	Included in WinSLAMM Model?	BMP Type	Located in Campus Permit Area?
Human Ecology	2010	Stormwater Treatment Unit	Y	Sep	Y
Human Ecology	2010	Stormwater Treatment Unit	Y	Sep	Y
Human Ecology	2010	Stormwater Treatment Unit	Y	Sep	Y
Human Ecology	2010	Sand Interceptor	Y	Sep	Y
Human Ecology	2012	Green Roof	N	GR	Y
Jorns Bioswale	2013	Biofiltration/Rain Garden	Y	BS	Y
LaBahn Hockey/Swim Facility	2012	Green Roof	N	GR	N
Lake Mendota Drive		Grass Swales	Y	GS	Y
Leopold Biofiltration	2013	Biofiltration/Rain Garden	Y	BF	Y
Leopold Porous Pavement	2013	Porous Pavement	N	PP	Y
Lot 34 Biofiltration	2007	Biofiltration	Y	Bio	Y
Lot 60 Pond	2013	Wet Detention	Y	WP	Y
Lot 60 Porous Pavement		Porous Pavement	N	PP	Y
Lot 61 – East	2013	Biofiltration	Y	Bio	N
Lot 61-West	2013	Biofiltration	Y	Bio	N
Lot 76	2005	Oil/Sand Separator	Y	Sep	Y
Lot 76 Seepage Basin	2005	Biofiltration/Rain Garden	N	BF	Y
Lot 92 Porous Pavement		Porous Pavement	N	PP	N
Microbial Sciences	2007	Green Roof	N	GR	Y
Newell Smith Hall	2006	Rain Garden	N	Bio	N
Newell Smith Hall	2006	Porous Pavement	N	PP	N
Nicholas Hall Green Roof	2011	Green Roof	N	GR	Y
Nicholas Hall Porous Pavement	2011	Porous Pavement	N	PP	Y
Nielsen Pond	2006	Wet Detention	Y	WP	Y
North Park Street Redevelopment	2006	Vortechs, 24"	Y	Sep	N
North Park Street Redevelopment	2006	Vortsentry VS-40, 12"	Y	Sep	N
Ogg Hall	2005	Biofiltration	Y	Bio	N

Table 3-3 Existing Campus BMP's (as of 2015) (continued)

Name	Year Constructed	BMP	Included in WinSLAMM Model?	BMP Type	Located in Campus Permit Area?
Snow Pile Treatment	2009	Snow Storage	N	Misc	Y
Softball Facility	2012	Sediment Basin	Y	WP	Y
Softball Facility	2012	Filter Strip	Y	FS	Y
Sterling Hall Courtyard	2009	Green Roof	N	GR	Y
Tripp Hall Bike Parking	2010	Porous Pavement	Y	PP	Y
Union South	2011	Green Roof	N	GR	N
Union South	2010	Cistern	N	Misc	N
University Bay Drive	2014	Bioretention	Y	Bio	Y
University Square	2007	Green Roof	N	GR	N
UW Medical Foundation Centennial Bldg	2009	Green Roof	N	GR	Y
WI Energy Institute	2011	Biofiltration	Y	Bio	N
WI Energy Institute	2011	Stormceptor	Y	Sep	N
WIMR	2012	Infiltration Planter	N	Bio	Y
WIMR	2012	Infiltration Planter	N	Bio	Y
WIMR	2012	Green Roof	N	GR	Y
WIMR	2012	Biofiltration	Y	Bio	Y
WIMR	2012	Biofiltration	Y	Bio	Y

3.4 Wellhead Protection Areas

The presence of community water system wells and accompanying wellhead protection zones within or near campus are significant because they impact the type of green infrastructure used in proximity to the well. The DNR prohibits use of infiltration practices within 400 feet of a community water system well. Local agencies may also limit use of infiltration devices within a Wellhead Protection Area (WHPA). A WHPA is defined by federal law as "the surface and subsurface area surrounding a water well or well field, through which contaminants are reasonably likely to move toward and reach such water well or well field" (United States Environmental Protection Agency (USEPA), 2005). Wisconsin Administrative Code Chapter NR 811.12(5)(d) requires a 1,200-foot separation distance between a municipal water supply well and certain contamination sources.

There are three community water supply wells owned by the City of Madison and accompanying WHPA's that impact campus. These are shown in Figure 3-20. Campus BMPs planned for areas within these areas shown must comply with city WHPA plans.

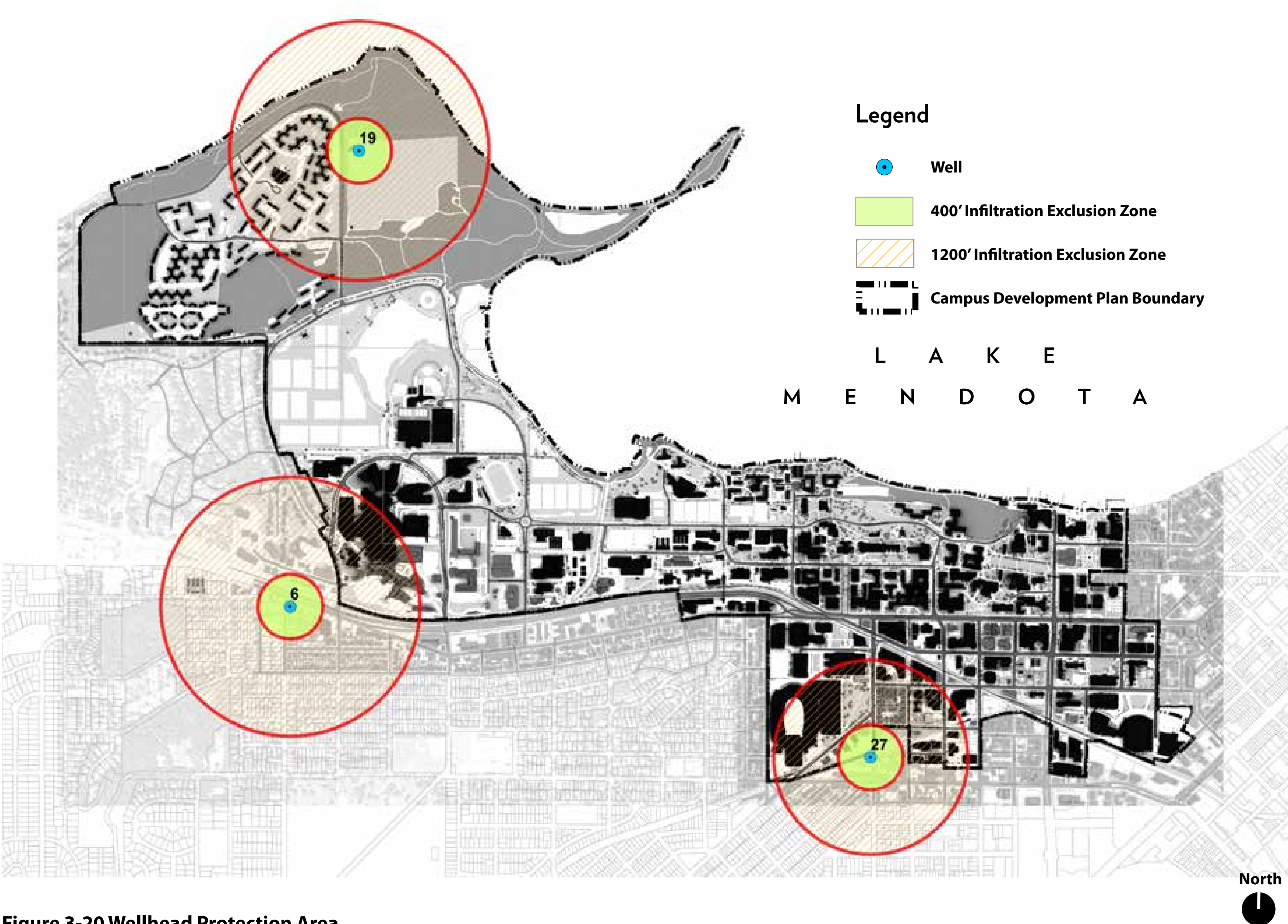


Figure 3-20 Wellhead Protection Area

4. STORMWATER ANALYSIS

4.1 Stormwater Analysis

Modeling Strategy

Stormwater management and green infrastructure enhancement strategies described in this report are based on computer modeling to estimate existing and potential future campus pollutant loads under various development scenarios. As discussed in previous chapters of this report, UW–Madison is mandated by DNR to achieve quantifiable reductions in phosphorus and TSS to waters of the Rock River watershed. Computer modeling described in this section estimates campus pollutant loads to establish baseline conditions for evaluation of future practice effectiveness. These models also estimate pollutant reductions achieved through best management practices implemented to date on campus. Finally, possible impacts of proposed land use changes and green infrastructure alternatives conceived during the master planning process are evaluated. Modeling results provide a scientific basis for selection of cost effective green infrastructure practices and baseline information for tracking future progress toward achieving mandated reductions.

Analysis Methodology

Pollutant loading for existing and future conditions was estimated using the WinSLAMM computer program. WinSLAMM is a computer program commonly used in Wisconsin to model the relationships between sources of urban nonpoint source pollutants and pollutant loading to downstream points of interest. The program also evaluates the pollutant trapping capabilities of different stormwater control practices such as infiltration devices, wet detention ponds, porous pavement, biofiltration, grass swales, and catch basins within the drainage system, or at outfalls.

WinSLAMM Parameter Files

WinSLAMM uses a series of user-specified parameter files to simulate pollutant probability distribution, source area runoff coefficients, particle size distributions, and pollutant delivery characteristics. Parameter files used for the analysis were selected based on DNR requirements, as summarized below:

- Pollutant Probability Distribution File – WI_GEO01.ppd
- Runoff Coefficient File – WI_SL06 Dec06.rsv
- Particulate Solids Concentration File – WI_avg01.psc
- Particulate Residue Delivery File – WI_dlv01.prr
- Street Delivery Files:
  - Residential/Other – WI_Res and Other Urban Dec06.std
  - Institutional/Commercial/Industrial – WI_Com Inst Indust Dec06.std
  - Freeway – Freeway Dec06.std
- Rain Files – WisReg – Milwaukee WI 1969.RAN

Modeled Areas

Pollutant loads were estimated from the entire campus for planning purposes. However, an intergovernmental agreement with the City of Madison specifies that the City of Madison is responsible for permit requirements for areas south of University Avenue and east of N. Park Street. U.S. Forest Products and Veteran's Administration also fall within campus permit responsibility under this agreement although they are not owned by UW–Madison. "Exempt Areas" are areas within the campus permit area that areas not served by a municipal separate storm sewer and are excluded by rule from pollutant calculations (Figure 4-1). Subsequent TMDL modeling guidance by DNR (October, 2014) considers inclusion of these areas in pollutant loading calculations as "optional". Exempt areas were not included in the pollutant calculations described in this report.

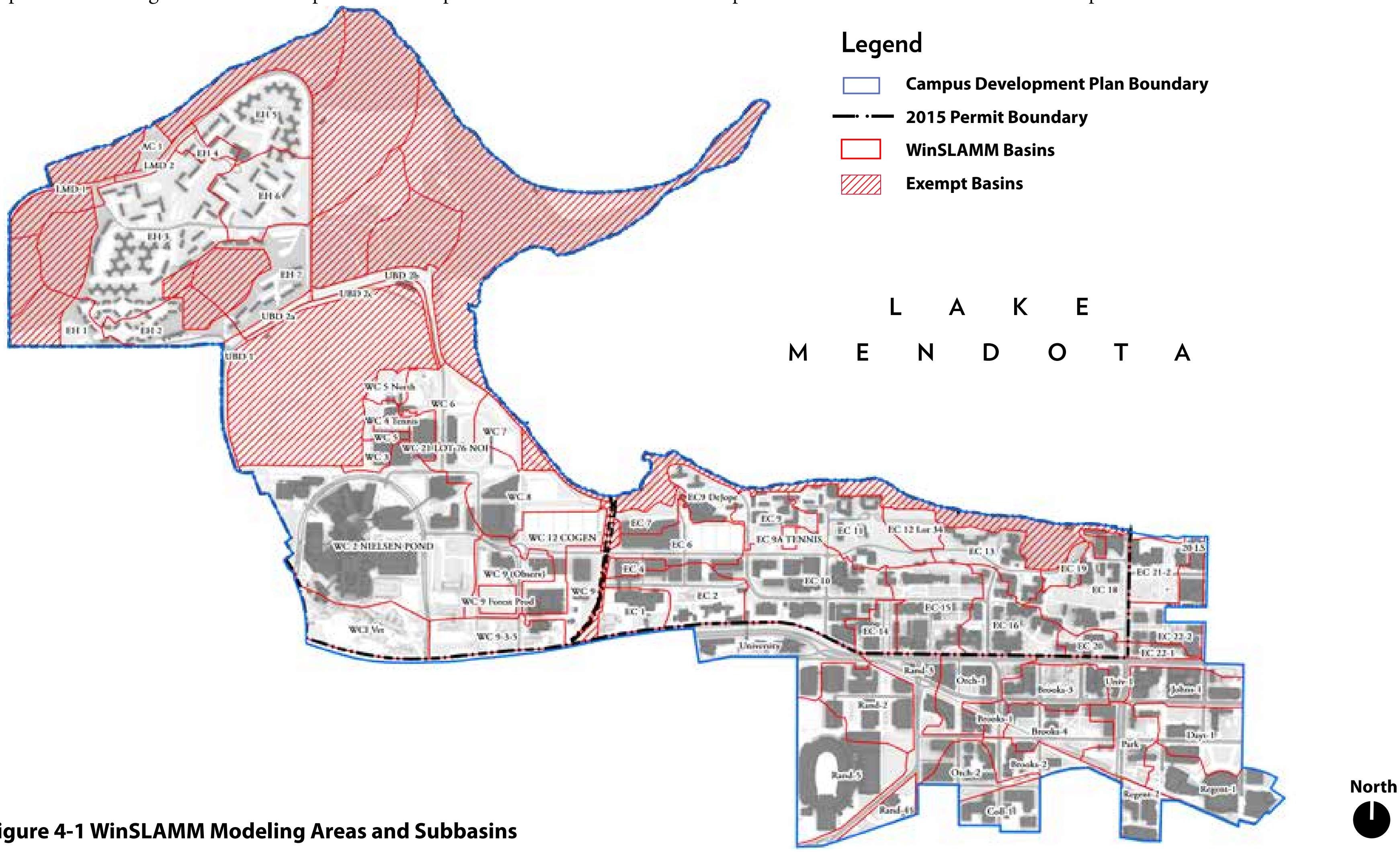


Figure 4-1 WinSLAMM Modeling Areas and Subbasins

Pollutant Source Areas

Stormwater and pollutant runoff rates and volumes are dependent on the type and condition of the surface upon which precipitation falls and the type of stormwater conveyance system. Stormwater runoff rates are higher from paved surfaces than from unpaved surfaces due to the limited infiltration capacity of the pavement. Higher runoff rates are seen from unpaved areas underlain with impervious soils such as clay than with more pervious soils such as sand. Dense, deep rooted vegetation better promotes infiltration reducing surface runoff rates in comparison with turfed areas or areas having limited vegetative cover.

The types and volume of pollutants delivered to an outfall for a series of rain events can be estimated based on the size and surface cover of the tributary area (i.e., "source areas"), the type of drainage system, and other related factors. Stormwater runoff from a parking lot or street typically carries a higher load of sediment, metals, oil, and grease due to the presence of vehicle drippings, road salt, and other urban pollutants than from a rooftop which typically has a "cleaner" surface.

WinSLAMM input was based on measurement of pollutant "source areas" such as parking lots, roadways, and other impervious areas using the AutoCAD and ArcGIS computer programs. The following scenarios were modeled:

1. Existing (2015) land use conditions without stormwater management practices.
2. Existing (2015) land use conditions with existing campus stormwater management practices.
3. Master Plan land use conditions with conceptual stormwater controls.

Comparison of TSS loading for "with stormwater controls" and "without stormwater controls" conditions provides estimates of the amount of TSS captured annually under each scenario. This provides guidance to sizing, location, and type of practices required to comply with regulatory requirements.

Source area breakdowns for the permit area and total campus are provided in Figures 4-2 and 4-3, respectively. Figure 4-4 is a map of source area locations.

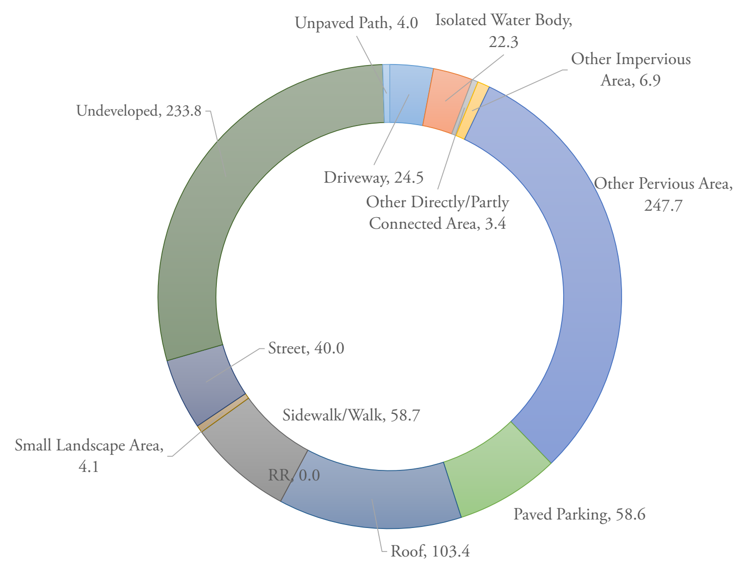


Figure 4-2 Pollutant Source Area – Permit Area Only

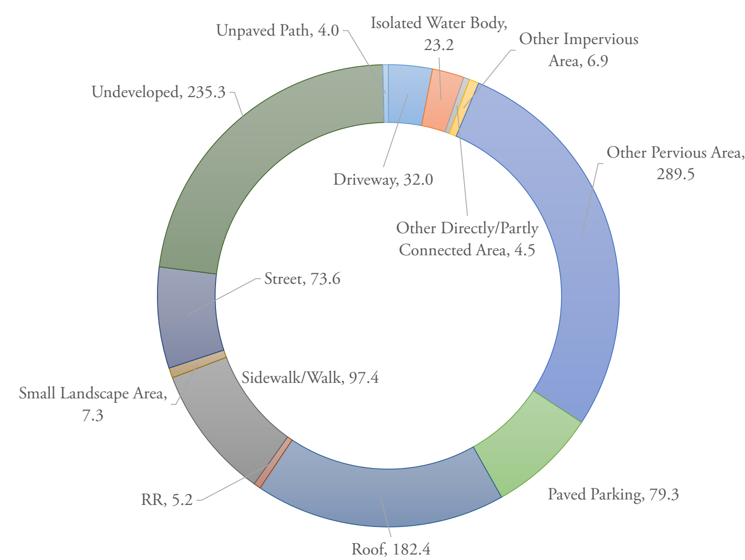


Figure 4-3 Pollutant Source Area – Total Campus Development Plan Boundary

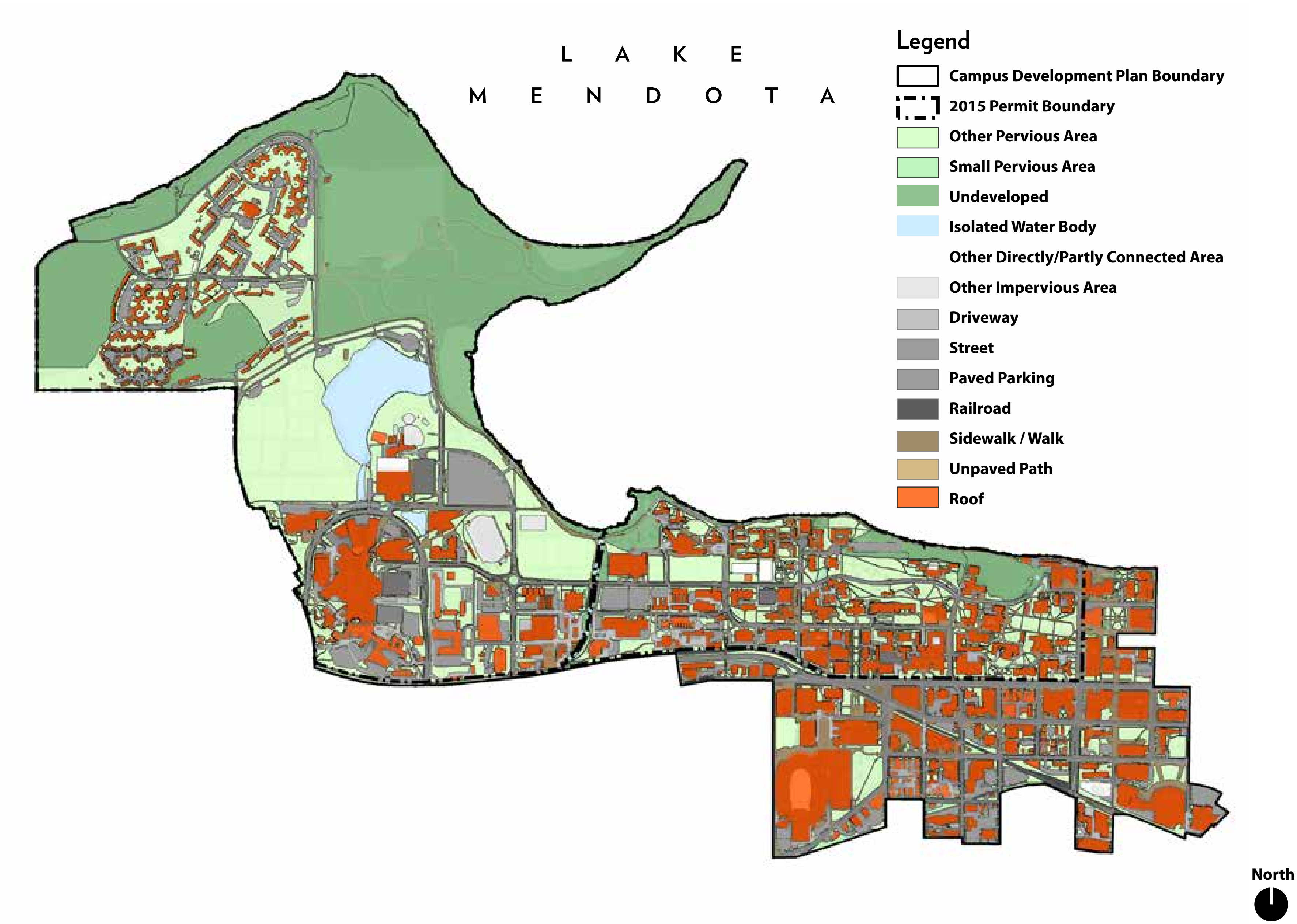


Figure 4-4 Source Area Map

Baseline Pollutant Loading Estimates

Total Suspended Solids – Permit Area

As indicated in Table 4-1, the WinSLAMM model estimates that approximately 168,000 pounds of TSS currently discharges from the permit area on an average annual basis. On a unit basis, the highest loading rates are currently from existing streets, driveways, and parking lots (Figure 4-5), with lower loading rates from sidewalks and rooftops. Generally, East Campus subbasins are currently the highest loading sources due to the relative absence of BMPs (Figure 4-6). West campus loading rates are slightly less due to the presence of Nielsen Pond, the Cogen Ponds, and the Lot 60 Pond. However, high loading rates still occur from untreated portions of Lot 60, the VA Hospital, and the Grounds/Environmental Services area near Willow Creek.

Total Suspended Solids – Non-permit Area (South Campus)

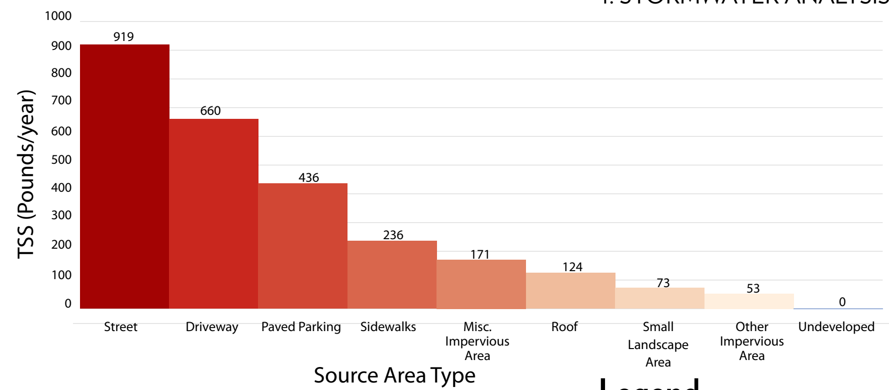
As indicated in Table 4-2, the WinSLAMM model estimates that approximately 92,000 pounds of TSS pounds of phosphorus currently discharges from the non-permit area (i.e., areas south of University Avenue and east of Park Street) on an average annual basis. Of this, approximately 39,000 pounds discharges from UW–Madison-owned properties with the remainder from city-owned rights-of-way or private properties. (Figure 4-6). The only known BMP's on non-campus properties in this area are street sweeping and catch basins. Campus BMP's in this area include underground detention chambers at Gordon Commons and the Charter Street Heating and Cooling Plant, small rain gardens at Lot 61, Ogg Hall, Smith Hall, and other scattered locations. Overall, however, the percent of TSS and phosphorus captured annually in this portion of campus is currently very low.

Table 4-1 Estimated 2015 TSS Loading by Basin-Permit Area

		2015 Conditions			
Basin	Catchment Area (ac)	Annual NC Particulate Solids Yield (lbs)	Annual Particulate Solids Yield (lbs)	Removed – 2015 Practices (Lbs)	Removed (%)
AC 1	2.5	39	39	0	0.00%
EC 1	7.9	2,372	2,372	0	0.00%
EC 2	13.7	6,592	6,090	503	7.63%
EC 4	2.4	1,574	1,502	73	4.61%
EC 6	12.7	4,079	3,418	661	16.21%
EC 7	4.2	815	815	0	0.00%
EC 9	8.2	2,304	1,918	386	16.74%
EC9 Dejope	6.8	621	69	552	88.94%
EC 9A TENNIS	0.8	51	51	0	0.00%
EC 10	30.0	12,212	10,900	1,312	10.74%
EC 11	16.3	6,087	5,432	655	10.76%
EC 12 Lot 34	5.1	1,204	93	1,111	92.25%
EC 13	11.5	3,675	3,472	203	5.51%
EC 14	5.4	1,511	1,416	94	6.25%
EC 15	18.4	5,516	4,921	595	10.78%
EC 16	15.0	4,590	4,230	359	7.83%
EC 18	16.6	5,350	4,817	533	9.97%
EC 19	3.9	1,423	1,216	207	14.53%
EC 20	4.2	1,242	1,190	52	4.21%
EH 1	4.9	869	124	745	85.72%
EH 2	9.8	1,310	32	1,278	97.57%
EH 3	43.3	9,408	2,071	7,337	77.99%
EH 4	2.7	860	860	0	0.00%
EH 5	19.7	6,367	4,927	1,440	22.62%
EH 6	18.2	4,683	878	3,805	81.26%
EH 7	14.1	2,907	307	2,600	89.44%
LMD 1	2.0	845	253	592	70.06%
LMD 2	1.9	709	212	496	70.06%
UBD1	2.6	1,328	892	436	32.82%
UBD 2a	1.5	494	12	482	97.55%
UBD 2b	5.4	1,360	348	1,012	74.39%
UBD 2c	3.5	1,189	1,189	0	0.00%
WC 12 COGEN	13.7	3,326	380	2,946	88.57%
WC 2 NIELSEN POND	72.0	25,655	12,272	13,383	52.16%
WC21 LOT76	3.0	1,697	192	1,505	88.69%
WC 3	2.7	757	757	0	0.00%
WC 4 Tennis	1.5	485	485	0	0.00%
WC 5	3.0	617	497	120	19.43%
WC 5 North	3.0	551	551	0	0.00%
WC 6	11.5	4,706	863	3,843	81.67%
WC 7	5.7	3,131	221	2,910	92.95%
WC 8	21.4	9,810	9,359	452	4.60%
WC 9	8.3	4,803	4,010	793	16.51%
WC 9-3-5	12.2	4,752	4,439	313	6.58%
WC 9 (Observ)	10.1	6,327	5,348	978	15.46%
WC 9 Forest Prod	2.8	716	716	0	0.00%
WCIVet	16.1	6,722	6,570	152	2.26%
Total	501.8	167,604	112,690	54,914	32.76%

Table 4-2 Estimated 2015 TSS Loading by Basin – Nonpermit Area

	Catchment Area (Ac)		"No Controls" Condition			TSS Removed – 2015 Practices			
Catchment	Total-Within Campus Boundary	UW–Madison Ownership Only	Annual NC Particulate Solids Yield (Total within Campus Boundary)	Annual NC Particulate Solids Yield (UW–Madison Ownership Only)	Annual NC Particulate Solids Yield (Non-campus Lands)	TSS Removed by Campus Practices (Lbs)	TSS Removed by Campus Practices (Lbs)	% Removal (Based on Total Area within Campus Boundary	% Removal (Based on UW–Madison Ownership within Campus Boundary
20 LS	0.5	0.5	102	102	0	0	0	0.00%	0.00%
Brooks-1	2.8	1.0	1,414	420	995	0	0	0.00%	0.00%
Brooks-2	7.2	5.0	3,645	1,829	1,816	0	0	0.00%	0.00%
Brooks-3	11.0	4.7	5,800	947	4,853	0	0	0.00%	0.00%
Brooks-4	11.2	5.8	5,187	1,344	3,843	0	0	0.00%	0.00%
Coll-1	8.5	5.4	4,610	2,240	2,370	135	135	2.92%	6.01%
Dayt-1	13.5	10.9	5,401	2,527	2,874	98	115	1.82%	4.56%
EC21-1	0.6	0.5	160	115	45	0	0	0.00%	0.00%
EC 21-2	9.0	8.2	2,610	1,710	900	0	0	0.00%	0.00%
EC 22-1	2.4	2.1	497	497	0	57	57	11.57%	11.57%
EC 22-2	11.8	8.0	3,294	2,004	1,290	0	0	0.00%	0.00%
Johns-1	10.9	7.5	5,089	1,653	3,436	0	0	0.00%	0.00%
Orch-1	13.1	7.4	6,444	2,011	4,433	0	0	0.00%	0.00%
Orch-2	8.1	3.0	3,568	924	2,644	0	0	0.00%	0.00%
Park	10.1	5.2	4,546	1,384	3,161	57	57	1.25%	4.11%
Rand-2	16.3	16.3	4,140	4,140	0	0	0	0.00%	0.00%
Rand-3	14.9	3.0	10,357	648	9,709	0	0	0.00%	0.00%
Rand-4	4.4	2.7	1,521	1,038	483	0	0	0.00%	0.00%
Rand-5	25.9	25.1	6,345	5,359	986	0	0	0.00%	0.00%
Regent-1	16.2	14.0	5,076	4,273	804	67	67	1.31%	1.56%
Regent-2	6.0	4.3	1,641	1,148	493	0	0	0.00%	0.00%
Univ-1	7.2	1.7	4,034	361	3,673	0	0	0.00%	0.00%
University	20.3	7.6	6,441	2,117	4,324	131	131	2.04%	6.19%
TOTAL	232.1	149.9	91,921	38,792	53,129	545	562	0.59%	1.45%



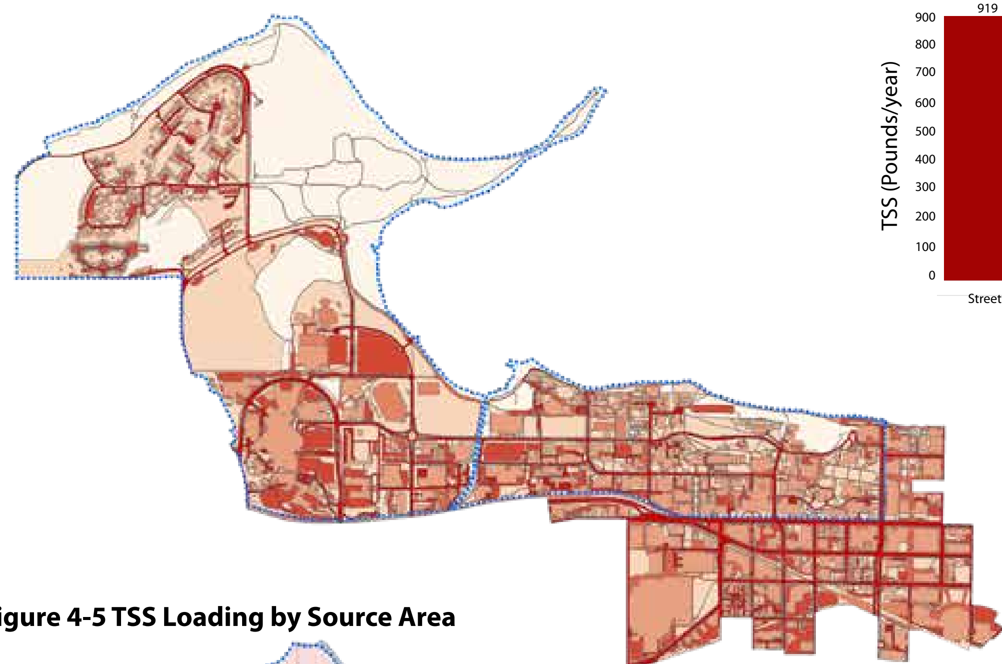


Figure 4-5 TSS Loading by Source Area

Legend

TSS Loading (lbs/ac/yr)

- 0
- 53
- 73
- 124
- 171
- 236
- 436
- 660
- 919
- Campus Development Plan Boundary

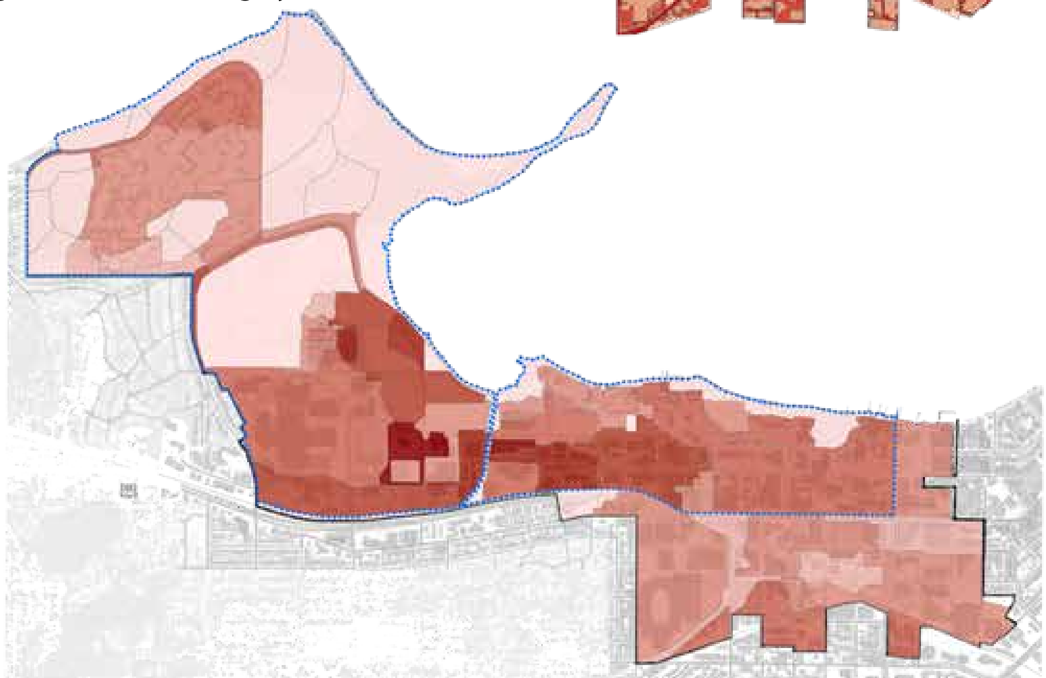


Figure 4-6 TSS Loading by Subbasin

Legend

TSS Loading (lbs/yr)

- 0.00 – 100.00
- 100.01 – 200.00
- 200.01 – 300.00
- 300.01 – 400.00
- 400.01 – 500.00
- 500.01 – 600.00
- 600.01 – 700.00
- Campus Development Plan Boundary

Note: South Campus analysis results shown exclude city-owned ROW and private property.

North

Total Phosphorus – Permit Area

WinSLAMM results indicate that approximately 565 pounds of phosphorus discharges from the campus permit area to waters of the Rock River watershed under current (2015) land use conditions. Approximately 143 pounds of phosphorus is currently captured through existing BMP's, resulting in approximately a 25.4% annual reduction.

Phosphorus loading for 2015 site conditions in the permit area is summarized in Table 4-3.

Total Phosphorus – Nonpermit Area (South Campus)

WinSLAMM results indicate that approximately 284 pounds of phosphorus discharges from the non-permit area (i.e., areas south of University Avenue and east of Park Street) to waters of the Rock River watershed under current (2015) land use conditions. Of this, approximately 165 pounds discharges from UW–Madison-owned properties with the remainder from noncampus areas such as city rights-of-way and private properties. Phosphorus loading for 2015 site conditions in the permit area is summarized in Table 4-4.

Table 4-3 Existing Phosphorus Loading By Basin (Permit Area)

Catchment	Catchment Area (ac)	2015 Conditions			
		Annual NC Total Phosphorous Yield (lbs)	Annual Total Phosphorous Yield (lbs)	Removed – 2015 Practices(Lbs)	Removed (%)
AC 1	2.5	0.7	0.7	0.0	0.0%
EC 1	7.9	9.8	9.8	0.0	0.0%
EC 2	13.7	20.5	19.8	0.7	3.5%
EC 4	2.4	2.7	2.6	0.1	3.8%
EC 6	12.7	14.0	13.2	0.9	6.2%
EC 7	4.2	3.5	3.5	0.0	0.0%
EC 9	8.2	9.6	7.8	1.8	18.9%
EC9 Dejope	6.8	7.3	4.9	2.4	33.2%
EC 9A TENNIS	0.8	0.2	0.2	0.0	0.0%
EC 10	30.0	39.1	37.2	1.9	4.8%
EC 11	16.3	19.3	18.3	0.9	4.8%
EC 12 Lot 34	5.1	3.6	0.0	3.6	98.8%
EC 13	11.5	12.9	12.6	0.3	2.3%
EC 14	5.4	6.5	6.3	0.1	2.1%
EC 15	18.4	22.2	20.7	1.5	6.8%
EC 16	15.0	18.7	18.1	0.5	2.8%
EC 18	16.6	19.8	19.0	0.8	3.9%
EC 19	3.9	4.7	4.4	0.3	6.4%
EC 20	4.2	5.4	5.3	0.1	1.4%
EH 1	4.9	3.7	1.3	2.4	64.0%
EH 2	9.8	6.0	0.5	5.5	92.2%
EH 3	43.3	36.1	11.8	24.3	67.3%
EH 4	2.7	2.9	2.9	0.0	0.0%
EH 5	19.7	22.1	18.1	4.0	18.0%
EH 6	18.2	16.8	6.4	10.4	61.7%
EH 7	14.1	11.8	1.8	10.0	84.7%

Basin	Catchment Area (ac)	2015 Conditions			
		Annual NC Total Phosphorous Yield (lbs)	Annual Total Phosphorous Yield (lbs)	Removed – 2015 Practices(Lbs)	Removed (%)
LMD 1	2.0	2.7	0.9	1.8	65.8%
LMD 2	1.9	2.4	0.8	1.6	65.8%
UBD1	2.6	4.3	3.1	1.2	28.3%
UBD 2a	1.5	1.8	0.1	1.7	92.2%
UBD 2b	5.4	5.7	1.5	4.3	74.4%
UBD 2c	3.5	3.9	3.9	0.0	0.0%
WC 12 COGEN	13.7	13.5	10.7	2.9	21.1%
WC 2 NIELSEN POND	72.0	85.5	45.9	39.6	46.3%
WC 21 Lot 76	3.0	3.3	2.7	0.6	16.9%
WC 3	2.7	2.4	2.4	0.0	0.0%
WC 4 Tennis	1.5	1.6	1.6	0.0	0.0%
WC 5	3.0	2.9	2.5	0.4	14.6%
WC 5 North	3.0	2.2	2.2	0.0	0.0%
WC 6	11.5	13.0	4.1	8.9	68.4%
WC 7	5.7	6.5	2.1	4.4	68.4%
WC 8	21.4	28.1	27.4	0.7	2.4%
WC 9	8.3	13.9	13.0	0.9	6.5%
WC 9-3-5	12.2	15.5	15.0	0.4	2.9%
WC 9 (Observ)	10.1	14.5	13.1	1.4	9.7%
WC 9 Forest Prod	2.8	2.7	2.7	0.0	0.0%
WCIVet	16.1	19.9	19.6	0.2	1.1%
Total	501.8	566.0	422.6	143.3	25.3%

Table 4-4 Existing Phosphorus Loading By Basin (Non-permit Area)

	Catchment Area (acres)				
Catchment	Total-Within Campus Boundary	UW–Madison Ownership Only	Annual NC Particulate Solids Yield (Total Within Campus Boundary)	Annual NC Particulate Solids Yield (UW–Madison Ownership Only)	Annual NC Particulate Solids Yield (Non-Campus Lands)
20 LS	0.5	0.5	0.5	0.5	0.0
Brooks-1	2.8	1.0	3.4	1.1	2.3
Brooks-2	7.2	5.0	8.4	4.8	3.6
Brooks-3	11.0	4.7	16.3	5.3	11.0
Brooks-4	11.2	5.8	14.1	5.7	8.4
Coll-1	8.5	5.4	10.9	6.2	4.7
Dayt-1	13.5	10.9	16.4	11.4	5.1
EC21-1	0.6	0.5	1.2	0.5	0.7
EC 21-2	9.0	8.2	10.3	8.5	1.8
EC 22-1	2.4	2.1	2.4	2.4	0.0
EC 22-2	11.8	8.0	14.1	9.3	4.9
Johns-1	10.9	7.5	15.3	8.4	6.9
Orch-1	13.1	7.4	17.8	8.5	9.3
Orch-2	8.1	3.0	11.0	3.1	7.8
Park	10.1	5.2	11.9	5.7	6.1
Rand-2	16.3	16.3	19.3	19.3	-0.0
Rand-3	14.9	3.0	23.9	3.4	20.5
Rand-4	4.4	2.7	4.3	2.5	1.8
Rand-5	25.9	25.1	28.6	27.0	1.7
Regent-1	16.2	14.0	17.1	15.8	1.3
Regent-2	6.0	4.3	8.3	5.3	3.0
Univ-1	7.2	1.7	9.6	2.0	7.6
University	20.3	7.6	19.2	8.9	10.4
TOTAL	232.1	149.9	284.3	165.5	118.8

Existing Best Management Practice Effectiveness

Since completion the 2008 Stormwater Management Study, dozens of BMPs have been installed throughout campus. A wide variety of practices such as green roofs, wet detention ponds, biofiltration basins pervious pavements. In addition, non-structural practices such as street sweeping, education of facilities staff, and improved "housekeeping" efforts have advanced.

WinSLAMM modeling results indicate that these practices capture approximately 53,000 pounds of TSS and 143 pounds of phosphorus annually that would otherwise discharge to adjacent waterways. The greatest proportion of this is achieved by wet detention ponds (i.e., Nielsen Pond, the Cogen Ponds, and the Lot 60 Pond), with a large proportion also captured through biofiltration practices. A lesser but significant proportion is captured by street sweeping. Other treatment technologies such as permeable pavement, hydrodynamic separators, grassed swales are also used on campus but presently account for less than ten percent of the total pollutant capture (Figure 4-7).

Over ten green roofs have been constructed on campus at locations such as the Education Building, Gordon Commons, and Microbial Sciences. While these are effective at reducing annual runoff volume, DNR does not currently consider them effective at capturing sediment and phosphorus. Consequently, pollutant reductions summarized in this report do not include green roof impacts.

BMP locations and types are shown in Figure 4-8.

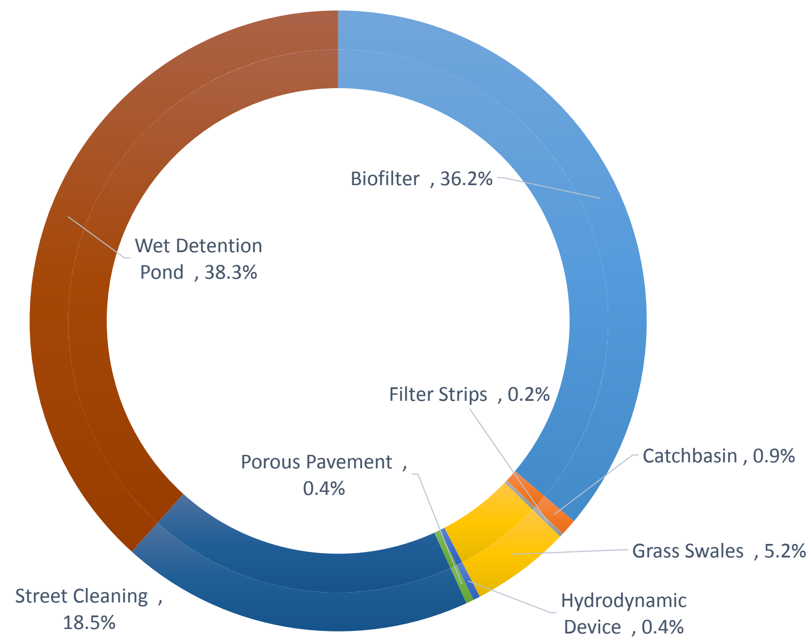


Figure 4-7 Percentage of Total TSS Captured by BMP Type

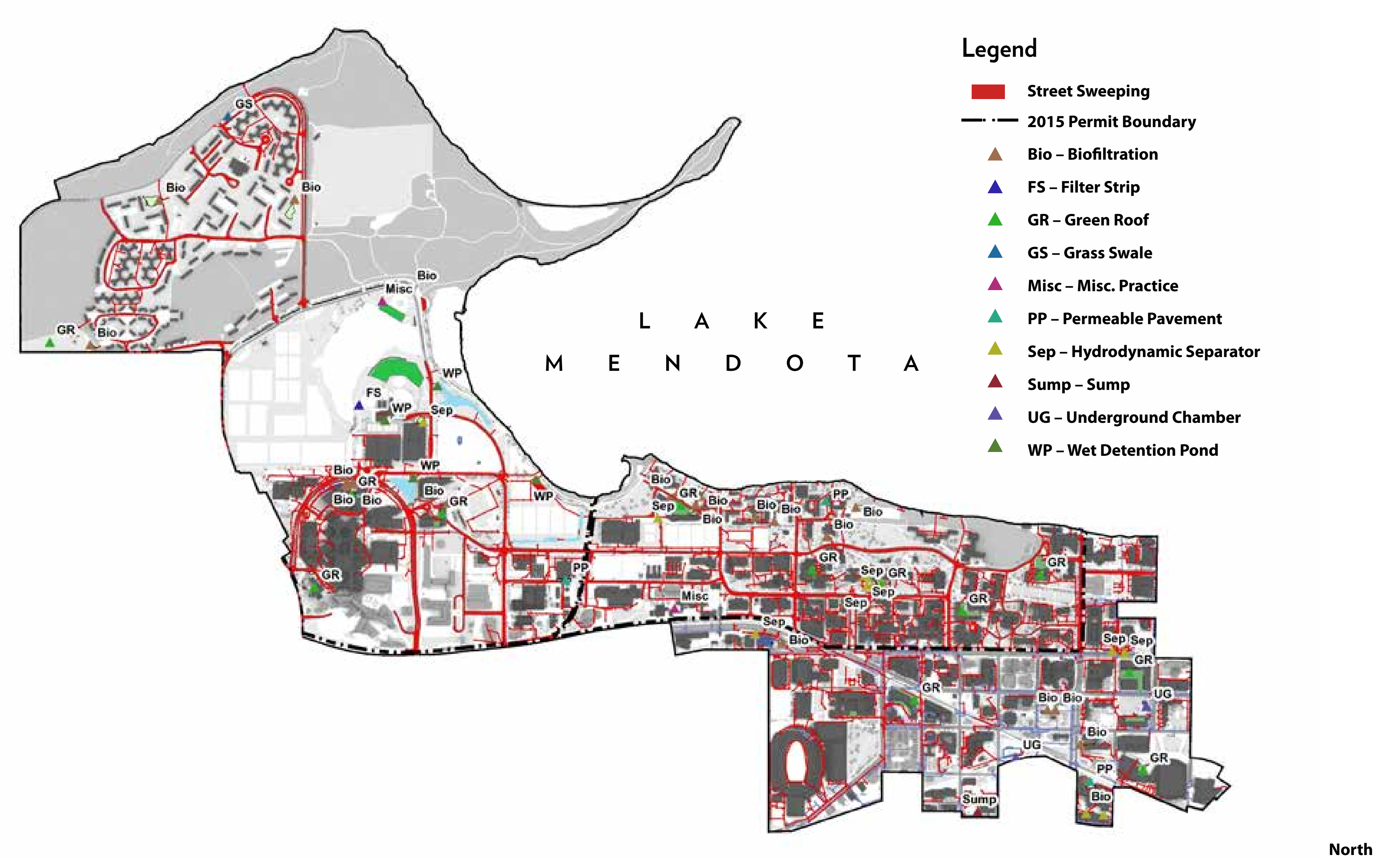


Figure 4-8 BMP Types and Locations on Campus

4.2 Peak Discharge and Runoff Volume Analysis

Analysis Methodology

Development impacts on stormwater runoff peak discharges and runoff volumes were estimated through computer modeling using the HydroCAD computer program. HydroCAD is a hydrograph-producing runoff calculation method using NRCS TR-20 methodology, consistent with local and state technical requirements. The HydroCAD program estimates peak discharges and volumes based on numerical representations of factors affecting runoff such as type of land cover and soils, tributary area size, rainfall depths and temporal patterns, drainage times, and routing. Separate models were created to estimate stormwater runoff for existing and proposed conditions. For each model, peak discharge rates and runoff volumes were estimated for the 1-year (i.e., 50% annual probability) storm event through the 100-year (i.e., 1% annual probability) storm event.

Runoff hydrographs were based on the following:

1. Rainfall Depths per the publication NOAA 14 Rainfall Atlas.
2. NRCS Type 2 Rainfall Distributions
3. Antecedent Moisture Condition 2

Peak Discharge and Runoff Volume Estimates

Estimated peak discharge rates for the 1-year, 10-year, and 100-year design storm events for pre-settlement and 2015 conditions (without peak discharge controls) for each subbasin are summarized in Table 4-3. Runoff volumes are shown in Table 4-4. A map showing catchment names is included in Figure 4-9.

Table 4-5 Peak Discharge Rates

Peak Discharge Rates								
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
12 PP	49.2	73	77.2	137.1	28.7	71.8	1.9	20.6
12 PP-1	23.6	59	22.2	28.6	6.8	10.5	0.3	0.8
14 LS	1.8	82	4.0	12.4	2.0	7.5	0.5	3.2
15 Willow C	0.7	80	2.9	4.5	1.5	2.7	0.4	1.1
15 WILLOWC	0.7	89	2.9	5.0	1.5	3.3	0.4	1.7
20 LS	0.5	93	1.0	4.3	0.5	2.9	0.1	1.6
AC1	2.5	73	6.9	7.5	3.5	3.9	0.9	1.1
Brooks-1	2.8	85	3.3	19.8	1.3	12.8	0.1	6.8
Brooks-2	7.2	89	8.5	55.1	3.4	36.7	0.4	20.2
Brooks-3	11.0	94	12.9	91.5	5.1	62.8	0.6	36.1
Brooks-4	11.2	85	13.1	78.9	5.2	51.2	0.6	27.0
Coll-1	8.5	93	10.0	69.5	4.0	47.4	0.4	27.1
Dayt-1	13.5	88	19.2	101.5	8.6	66.6	1.5	35.5
EC 1-1	6.8	90	15.1	52.0	7.6	34.4	1.9	18.5
EC 1-2	0.6	95	1.7	4.9	0.9	3.4	0.2	1.9
EC 1-3	1.7	87	4.8	12.5	2.5	8.0	0.7	4.0
EC 14	5.4	88	6.6	40.2	2.7	26.6	0.3	14.4
EC 15	18.4	86	21.5	130.5	8.6	84.9	0.9	45.0
EC 16-1	6.4	83	7.6	43.5	3.0	27.8	0.3	14.3
EC 16-2	8.6	88	10.1	64.5	4.0	42.8	0.4	23.4
EC 18-1	3.5	90	5.7	27.4	2.3	18.4	0.2	10.3
EC 18-2	10.4	77	23.3	46.5	9.5	27.9	0.9	13.1
EC 18-3	1.5	95	1.8	12.8	0.7	8.8	0.1	5.1

Table 4-5 Peak Discharge Rates (continued)

Peak Discharge Rates								
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
EC 18-4	1.2	96	1.6	10.6	0.7	7.3	0.1	4.3
EC 19	3.9	79	5.9	24.2	2.3	15.0	0.2	7.4
EC 19LS-3	7.3	77	35.7	45.4	18.0	26.4	4.5	10.6
EC 2	12.9	93	18.9	103.8	9.4	70.1	2.3	38.9
EC 20-1	3.0	87	3.5	21.6	1.4	14.2	0.2	7.6
EC 20-2	1.3	82	1.5	8.4	0.6	5.3	0.1	2.7
EC 2-1	0.8	94	0.9	6.8	0.4	4.6	0.1	2.7
EC 21-2	9.0	90	14.8	70.6	6.8	46.9	1.3	25.5
EC 22-1	2.4	84	2.8	16.3	1.1	10.5	0.1	5.5
EC 22-2	11.6	95	21.1	97.7	9.7	67.0	1.8	38.4
EC 6	12.7	88	18.0	43.0	9.1	27.5	2.4	13.6
EC 7	4.2	89	7.7	31.9	3.9	20.9	1.0	10.8
EC 9-10	0.8	92	0.9	6.3	0.4	4.3	0.0	2.4
EC 9-11	1.0	77	2.3	5.7	1.0	3.4	0.1	1.6
EC 9-6	0.2	93	0.4	1.7	0.2	1.1	0.0	0.6
EC 9-6	1.2	93	2.2	9.8	1.1	6.6	0.2	3.7
EC 9-7	1.0	83	1.8	6.7	0.8	4.3	0.1	2.1
EC10	22.7	90	28.6	171.9	13.0	113.7	2.5	61.2
EC10-2	8.1	93	12.5	66.1	6.3	44.7	1.6	24.8
EC11-1	5.1	71	12.9	20.0	5.3	11.1	0.5	4.5
EC11-2	4.4	87	7.7	32.2	3.1	21.1	0.3	11.4
EC11-3	5.1	86	8.8	36.1	3.5	23.5	0.3	12.5
EC11-4	1.3	84	2.1	8.7	0.8	5.6	0.1	2.9
EC11-5	0.5	97	1.1	4.0	0.4	2.8	0.0	1.6
EC12	5.1	73	14.3	22.1	6.0	12.7	0.6	5.5
EC13-1	2.8	92	5.9	21.9	2.4	14.8	0.2	8.4
EC13-2	5.6	79	12.3	34.9	5.0	21.6	0.5	10.6
EC13-3	3.1	81	5.5	19.9	2.2	12.5	0.2	6.2
EC15 Willow	0.2	87	0.4	1.8	0.2	1.1	0.1	0.6
EC19LS-1	6.5	64	11.9	13.4	4.8	6.3	0.5	2.0

Table 4-5 Peak Discharge Rates (continued)

Peak Discharge Rates								
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
EC19LS-10	1.4	77	4.1	5.5	2.0	3.1	0.4	1.2
EC19LS-11	1.0	81	2.8	6.7	1.5	4.1	0.4	1.7
EC19LS-2	0.9	60	2.8	2.7	1.2	1.1	0.1	0.2
EC19LS-4	1.0	59	3.4	3.0	1.4	1.2	0.2	0.1
EC19LS-5	1.2	61	4.0	3.8	1.7	1.7	0.2	0.3
EC19LS-6	0.8	61	2.0	2.9	0.8	1.3	0.1	0.2
EC19LS-7	1.3	66	3.6	5.6	1.5	2.8	0.1	0.8
EC19LS-8	0.6	65	1.6	2.4	0.7	1.2	0.1	0.3
EC19LS-9	0.7	65	2.0	2.9	0.8	1.5	0.1	0.4
EC21-1	0.6	90	3.2	4.9	1.7	3.3	0.5	1.8
EC4-1	1.6	97	2.9	13.9	1.5	9.7	0.4	5.7
EC4-2	0.8	96	1.4	6.7	0.7	4.6	0.2	2.6
EC9-1	0.5	85	1.3	3.2	0.6	2.1	0.1	1.1
EC9-2	0.5	80	1.4	3.2	0.7	1.9	0.1	0.8
EC9-3	0.9	93	3.7	7.2	1.9	4.9	0.5	2.7
EC9-4	2.5	92	4.8	20.2	2.4	13.6	0.6	7.4
EC9-5	2.5	89	4.3	19.5	2.1	12.7	0.5	6.6
EC9-8	0.1	96	0.4	0.9	0.2	0.6	0.0	0.4
EC9-9	4.0	89	6.1	30.7	2.9	20.2	0.6	10.7
EH1	4.9	72	6.5	16.7	2.0	9.3	0.1	3.9
EH10	17.9	59	12.5	16.1	3.9	6.0	0.2	0.5
EH11	14.1	59	13.0	16.7	4.0	6.2	0.2	0.5
EH1-1	6.9	64	10.6	13.2	4.1	5.8	0.4	0.9
EH2	9.9	75	12.0	29.4	3.7	17.3	0.1	8.2
EH2-1	5.7	65	10.5	11.5	4.5	5.2	0.6	0.9
EH2-2	6.1	72	19.7	21.1	10.0	11.0	2.5	3.1
EH3	43.2	76	41.4	126.4	13.4	74.7	0.6	34.8
EH3-1	10.3	72	25.5	27.3	12.7	14.2	3.1	3.9
EH4	2.7	81	4.6	13.9	1.6	8.6	0.1	4.2
EH4LS	9.8	73	21.3	24.7	10.5	13.3	2.4	4.3

Table 4-5 Peak Discharge Rates (continued)

Peak Discharge Rates								
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
EH5	19.7	79	19.3	69.5	5.9	42.6	0.2	21.1
EH5-1	15.8	70	30.6	35.8	14.1	18.1	2.6	4.8
EH6	18.2	75	17.7	51.5	5.4	29.9	0.2	13.6
EH6-1	1.7	59	2.0	2.6	0.6	1.0	0.0	0.1
EH7	14.1	74	19.1	52.1	5.9	29.9	0.2	13.0
EH7-1	3.3	58	4.3	5.2	1.3	1.9	0.0	0.1
EH8	9.0	59	12.3	15.9	3.8	6.0	0.1	0.5
EH9	38.9	59	27.0	33.2	8.9	12.7	0.5	1.4
Johns-1	10.9	94	13.5	91.0	5.5	62.4	0.7	35.9
LMD1	2.1	79	3.2	12.7	1.4	7.7	0.2	3.5
LMD2	1.9	79	3.3	11.8	1.5	7.0	0.3	3.0
Orch-1	13.1	93	15.4	107.6	6.1	73.4	0.7	41.9
Orch-2	8.1	96	9.5	69.2	3.8	47.8	0.4	27.7
Park	10.1	83	11.9	67.8	4.7	43.0	0.5	21.9
Rand-2	16.4	91	37.5	90.6	16.9	60.7	2.8	33.5
Rand-3	14.9	95	18.4	124.6	7.5	85.5	0.9	49.1
Rand-4	4.4	96	5.2	37.8	2.1	26.1	0.2	15.2
Rand-5	25.9	91	44.8	129.3	17.9	86.9	1.8	48.8
Regent-1	16.2	93	20.0	132.4	8.2	90.0	1.0	50.9
Regent-2	6.0	91	10.9	48.0	5.5	32.0	1.4	17.5
UBD 1	3.0	88	5.3	22.8	2.5	14.8	0.5	7.6
UBD2a	1.5	73	2.6	8.7	1.2	5.0	0.2	2.0
UBD2b	5.4	76	3.6	30.7	0.9	18.0	0.0	7.7
UBD2c	3.5	84	3.9	12.4	1.4	7.7	0.1	3.6
Univ-1	7.2	96	8.5	61.5	3.4	42.4	0.4	24.6
University	10.4	85	29.5	52.8	13.2	33.8	2.0	17.3
University	9.9	85	28.0	50.2	12.6	32.2	1.9	16.5
WC 7	5.7	90	9.0	44.2	4.3	29.2	0.9	15.4
WC 8	0.0	87	0.0	0.1	0.0	0.1	0.0	0.0
WC 8-2	5.1	84	10.6	36.3	5.4	22.7	1.4	10.5

Table 4-5 Peak Discharge Rates (continued)

Peak Discharge Rates								
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
WC12	13.7	84	18.4	40.2	8.8	24.8	1.9	11.4
WC12 1918 Marsh	67.8	86	15.3	189.7	1.9	119.3	0.0	56.6
WC2	73.2	90	77.2	554.7	29.4	368.8	2.9	201.1
WC21 Lot 76	3.0	96	0.0	24.9	0.0	17.1	0.0	9.8
WC3	2.7	94	0.0	22.5	0.0	15.2	0.0	8.5
WC5-1	3.0	87	0.0	12.1	0.0	7.7	0.0	3.8
WC5-3	3.0	91	0.0	23.4	0.0	15.5	0.0	8.2
WC5-4	1.4	97	0.0	12.3	0.0	8.5	0.0	4.9
WC-6	11.5	88	1.8	86.9	0.1	56.3	0.0	28.4
WC8-1	15.6	90	18.6	119.8	7.6	79.4	1.0	42.8
WC9-1	0.5	93	1.4	4.2	0.7	2.9	0.2	1.6
WC9-10	2.8	92	3.1	21.7	1.2	14.7	0.1	8.3
WC9-2	0.6	94	1.5	5.2	0.8	3.5	0.2	2.0
WC9-2	2.3	94	5.6	18.8	2.8	12.8	0.6	7.2
WC9-3	2.1	94	4.3	17.0	2.0	11.6	0.4	6.6
WC9-5	10.1	84	17.2	68.1	7.1	43.7	0.8	22.6
WC9-7	3.7	93	6.5	30.1	3.3	20.2	0.9	11.1
WC9-8	1.7	90	2.9	13.1	1.5	8.6	0.4	4.5
WC9-9	10.1	86	12.0	71.1	4.9	46.3	0.6	24.6
WCI VET	16.1	88	25.9	116.1	10.3	76.6	1.0	41.6

Table 4-6 Runoff Volumes

			Runoff Volume (Ac-Feet)					
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
12 PP	49.2	73	6.708	11.35	2.873	6.04	0.493	1.98
12 PP-1	23.6	59	2.611	3.20	1.014	1.37	0.116	0.23
14 LS	1.8	82	0.395	0.55	0.206	0.33	0.064	0.14
15 Willow C	0.7	80	0.148	0.20	0.077	0.12	0.024	0.05
15 WILLOWC	0.7	89	0.147	0.24	0.077	0.16	0.024	0.08
20 LS	0.5	93	0.126	0.23	0.066	0.15	0.021	0.09
AC1	2.5	73	0.531	0.58	0.273	0.31	0.082	0.10
Brooks-1	2.8	85	0.460	1.04	0.209	0.68	0.044	0.36
Brooks-2	7.2	89	1.190	2.94	0.542	1.95	0.114	1.07
Brooks-3	11.0	94	1.806	4.94	0.822	3.36	0.174	1.89
Brooks-4	11.2	85	1.841	4.16	0.838	2.72	0.177	1.45
Coll-1	8.5	93	1.397	3.75	0.636	2.54	0.134	1.42
Dayt-1	13.5	88	2.610	5.32	1.269	3.49	0.327	1.87
EC 1-1	6.8	90	1.434	2.55	0.738	1.69	0.221	0.91
EC 1-2	0.6	95	0.132	0.25	0.069	0.17	0.021	0.09
EC 1-3	1.7	87	0.375	0.59	0.196	0.38	0.061	0.19
EC 14	5.4	88	0.923	2.14	0.427	1.41	0.096	0.77
EC 15	18.4	86	3.020	6.89	1.375	4.51	0.291	2.41
EC 16-1	6.4	83	1.059	2.28	0.482	1.47	0.102	0.77
EC 16-2	8.6	88	1.414	3.44	0.644	2.28	0.136	1.24
EC 18-1	3.5	90	0.583	1.47	0.266	0.98	0.056	0.54
EC 18-2	10.4	77	1.723	3.13	0.786	1.93	0.167	0.94
EC 18-3	1.5	95	0.250	0.69	0.114	0.47	0.024	0.27
EC 18-4	1.2	96	0.203	0.57	0.093	0.39	0.020	0.22
EC 19	3.9	79	0.640	1.26	0.291	0.79	0.062	0.41
EC 19LS-3	7.3	77	1.596	2.16	0.812	1.26	0.236	0.53
EC 2	12.9	93	2.700	5.14	1.386	3.46	0.412	1.91
EC 20-1	3.0	87	0.489	1.15	0.223	0.75	0.047	0.41
EC 20-2	1.3	82	0.207	0.44	0.094	0.28	0.020	0.15

Table 4-6 Runoff Volumes (continued)

			Runoff Volume (Ac-Feet)					
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
EC 2-1	0.8	94	0.135	0.34	0.062	0.23	0.014	0.13
EC 21-2	9.0	90	1.802	3.71	0.890	2.46	0.239	1.33
EC 22-1	2.4	84	0.388	0.86	0.177	0.56	0.037	0.30
EC 22-2	11.6	95	2.342	5.26	1.156	3.57	0.311	2.01
EC 6	12.7	88	2.742	4.49	1.425	2.88	0.438	1.44
EC 7	4.2	89	0.910	1.54	0.474	1.00	0.146	0.52
EC 9-10	0.8	92	0.130	0.34	0.059	0.23	0.013	0.13
EC 9-11	1.0	77	0.160	0.29	0.073	0.18	0.016	0.09
EC 9-6	0.2	93	0.046	0.09	0.024	0.06	0.007	0.03
EC 9-6	1.2	93	0.269	0.52	0.138	0.35	0.041	0.19
EC 9-7	1.0	83	0.179	0.35	0.085	0.22	0.020	0.11
EC10	22.7	90	4.114	8.45	1.993	5.60	0.508	3.03
EC10-2	8.1	93	1.768	3.27	0.919	2.20	0.283	1.21
EC11-1	5.1	71	0.851	1.31	0.388	0.76	0.083	0.34
EC11-2	4.4	87	0.731	1.71	0.333	1.12	0.071	0.61
EC11-3	5.1	86	0.838	1.91	0.382	1.25	0.081	0.67
EC11-4	1.3	84	0.209	0.46	0.095	0.29	0.020	0.16
EC11-5	0.5	97	0.077	0.22	0.035	0.15	0.007	0.08
EC12	5.1	73	0.849	1.38	0.388	0.82	0.083	0.38
EC13-1	2.8	92	0.458	1.18	0.209	0.79	0.044	0.44
EC13-2	5.6	79	0.932	1.82	0.425	1.14	0.091	0.58
EC13-3	3.1	81	0.512	1.04	0.234	0.66	0.050	0.34
EC15 Willow	0.2	87	0.052	0.08	0.027	0.05	0.008	0.03
EC19LS-1	6.5	64	1.071	1.26	0.489	0.66	0.104	0.24
EC19LS-10	1.4	77	0.295	0.40	0.150	0.23	0.044	0.09
EC19LS-11	1.0	81	0.232	0.32	0.123	0.19	0.039	0.08
EC19LS-2	0.9	60	0.145	0.14	0.066	0.07	0.014	0.02
EC19LS-4	1.0	59	0.175	0.16	0.080	0.07	0.017	0.02
EC19LS-5	1.2	61	0.207	0.21	0.094	0.10	0.020	0.03

Table 4-6 Runoff Volumes (continued)

			Runoff Volume (Ac-Feet)					
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
EC19LS-6	0.8	61	0.136	0.14	0.062	0.07	0.013	0.02
EC19LS-7	1.3	66	0.211	0.26	0.096	0.14	0.021	0.05
EC19LS-8	0.6	65	0.093	0.11	0.042	0.06	0.009	0.02
EC19LS-9	0.7	65	0.116	0.14	0.053	0.08	0.011	0.03
EC21-1	0.6	90	0.146	0.26	0.076	0.17	0.024	0.09
EC4-1	1.6	97	0.355	0.71	0.185	0.49	0.057	0.28
EC4-2	0.8	96	0.174	0.34	0.090	0.23	0.028	0.13
EC9-1	0.5	85	0.091	0.17	0.045	0.11	0.012	0.06
EC9-2	0.5	80	0.099	0.16	0.049	0.09	0.013	0.04
EC9-3	0.9	93	0.210	0.38	0.111	0.25	0.036	0.14
EC9-4	2.5	92	0.585	1.05	0.309	0.70	0.099	0.38
EC9-5	2.5	89	0.581	1.00	0.303	0.65	0.093	0.33
EC9-8	0.1	96	0.017	0.05	0.008	0.03	0.002	0.02
EC9-9	4.0	89	0.854	1.59	0.433	1.04	0.125	0.55
EH1	4.9	72	0.546	1.17	0.213	0.68	0.025	0.31
EH10	17.9	59	1.961	2.41	0.759	1.03	0.085	0.17
EH11	14.1	59	1.558	1.91	0.605	0.82	0.069	0.14
EH1-1	6.9	64	0.980	1.17	0.428	0.55	0.079	0.13
EH2	9.9	75	1.099	2.61	0.427	1.59	0.049	0.78
EH2-1	5.7	65	0.935	1.02	0.432	0.49	0.096	0.12
EH2-2	6.1	72	1.299	1.39	0.669	0.73	0.200	0.24
EH3	43.2	76	5.043	11.70	2.010	7.14	0.258	3.45
EH3-1	10.3	72	2.198	2.35	1.131	1.24	0.338	0.40
EH4	2.7	81	0.340	0.84	0.139	0.53	0.020	0.27
EH4LS	9.8	73	2.003	2.36	1.016	1.30	0.293	0.48
EH5	19.7	79	2.187	5.76	0.849	3.62	0.097	1.84
EH5-1	15.8	70	2.900	3.39	1.408	1.77	0.361	0.57
EH6	18.2	75	2.013	4.67	0.782	2.81	0.089	1.33
EH6-1	1.7	59	0.195	0.24	0.076	0.11	0.009	0.02

Table 4-6 Runoff Volumes (continued)

			Runoff Volume (Ac-Feet)					
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
EH7	14.1	74	1.571	3.52	0.611	2.10	0.071	0.98
EH7-1	3.3	58	0.372	0.43	0.145	0.18	0.017	0.03
EH8	9.0	59	1.007	1.25	0.392	0.54	0.045	0.10
EH9	38.9	59	4.472	5.32	1.775	2.32	0.224	0.44
Johns-1	10.9	94	1.873	4.91	0.868	3.34	0.194	1.88
LMD1	2.1	79	0.350	0.60	0.165	0.37	0.038	0.18
LMD2	1.9	79	0.358	0.54	0.176	0.32	0.047	0.15
Orch-1	13.1	93	2.157	5.80	0.982	3.93	0.208	2.21
Orch-2	8.1	96	1.338	3.75	0.609	2.56	0.129	1.45
Park	10.1	83	1.666	3.55	0.758	2.28	0.160	1.19
Rand-2	16.4	91	3.195	6.89	1.556	4.60	0.402	2.52
Rand-3	14.9	95	2.553	6.72	1.183	4.57	0.264	2.58
Rand-4	4.4	96	0.727	2.04	0.331	1.40	0.070	0.79
Rand-5	25.9	91	4.292	10.83	1.957	7.26	0.416	4.02
Regent-1	16.2	93	2.778	7.10	1.287	4.79	0.288	2.67
Regent-2	6.0	91	1.434	2.52	0.757	1.67	0.241	0.91
UBD 1	3.0	88	0.578	1.09	0.285	0.71	0.076	0.36
UBD2a	1.5	73	0.280	0.36	0.138	0.21	0.037	0.09
UBD2b	5.4	76	0.474	1.44	0.162	0.86	0.009	0.40
UBD2c	3.5	84	0.448	1.11	0.187	0.69	0.029	0.33
Univ-1	7.2	96	1.188	3.33	0.541	2.27	0.114	1.29
University	10.4	85	1.948	3.83	0.935	2.47	0.232	1.28
University	9.9	85	1.853	3.64	0.889	2.35	0.220	1.22
WC 7	5.7	90	1.113	2.14	0.556	1.40	0.154	0.74
WC 8	0.0	87	0.003	0.01	0.002	0.00	0.000	0.00
WC 8-2	5.1	84	1.121	1.68	0.584	1.04	0.180	0.48
WC12	13.7	84	2.674	4.40	1.335	2.72	0.369	1.29
WC12 1918 Marsh	67.8	86	3.394	23.09	0.777	14.52	0.000	7.02
WC2	73.2	90	10.336	27.46	4.507	18.29	0.825	10.02

Table 4-6 Runoff Volumes (continued)

Runoff Volume (Ac-Feet)								
			100-Year		10-Year		1-Year	
Catchment	Drainage Area (Ac)	Runoff Curve No.	Preset.	Exist.	Preset.	Exist.	Preset.	Exist.
WC21 Lot 76	3.0	96	0.010	1.25	0.000	0.85	0.000	0.48
WC3	2.7	94	0.009	1.11	0.000	0.75	0.000	0.42
WC5-1	3.0	87	0.010	1.05	0.000	0.67	0.000	0.33
WC5-3	3.0	91	0.010	1.14	0.000	0.75	0.000	0.39
WC5-4	1.4	97	0.005	0.62	0.000	0.43	0.000	0.24
WC-6	11.5	88	0.427	4.13	0.071	2.65	0.000	1.34
WC8-1	15.6	90	2.415	5.88	1.095	3.90	0.228	2.11
WC9-1	0.5	93	0.116	0.21	0.061	0.14	0.019	0.08
WC9-10	2.8	92	0.408	1.09	0.181	0.74	0.036	0.42
WC9-2	0.6	94	0.129	0.26	0.066	0.17	0.019	0.10
WC9-2	2.3	94	0.470	0.94	0.238	0.63	0.069	0.35
WC9-3	2.1	94	0.383	0.85	0.186	0.58	0.048	0.33
WC9-5	10.1	84	1.579	3.34	0.717	2.17	0.151	1.15
WC9-7	3.7	93	0.814	1.48	0.424	0.99	0.131	0.54
WC9-8	1.7	90	0.367	0.63	0.191	0.41	0.059	0.22
WC9-9	10.1	86	1.554	3.51	0.705	2.30	0.147	1.24
WCI VET	16.1	88	2.398	5.77	1.069	3.83	0.211	2.10

Figure 4-9 HydroCAD Catchment Names

5. GREEN INFRASTRUCTURE MASTER PLAN

5.1 Summary of Recommendations

The purpose of this chapter is to document a series of recommendations which together make up the Green Infrastructure Master Plan for UW–Madison's campus. These recommendations are grouped into five different categories which are summarized below and described in more detail throughout this chapter:

1. Stormwater Performance Standards and Policies: This section provides a discussion on the current and proposed stormwater management performance standards which individual construction projects on campus are required to achieve, as well as alternatives to achieving the standards where it is not feasible.
2. Multi-Site Green Infrastructure Practices: This section describes structural green infrastructure practices, or BMPs, which if implemented would provide treatment on a larger scale than just one building site and which may include street right-of-ways and other parts of campus which are not necessarily slated for a redevelopment project.
3. Site-Based Green Infrastructure Practices: This section offers descriptions of structural BMPs which could be used on individual redevelopment project sites to achieve the proposed performance standards, and summarizes the list of BMPs in a matrix to allow UW–Madison staff and design teams to easily identify site appropriate BMPs as projects are planned for development.
4. Opportunities with Future Land Use Changes: This section highlights the most significant areas of campus which are planned for redevelopment and describes the impact of the proposed land use changes on the overall campus stormwater management and green infrastructure objectives and permit requirements.
5. Opportunities with Utility Improvement Projects: This section identifies planned utility improvement projects which will disturb areas of campus and which may provide an opportunity to implement green infrastructure practices which may not be advanced through other means.

This chapter suggests structural and non-structural approaches to achieving stormwater management/green infrastructure goals and estimates potential numeric progress toward achieving regulatory objectives offered by major structural practices. While the specific policies and practices recommended in this report should not be considered mandates, it is important to recognize that there are specific regulatory mandates driving many of the recommendations. Therefore, the decision to implement, not implement, or modify each of the identified practices will impact progress toward meeting regulatory mandates.

5.2 Stormwater Performance Standards and Policies

Current Policy and Procedures

In 2004, a report was completed by the UW–Madison Gaylord Nelson Institute for Environmental Studies entitled “Innovating Stormwater Management on the University of Wisconsin–Madison Campus.” Based on preliminary recommendations of that report, a resolution was introduced and was unanimously passed by the University Campus Planning Committee (CPC) on October 2, 2003 which in part stated the following:

> “It is therefore recommend(ed) that the University of Wisconsin–Madison commit to a policy that ensures that the amount of runoff from newly developed and redeveloped areas be no greater than the amount that occurred under native conditions.”

The resolution also stated that “Implementation of this policy could be achieved by use of conservation practices on site, by improving stormwater management practices elsewhere on campus, or by a combination of on – and off-site improvements.”

This was a bold and forward thinking policy which represents the university’s goal of minimizing the campus’ adverse impacts on the natural environment and to become an ever more sustainable community. This recommended policy has been the stated goal for each new building project since the resolution was passed. However, the specific mechanics of implementing and achieving the policy have never been identified. Therefore, each new building design project team has needed to individually investigate the feasibility of meeting that recommended policy and each project has also shown that matching the amount of site runoff to native conditions is not feasible due to a number of factors including the lack of available open space suitable for stormwater management, the UW–Madison’s high demand on developable land for buildings and infrastructure, the poor infiltration capacity of soils on campus, and the need to avoid infiltrating polluted runoff.

Also, UW–Madison has not had the authority to transfer project funds into a separate escrow account for future use in constructing off-site stormwater BMPs elsewhere on campus and this concept cannot currently be otherwise administratively and logistically implemented. As part of this plan, it is recommended that UW–Madison investigate creating a fee-in-lieu system that would allow individual project sponsors to mitigate their stormwater management impacts by paying into a fund that would go towards implementation of larger green infrastructure improvements. The idea is to create a source of revenue for UW–Madison to implement district-wide BMPs by collecting a fee (similar to a stormwater utility) from a project which may be unable to achieve the performance standards for their particular building. This requires additional study by FP&M staff and campus leadership to determine the feasibility of such a fund.

In light of these issues, this Green Infrastructure and Stormwater Master Plan recommends the CPC-adopted policy of meeting native conditions be re-addressed and clarified.

Adding to the complexity, the Department of Administration Division of Facilities Development (DOA DFD), which funds and oversees many projects on campus, has adopted Sustainability Guidelines which have separate stormwater standards which loosely follow the USGBC LEED stormwater credits. The DFD guidelines measure slightly different metrics and are therefore difficult to compare with the proposed campus performance standards but in general are a similar level of stringency and can be accomplished through many of the same practices.

Regulatory Framework

As described earlier in this document, UW–Madison is subject to regulatory requirements for stormwater through the WPDES Municipal Stormwater Discharge Permit issued by the WDNR. In addition, although UW–Madison is a state-owned institution, since the campus is located within the City of Madison, UW–Madison has enforced an informal policy of requiring construction projects on campus to adhere to City of Madison stormwater performance standards which are documented in Chapter 37 of their municipal ordinances. However this policy has not been formally adopted or documented.

Table 5-1 summarizes the various post-construction performance standards which are applicable to UW–Madison's campus.

Proposed Site-Based Stormwater Standards

As part of the Green Infrastructure Master Plan, it is recommended that the UW–Madison adopt a formal set of stormwater management performance standards which supersede previously adopted standards and which are consistently enforced on major construction projects and renovations. There will always be exceptions to the rule in that not every project will be able to meet proposed standards without undue hardship or cost. However, with clearly defined standards clarity will be provided to design teams and to UW–Madison reviewers as to what standards should be achieved.

The following outlines the proposed stormwater management performance standards which UW–Madison should adopt to reflect campus values and achieve current and anticipated regulatory requirements.

To meet the campus goals and objectives for stormwater management including the need to meet regulatory requirements, the following standards will be mandated for all future construction projects which disturb more than 20,000 square feet.

Each project site must adhere and meet the regulatory requirements for that site including applicable municipal zoning requirements. Every project design team must determine the regulatory requirements and address the site's compliance to those requirements. The UW–Madison imposes the following requirements that may be above the regulatory requirements.

Proposed Site-Design Standards (Post-Construction)

Total Suspended Solids
Best management practices shall be designed, installed, and maintained to control total suspended solids (TSS) carried in runoff from post-construction building sites. These BMPs should reduce the total annual suspended solids by 80 percent for all new development or redevelopment projects, regardless of size, as compared with predevelopment (pre-construction) loading.

At least 40 percent of the required TSS reduction must be met on-site and off-site mitigation may account for the remaining 40 percent reduction. Off-site mitigation should occur within the same watershed as the project within the Campus Development Plan Boundary (either the Lake Mendota or Lake Monona watershed). If no physical location is available for an off-site BMP then the project may contribute financially to another planned or completed off-site stormwater management project in lieu of on-site controls.

Volume Reduction
Volume reduction is one of the highest stormwater management priorities on campus. Best management practices shall be designed, installed, and maintained to reduce the total volume of runoff leaving a site by the equivalent of one inch of runoff volume based on average annual rainfall. If this is not feasible, off-site infiltration or volume reduction practices may be utilized to meet this requirement as part of the project stormwater plan.

Peak Discharge
Peak discharge rates from each project site will be controlled as necessary to mitigate erosion of downstream open channels and damage to conveyance systems including outfalls. Best management practices shall be employed as needed to maintain or reduce the peak runoff discharge rates, to the maximum extent practicable, as compared to predevelopment conditions for the 2-year 24-hour design storm event. This requirement shall be evaluated for each drainage channel separately.

Peak discharge shall also be managed as necessary to mitigate known downstream flooding, conveyance backups, or other system failures. Discharges will be controlled for the 2 and 10-year design storm event or for those design storm events required by the conveyance owner. This requirement shall be evaluated for each drainage system separately.

Where the downstream conveyance system for a project site is owned by a neighboring municipality (City of Madison or Village of Shorewood Hills), the project site must meet that municipality's peak discharge performance standard.

Table 5-1 Matrix of Relevant Applicable Post-Construction Stormwater Performance Standards

Performance Standard	Current NR 151/216	DFD Sustainability Guidelines	Rock River TMDL WLA & New Permit Target	City of Madison, Chapter 37
Total Suspended Solids				
TSS reduction (post-construction site)	80% for new development, 40% for redevelopment (applies to roads and parking surfaces), compared with no controls.	80% TSS removal, all projects	Not specified on a per site basis	80% for new development or redevelopment in TMDL areas, compared with existing condition.
Total Phosphorus				
TP reduction (post-construction site)	Not specified	40% TP removal (average annual basis), all projects	Not specified on a per site basis	Not specified on a per site basis
Oil & Grease Control				
Oil & grease control	BMP's Required for Fueling and Vehicle Maintenance Areas	N/A	N/A	Applies if >= 40 Parking Spaces. Treat first 0.5 inches of runoff for oil & grease.
Runoff Rate Control				
Runoff rate control	Maintain 1-yr & 2-yr, 24 hr predevelopment peak flow (except where discharging directly to a large lake or river).	Maintain 1.5-yr 24-hr predevelopment peak discharge (<50% imperviousness) or 25% decrease in rate and quantity of runoff (>50% imperviousness).	N/A	Maintain 2-yr & 10-yr, 24 hr predevelopment runoff rate; safely pass 100-yr; applies if >20,000 SF increase in impervious area.
Infiltration				
Infiltration volume (annual basis)	Maintain 60-90% of predevelopment infiltration volume (depending on site imperviousness), redevelopment projects exempt.	Not specifically stated; see runoff rate control.	N/A	New Development: maintain 90% of predevelopment volume.
Protective Areas				
Protective areas	No impervious surfaces in protective areas (50' for lakes and perennial streams), redevelopment projects exempt.	N/A	N/A	Comply with NR 151

Construction Erosion Control & Sediment Standards

A significant source of sediment and other pollutants that end up in the Yahara Lakes comes from construction sites. Despite erosion control permitting and monitoring processes, sediment-laden runoff is a heavy contributor to phosphorus in our waters. It is critical that every construction site on UW–Madison campus, regardless of size, set a positive example by treating erosion control practices seriously and enforcing standards.

Currently WDNR requires that all sites which disturb greater than one acre of land obtain coverage under a general erosion control WPDES permit. The City of Madison enforces erosion control permitting for sites greater than 4,000 square feet. While formal permits may not be necessary for smaller projects, UW–Madison should insist that all projects have erosion control plans and implement BMPs to minimize the amount of sediment leaving the site through runoff.

WDNR and the city now measure sediment from construction sites by tons per acre per year, as calculated by the Urban Soil Loss Equation (or USLE). WDNR enforces this on one-acre sites, the city on sites greater than 4,000 SF. UW–Madison should follow this standard of no greater than five tons of sediment per acre per year, but for all projects, regardless of size.

All projects must protect adjacent streets from tracked sediment which comes from construction vehicles which are improperly cleaned prior to leaving construction sites.

Table 5-2 shows a matrix of the existing erosion control standards which are applicable to UW–Madison.

Developed Urban Area Performance Standards

UW–Madison is regulated as an MS4 (municipal separate storm sewer system) for the purposes of its WPDES permit. In Wisconsin, NR 216 mandates that MS4s perform a series of practices and standards in addition to meeting set performance standards for the entire MS4 area. These include engaging in public education and outreach, public involvement and participation, illicit discharge detection and elimination, and pollution prevention activities and practices in addition to the post-construction and construction performance standards already discussed. As discussed in Chapter 2, with the adoption of the Rock River TMDL, UW–Madison's MS4 standard of meeting 40 percent TSS reduction on a campus-wide basis increased to equal the relevant waste load allocation (WLA) set forth in the TMDL. Reach 64, which is the reach in which UW–Madison resides, has a WLA equivalent to 73 percent reduction of TSS.

Table 5-3 summarizes the developed urbanized area performance standards that apply to UW–Madison.

Pollution Prevention Policies and Practices

UW–Madison already engages in many pollution prevention activities on campus which contribute to its overall permit requirements and prevent contamination of runoff. These include regular street sweeping and sweeping of parking structures; collection of leaf litter and other yard waste and debris; proper storage of bulk materials such as road salt, topsoil, and compost; snow pile storage and runoff treatment practices; fueling and maintenance of vehicles in areas that drain to oil and grease traps or are covered; diversion of runoff from animal yards to manure holding tanks or sanitary sewers; and others. These practices should continue to be maintained and verified on a regular basis to ensure they are still performing as designed or serving their intended purpose.

It became clear, however, during the master planning process, that there is some ambiguity related to maintenance of existing BMPs on campus. This will only become more important as new BMPs are constructed. Currently below-surface features such as sumps are checked and maintained by the Plumbing Shop and above-surface features such as inlet grates and rain gardens are handled by Grounds. Therefore two different groups may be inspecting the same facilities but looking for different things. This system seems inefficient and would be better off handled by one group who systematically keeps records of BMP inspections and maintenance practices.

UW–Madison should also explore partnerships and cost-sharing agreements with the City of Madison, which has more maintenance vehicles and staff for things like sump cleaning and street sweeping (especially vacuum cleaning of permeable pavements on campus).

Table 5-2 Matrix of Applicable Construction Site Erosion and Sediment Control Standards

Performance Standard	Current NR 151/216	DFD Sustainability Guidelines	Rock River TMDL WLA & New Permit Target	City of Madison, Chapter 37
Erosion and sediment-control BMPs	Projects over 1 acre	N/A	N/A	Projects >4,000 sf
TSS reduction in construction runoff	80% reduction, projects over 1 acre	N/A	N/A	< 5 Tons/ac/yr
Prevent sediment tracking, discharge into waters	All projects	N/A	N/A	All projects

Table 5-3 Matrix of Applicable Developed Urbanized Area (MS4) Stormwater Performance Standards

Performance Standard	Current NR151/216	DFD Sustainability Guidelines	Rock River TMDL WLA & New Permit Target	City of Madison, Chapter 37
TSS Reduction (MS4 permit)	40% TSS for permitted MS4	N/A	73% TSS reduction from entire campus (Reach 64)	73% TSS reduction from entire campus (Reach 64)
Total Phosphorus (TP) Reduction (MS4)	Not specified	N/A	61% TP reduction from entire campus (Reach 64)	61% TP reduction from entire campus (Reach 64)
Public Education and Outreach	Implement education and outreach materials and programs	N/A	N/A	Comply with NR216
Public Involvement and Participation	Notify public of activities	N/A	N/A	Comply with NR216
Illicit Discharge Detection and Elimination	Establish a program to detect and enforce I&I	N/A	N/A	Comply with NR216
Construction Site Pollution Control	Procedures for inspecting, enforcing BMPs	N/A	Achieve TMDL WLA & ultimately, WQS	Applies to Land Disturbances > 4000SF
Post-Construction Site Stormwater Management	Enforce site BMPs and install regional BMPs to achieve performance standards	N/A	Achieve TMDL WLA & ultimately, WQS	Applies to Land Disturbances >20,000SF
Pollution Prevention	Source area controls (street sweeping, yard waste removal, etc)	N/A	Achieve TMDL WLA & ultimately, WQS	Comply with NR216

5.3 Multi-Site Green Infrastructure Practices

Figure 5-1 summarizes the structural BMPs which have been identified as opportunities on UW–Madison campus. As discussed previously, this Green Infrastructure and Stormwater Management Master Plan includes recommendations ranging from site-based to multi-site, or district-based practices. The multi-site practices are intended to cover larger tributary areas than just one building project or development block. In most cases, the intent is to capture and treat stormwater that is already being collected through existing campus infrastructure, and divert it to a treatment device or area to address a larger quantity of runoff. This offers the opportunity to capture and treat polluted runoff from streets and other campus spaces not necessarily associated with a particular building site.

These identified multi-site practices are described in more detail by campus district below. WinSLAMM modeling was performed based on the assumed design parameters described for each BMP located within the permit boundary. The modeling approach was similar to that described in Section 4.1 for existing conditions. The cumulative impact of the proposed BMPs with regards to permit compliance within the permit boundary is summarized in a later section.

As shown in Figure 5-1, most of the redevelopment sites on South Campus are confined to smaller blocks so green infrastructure practices would primarily be implemented on a site-by-site basis. Site-based green infrastructure on South Campus in particular should consider green roofs since sites are often limited in space and green roofs offer additional usable open space. Green roofs are not specifically referenced on Figure 5-1 as they would be incorporated into building projects on a per-project basis. Consideration should also be given to providing stormwater detention as portions of the public storm sewer system in the South Campus are under capacity and low-lying, creating flooding issues downstream such as along Regent Street. UW–Madison should follow the city's recommendations for peak flow control in this area on a project by project basis.

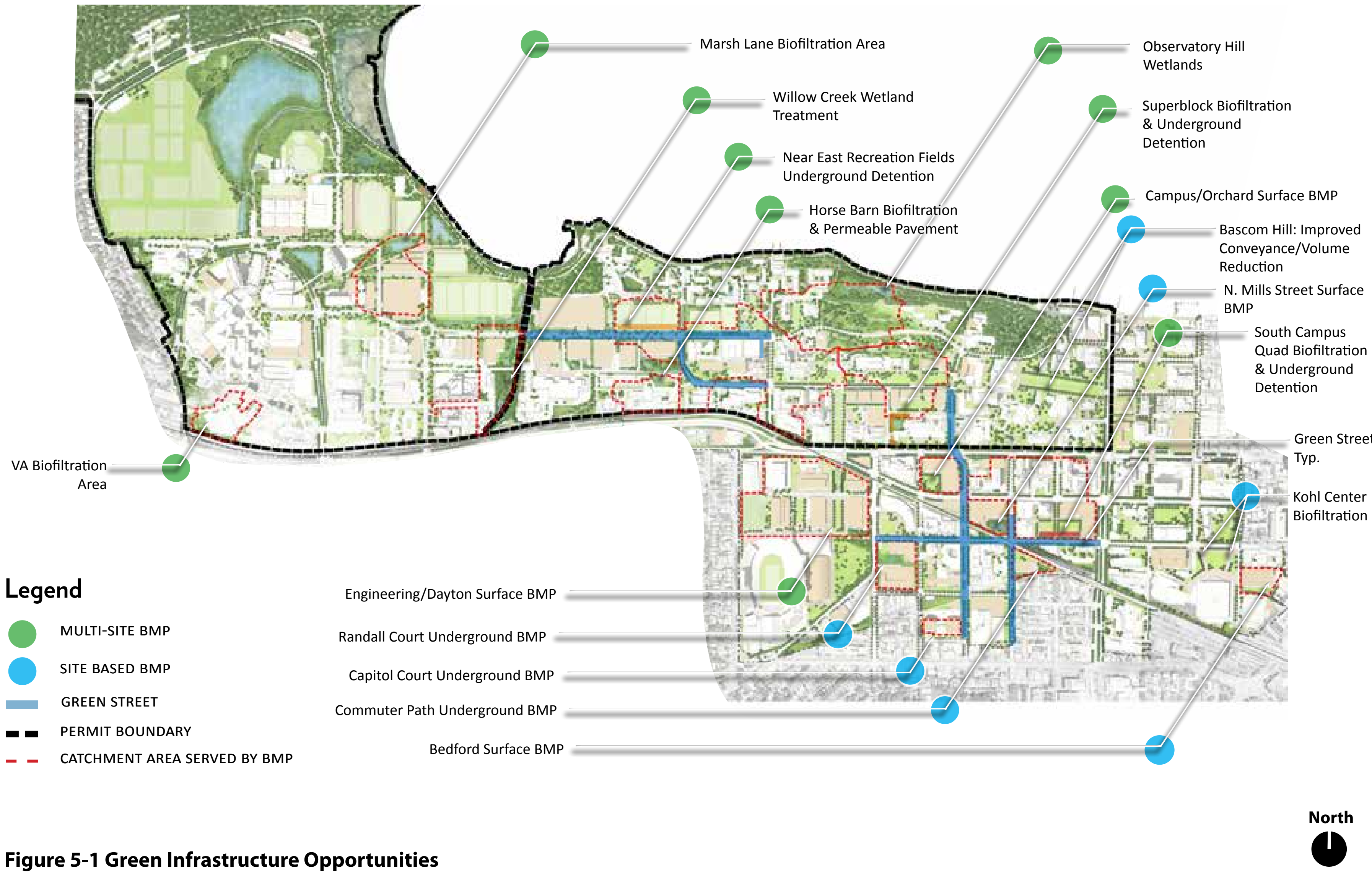


Figure 5-1 Green Infrastructure Opportunities

West Campus

Marsh Lane Biofiltration Area

The Master Plan shows the existing soccer and track complex to be relocated to the existing Lot 60 footprint, and replaced with new academic buildings. This provides an opportunity to create a BMP that can treat runoff from about 9.9 acres, bounded on the south by Observatory Drive (shown in Figure 5-3).

This BMP is envisioned either as a biofiltration area, constructed wetland or wet pond. The goal is to capture approximately 3,100 pounds per year of TSS on an average annual basis (Figure 5-4).

This BMP could also provide additional benefits such as pollutant capture, peak flow and volume reductions, and ecosystem services. It could be designed to have accessible boardwalks or paths through or around it, or bench seating with a natural aesthetic and interpretive signs for community awareness and education.

Figure 5-2 Cross Section Rendering of a Biofiltration Area With Wet Pool

Figure 5-3 Birds-Eye View of Potential Catchment Area for Proposed Marsh Lane Biofiltration Area

Potential Catchment Area: 9.9 acres

Design Assumptions:
Surface Area: 9,100 sf
Max Depth: 28 inches
Primary Control: 6 inches

Model Results:
TSS Captured: 3,100 lbs/year
Trapping Efficiency: 74%

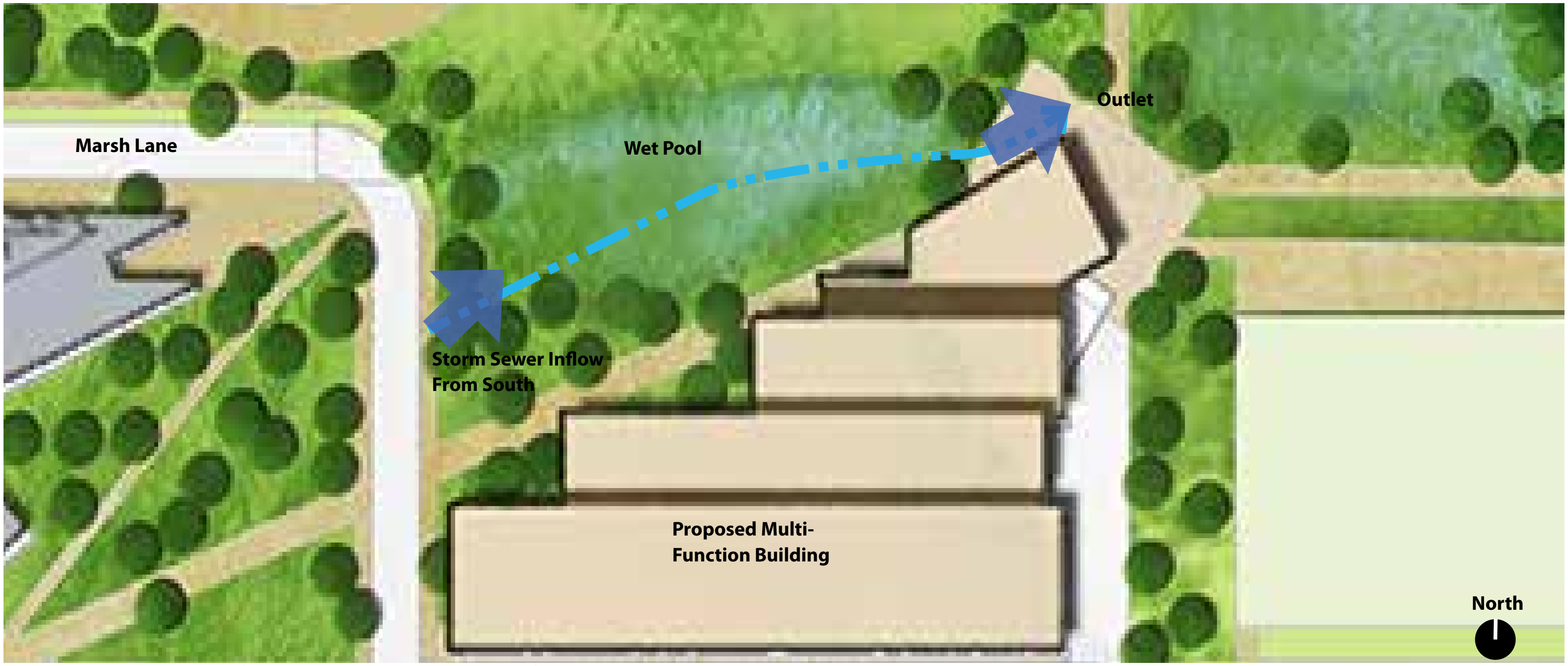


Figure 5-4 Close-Up of Proposed Marsh Lane Biofiltration Area

Near West Campus

Veterans Administration (VA) Biofiltration Area

Although the Veterans Administration (VA) facilities located on Campus Drive and University Bay Drive are not owned by UW–Madison, the VA property falls within the UW–Madison's WPDES permit boundary agreement with the City of Madison. Therefore, the UW–Madison has incentive to control stormwater runoff from the VA facilities including their large surface parking lots. Any project of this nature would need to be a partnership between the UW–Madison and the VA.

A biofiltration practice is recommended for the southeast corner of the VA's surface parking lot in an area that is currently lawn (Figure 5-7). Minor re-grading may be required but the parking lot already drains in that direction. The BMP would receive untreated runoff from the parking lot and adjacent areas (approximately 4.2 acres, shown in Figure 5-6). The goal is to capture a minimum of 1,500 lbs of TSS on an average annual basis.

Figure 5-5 Parking Lot Median Bio Filters

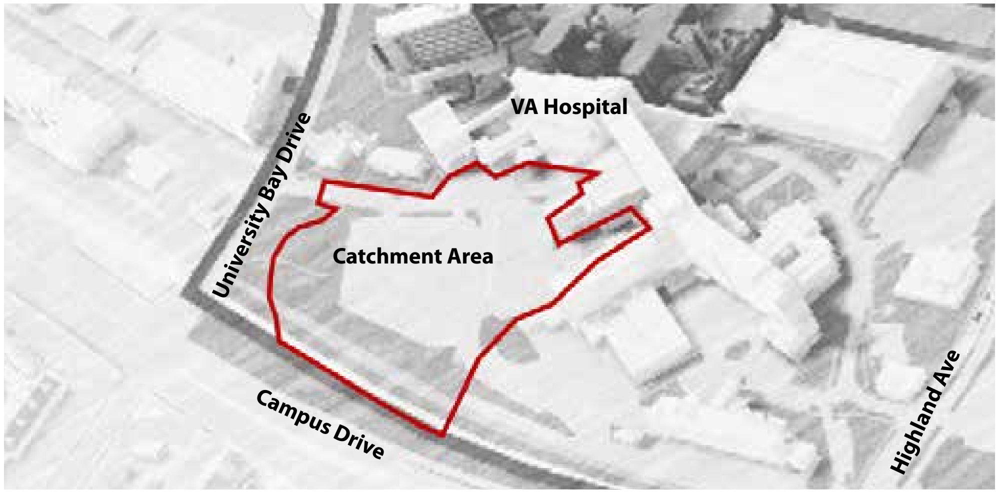


Figure 5-6 Birds-Eye View of Potential Catchment Area to VA Biofiltration Area

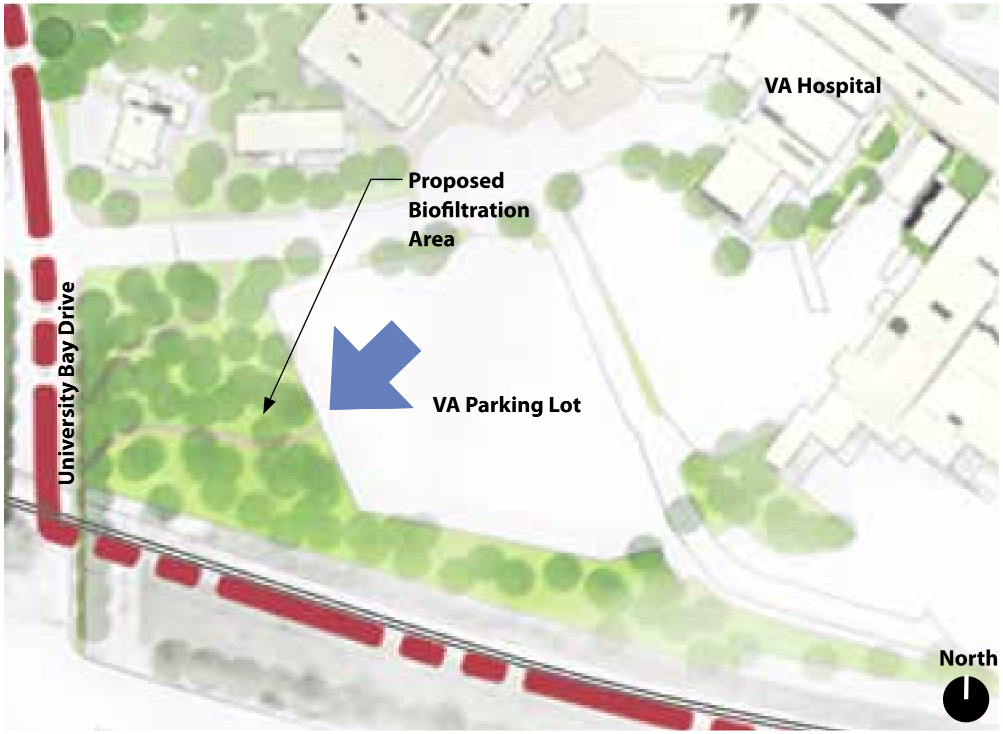


Figure 5-7 Proposed Biofiltration Area at VA Parking Lot

Potential Catchment Area: 4.2 acres

Design Assumptions:
Surface Area: 3,000 sf
Max Depth: 2 feet
Model Results:

TSS Captured: 1,500 lbs/year
Trapping Efficiency: 79%

Near West Campus

Horse Barn Biofiltration & Permeable Pavement

A biofiltration area is recommended near the Horse Barn that would collect and treat runoff from an area of approximately 4.4 acres. The goal is to capture approximately 1,500 lbs of TSS per year on an average annual basis (see Figure 5-9). The assumed area of the biofiltration area is 5,200 square feet and the max depth is approximately 14 inches.

In addition, the parking lot south of the horse barn near the old Meat and Muscle Building has poor drainage due to steam tunnels cutting it off from the storm sewer system to the north. This is an area that has been identified as a possible permeable pavement project to provide better drainage.

Willow Creek Wetlands

The western banks of Willow Creek are recommended to be redesigned to accommodate constructed wetlands that are perched above the creek (see Figure 5-11). The practice will treat runoff from a tributary area of approximately 8.3 acres (see Figure 5-12). Much of this area is currently used as the existing yard for UW–Madison Grounds and is paved with direct runoff into the creek. The wetlands are shown with boardwalks and paths for passive recreation. The wetlands would also help rehabilitate the ecosystem and aesthetics of Willow Creek. The goal for the Willow Creek BMP a capture rate of approximately 2,200 pounds per year of TSS on an average annual basis.

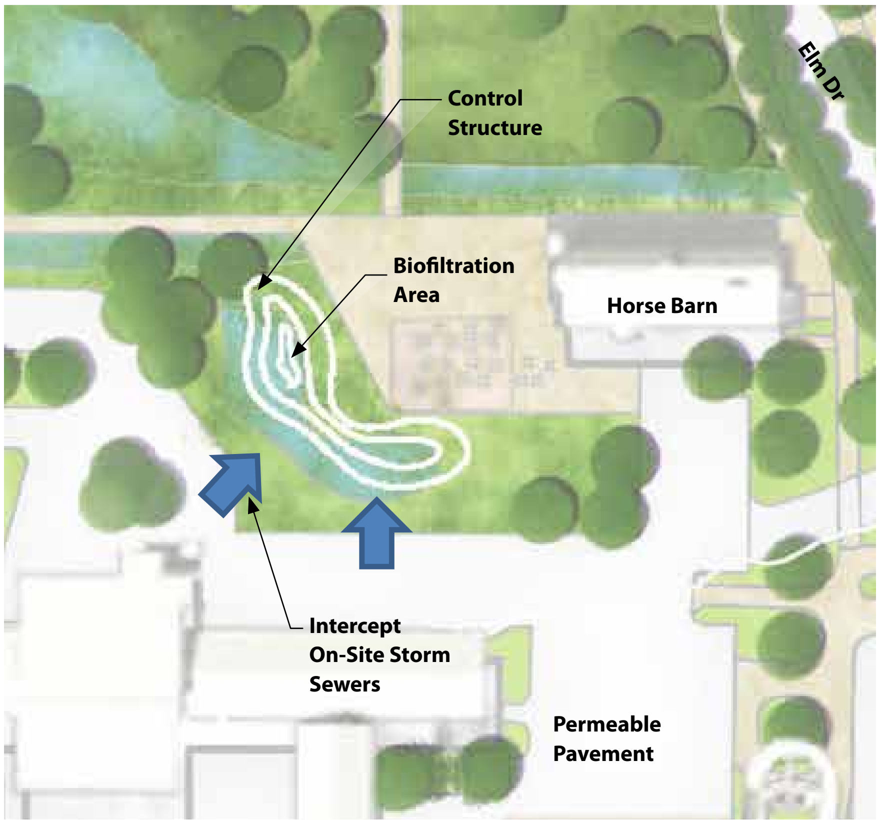


Figure 5-9 Close-Up of Horse Barn Biofiltration Area

Figure 5-10 Milliken State Park Constructed Wetlands, Detroit, MI

Figure 5-11 Close-Up of Willow Creek Wetlands

Potential Catchment Area: 8.3 acres

Design Assumptions:

Surface Area: 8,400 sf
Max Depth: 18 inches
Primary Control: 6 inches

Model Results:
TSS Captured: 4,100 lbs/year
Trapping Eff: 86%

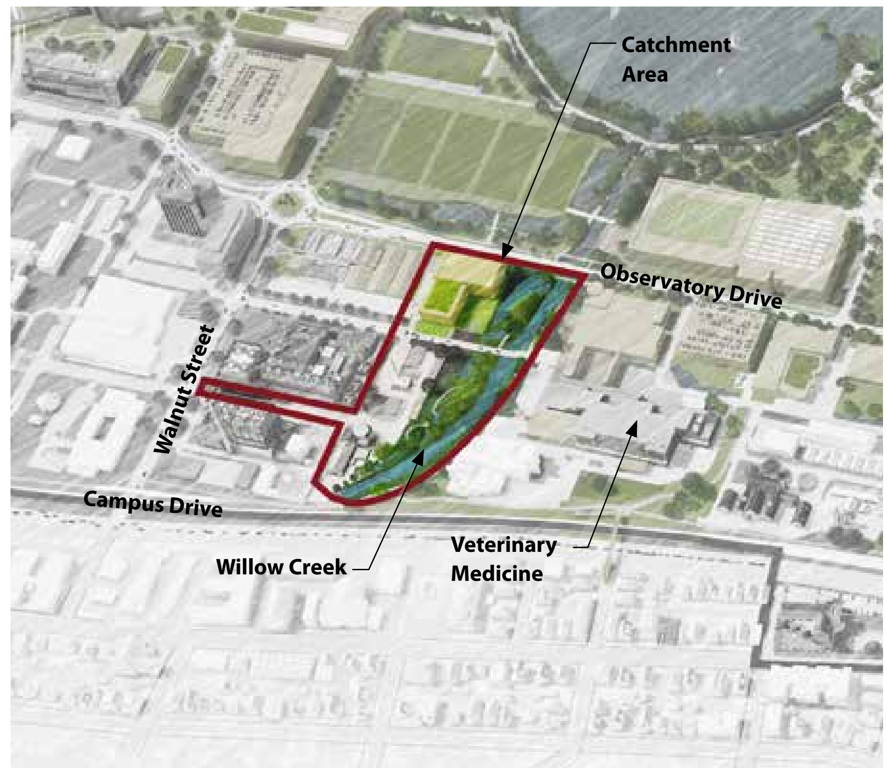


Figure 5-12 Birds-Eye View of Potential Catchment Area to Willow Creek Wetlands

Near East Recreation Fields Underground Detention Chamber

The Near East Recreation Fields, located on Observatory Drive just west of Elm Drive, are slated to be rebuilt with synthetic turf fields in the Rec Field Master Plan. These fields also sit at the confluence of several large storm sewers that collect a 32-acre catchment area before discharging to Lake Mendota (Figure 5-14). Due to the size and depths of the storm sewer pipes and the desire to maintain the entire surface area for recreation fields, the most feasible BMP for this location is an underground chamber for treatment of TSS. This one facility, while expensive, would capture approximately 7,400 lbs of TSS per year on an average annual basis, representing approximately 4.4% of the total TSS baseline load from the permit area. Capturing this amount of TSS would significantly advance the campus toward meeting its WDNR requirements for overall TSS reduction in the permit area.

Another benefit of this site is that it is one of the few large scale practices that can be implemented in the next 5 to 20 years.

The underground chamber would need to be fairly large to achieve this goal: 13,100 square feet by a minimum of 4.8 feet deep (Figure 5-15). It is assumed that the chamber would be designed to treat the first flush of rainfall with larger storm events bypassing the chamber. The chamber would need regular inspection and cleaning. Since the chamber isn't visible, consideration should be given to providing interpretive signage to inform passers by of what the practice is accomplishing.

Figure 5-13 Underground Detention Precast Units Being Installed

Potential Catchment Area: 32 acres

Design Assumptions:
Surface Area: 13,100 sf
Max Depth: 4.8 feet
Primary Control: 12 inches

Model Results:
TSS Captured: 7,400 lbs/year
Trapping Eff: 58%

Figure 5-14 Birds-Eye View of Potential Catchment Area to Near East Recreation Fields Underground Detention

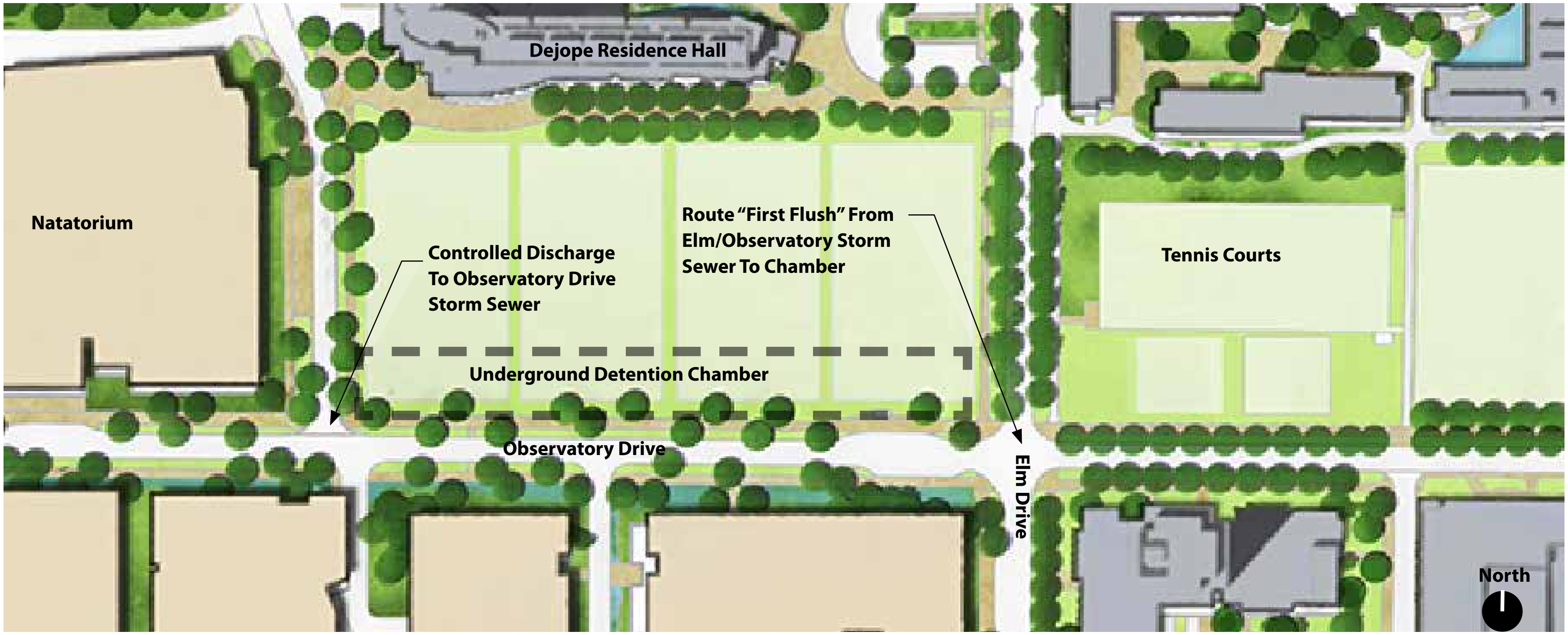


Figure 5-15 Close-Up of Underground Detention Chamber at Near East Recreation Fields

Central Campus

Observatory Hill Wetlands

One of the most transformative BMPs recommended in this plan is the removal of Lot 34 and replacement with an engineered wetland at the base of Observatory Hill. The catchment area for this practice is approximately 16 acres, and the TSS capture rate goal is nearly 3,900 lbs per year on an average annual basis. However the wetlands proposed at this location provide additional benefits beyond sediment and pollutant reduction: they are envisioned to act as a learning laboratory for students and faculty as well as an inspiring and unique environment for passive enjoyment (Figure 5-19). The Landscape Master Plan describes in more detail the aesthetic vision and plant communities proposed for this area.

The catchment area (Figure 5-18) extends from Babcock Drive to portions of Tripp Circle. This project will ultimately require some rerouting of existing storm sewers to get the proposed tributary area to drain to this BMP. Tripp Circle is identified in the Utility Master Plan as being reconstructed so this would be an opportune time to reroute the storm sewers or redirect roof drains and inlets.

Figure 5-16 Wetlands and Boardwalk, Clarksville, Tennessee

Figure 5-17 Wetlands at Sears Headquarters, Prairie Stone, Hoffman Estates, Illinois

Potential Catchment Area: 16 acres
Design Assumptions:

Surface Area: 9,600 sf
Max Depth: 4 feet
Primary Control: 6 inches

Model Results:
TSS Captured: 3,900 lbs/year
Trapping Eff: 86%

Figure 5-18 Birds-Eye View of Potential Catchment Area to Observatory Hill Wetlands

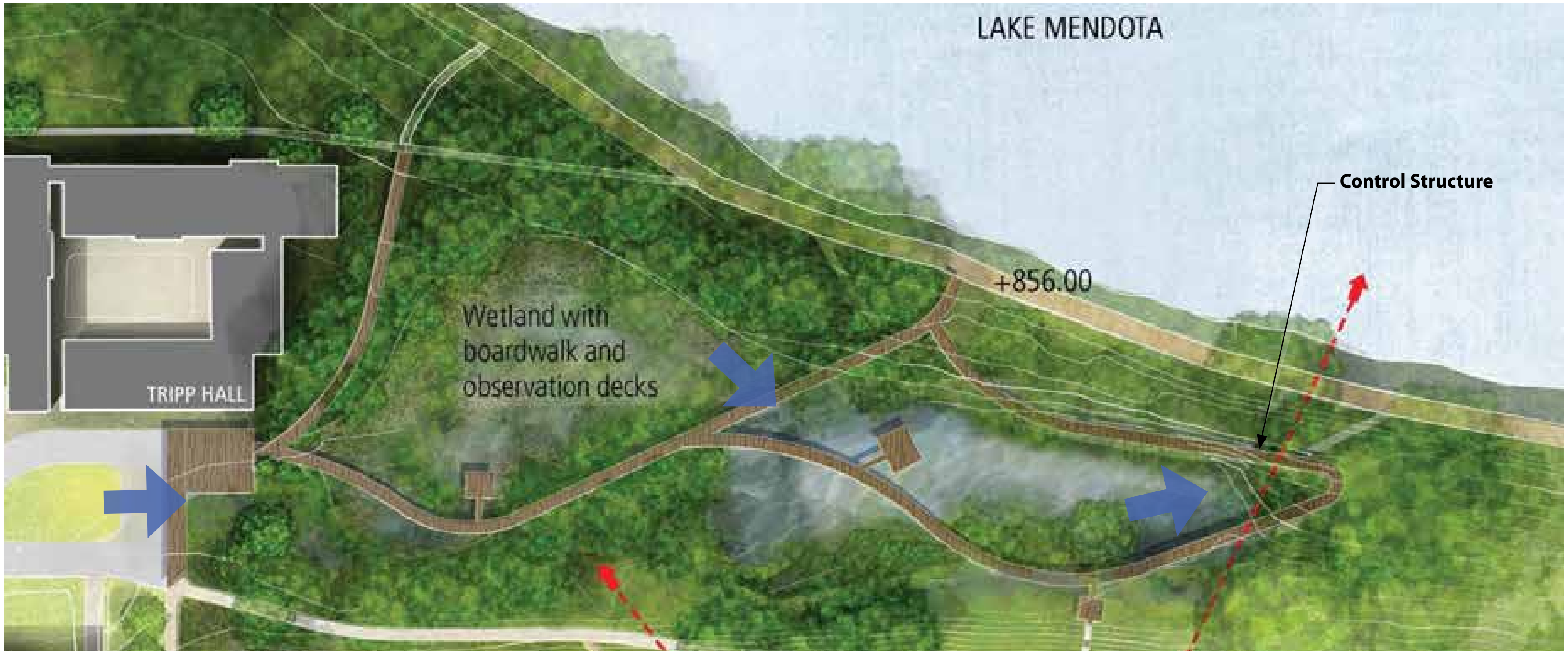


Figure 5-19 Close-Up of Proposed Observatory Hill Wetlands

Central Campus

Superblock Biofiltration and Underground Detention Chamber

The Master Plan area described as the Superblock is slated for significant redevelopment including several new buildings and the addition of two new streets through the center of the block to connect Linden Drive with University Avenue and that new north-south street with Charter Street. The Superblock includes a portion of Linden Drive, Nicholas Hall, and Agriculture Hall as well as most of the block east of Henry Mall. A new surface BMP (biofiltration) is recommended in the courtyard of the new Superblock with the intent of capturing TSS from the redevelopment area. This surface BMP could be a biofiltration area with a fairly urban or hard-edged design that would treat runoff from nearby impervious site features (streets, walks, roofs).

This surface feature may or may not be connected to a possible secondary below-grade multi-site BMP that is recommended to be constructed to treat the first flush of stormwater diverted from the existing storm sewer network at this location, which has an upstream catchment area of approximately 11 acres (see Figure 5-21). The underground chamber could be a wet or dry sump designed to capture sediment in the runoff, with the intent of capturing approximately 2,500 lbs per year on an average annual basis (Figure 5-22).

Figure 5-20 Biofiltration Area in Battle Creek, Michigan

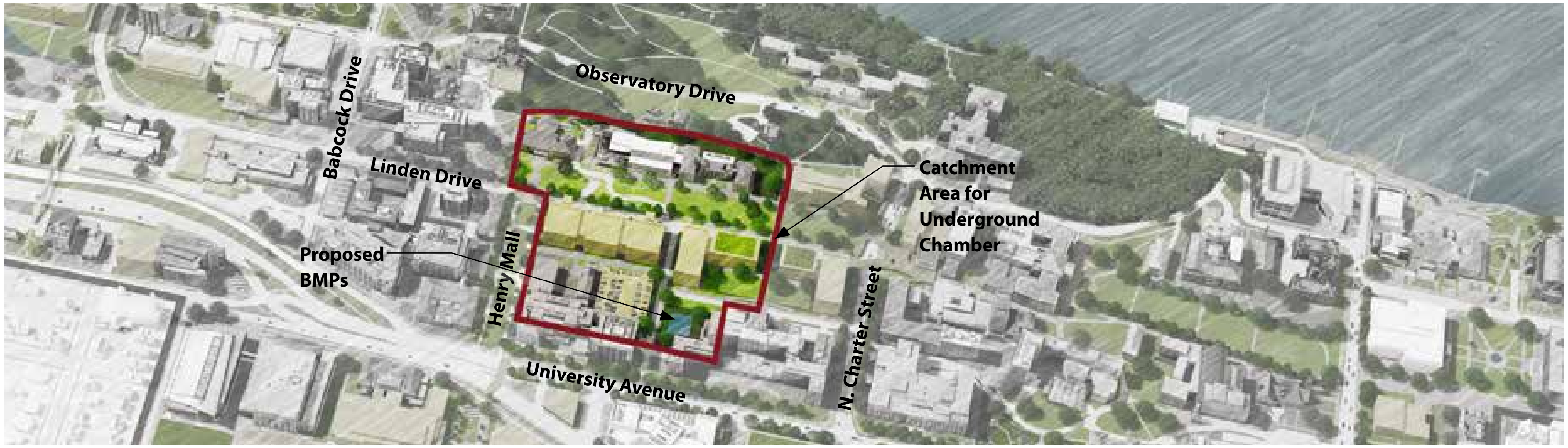


Figure 5-21 Birds-Eye View of Potential Catchment Area to Superblock Underground Detention

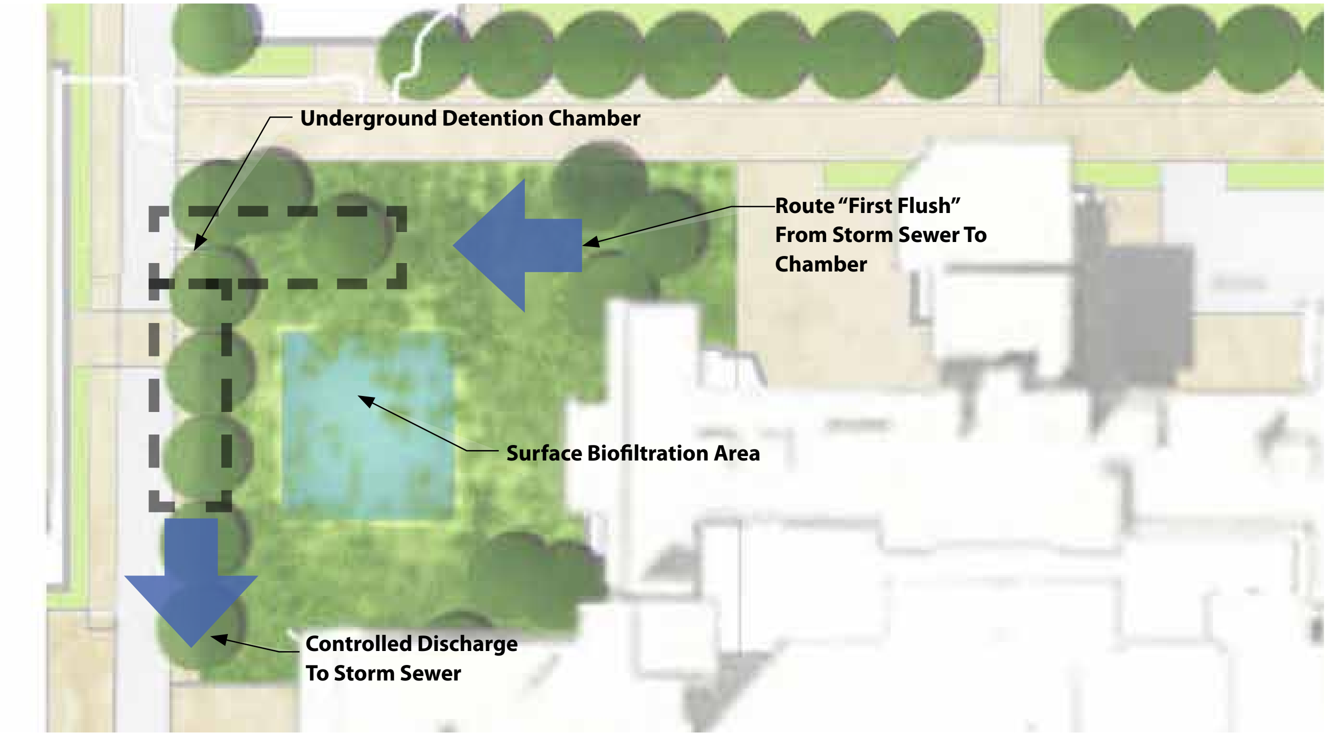


Figure 5-22 Close-Up of Proposed Underground Detention Chamber at Superblock

Underground Detention Chamber:

Potential Catchment Area: 11 acres

Design Assumptions:
Surface Area: 8,700 sf
Max Depth:2.5 feet
Primary Control: 6 inches

Model Results:
TSS Captured: 2,500 lbs/year
Trapping Eff: 71%

South Campus

South Campus Quad Biofiltration and Underground Detention

As with the Superblock and Near East Recreation Fields, the proposed South Campus Quad is a redevelopment project offering an opportunity to integrate a multi-site underground treatment chamber that would capture sediment from a wide tributary area. In this case the catchment area covers portions of the blocks south of University Avenue, east of N. Charter Street, down to W. Dayton Street. The South Campus Quad will also feature a surface BMP such as a biofiltration area with vertical edges, designed to fit within the urban plaza aesthetic planned for this quad. Again the surface BMP would treat runoff from the site and possibly surrounding streets or buildings. However the intent of the underground chamber is to treat the first flush from the entire 16-acre catchment area (see Figure 5-24), capturing approximately 4,300 lbs of TSS per year on an annual average basis.

Since South Campus is outside of the permit area, any TSS credit for the underground chamber would go to the City of Madison (and therefore is not included in the summary calculations towards the campus permit). However much of the load would likely come from city streets since those are the greatest source areas within that tributary. Therefore this practice should be considered a partnership between the UW–Madison and the City of Madison, with campus providing the land and the city funding the construction and maintenance costs.

Figure 5-23 Biofiltration Area at Centennial Hall, UW-La Crosse

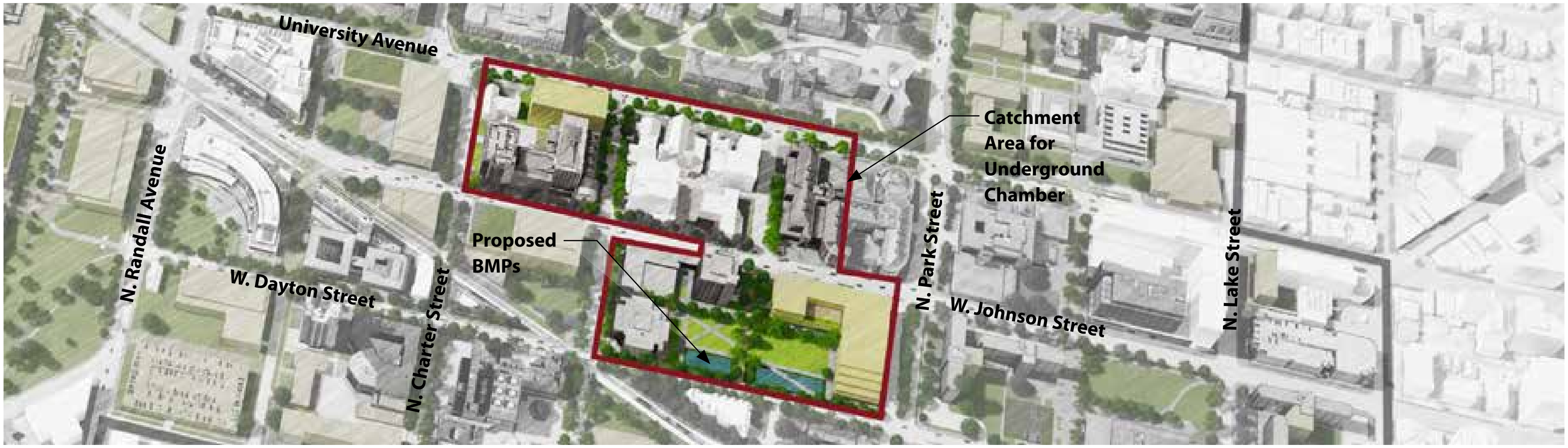


Figure 5-24 Birds-Eye View of Potential Catchment Area to South Campus Quad Underground Detention Chamber

Figure 5-25 Close-Up of South Campus Quad BMPs

Underground Detention Chamber:

Potential Catchment Area: 16 acres

Design Assumptions:
Surface Area: 14,000 sf
Max Depth: 6 ft

Model Results:
TSS Captured: 4,300 lbs/year
Trapping Eff: 71%

5.4 Site-Based Green Infrastructure Practices

Figure 5-26 Education Building First Floor Green Roof (Over Parking)

This section summarizes recommendations for site-based green infrastructure BMPs where larger-scale practices are not feasible.

The following green infrastructure practice opportunities are discussed in general and examples are provided. As new building or site projects are planned on campus, it is intended that the design team evaluate which practices are feasible and practical for the project site, and which practices achieve the desired metrics that are being targeted.

Figure 5-1 shows some of key site-based practices that have been identified as opportunities however this figure does not represent all practices that will be needed to be installed as development projects move forward.

Land Use Modification

In general, as sites get redeveloped on campus, design teams are expected to look at ways to address the campus green infrastructure goals and meet regulatory requirements. One way to lessen the impact of a site from a stormwater management standpoint is to modify the land use, where feasible. Rooftops and sidewalks are preferable to parking lots and roads because they produce less pollutants in the runoff. However pervious surfaces are preferable from a stormwater management standpoint because runoff volume is reduced through infiltration and evapotranspiration. Since pervious surfaces such as planter beds or lawns aren't always achievable on tight building sites, the impacts of impervious surfaces can be lessened by incorporating permeable pavements and green roofs. The vegetated rooftop that was built over the surface parking lot behind the Education Building is a great example of a previous land use modification on campus. In addition to improving the volume, rate, and quality of the stormwater runoff from this site, the roof provides outdoor gathering space and better views for occupants of the building.

Water Reuse and Harvesting

Southern Wisconsin has historically not had a strong market for harvesting and reuse of rain water because municipal water is relatively inexpensive and abundant compared with other parts of the country, providing little incentive for building owners and developers to install harvesting systems. In addition, plumbing codes in Wisconsin are typically not favorable towards the beneficial reuse of rain water within buildings, even for non-potable uses (landscape irrigation is typically allowed).

However there is a movement in the green building industry for owners to collect and reuse rain water for irrigation and gray water systems within the building (i.e. toilet flushing, cooling towers, etc). So-called Living Buildings go beyond LEED and require a more holistic approach to water usage.

Certainly from an educational and interpretive standpoint there is great value in water reuse and harvesting, and some cost savings could be realized over the life of a building. However the costs associated with designing, installing and operating rain water capture systems (typically above-ground or buried cisterns) and the associated infrastructure for distribution typically makes them cost prohibitive. Given budget constraints on most campus projects, these types of systems often get eliminated early on during the design process. Still, as buildings become progressively more sustainable, water needs to be part of the larger picture, and the market may become more favorable as cisterns become more mainstream (they already are in parts of the country where water is a scarce commodity).

Figure 5-27 Cisterns at Chesapeake Bay Foundation, Virginia Beach, Virginia

Figure 5-28 Rain Water Harvesting System, Brock Center, Virginia Beach, Virginia

Figure 5-29 Green Street, Normal, Illinois

Figure 5-30 Green Street, West Union, Iowa

Green Streets

Some of the highest concentrations of polluted runoff in urban areas comes from streets and the UW–Madison campus is no exception. As surface parking areas are replaced with structured parking, the primary source of sediment loading from campus will be streets, roads, and driveways. Green Streets can be an effective approach to managing runoff from high-pollutant load areas while offering aesthetic and educational value. Essentially BMPs are integrated into the streetscape whether they be rain garden planters, permeable pavements, or suspended pavement root enhancement systems (like Silva Cells) which allow urban street trees to grow to their full potential and provide stormwater detention and treatment as well.

There are a few issues that need to be considered when designing Green Streets, however. Salts from road de-icing (especially chlorides) can potentially lead to groundwater contamination if infiltrated. The City of Madison has avoided infiltrating runoff from streets where road de-icers containing sodium chlorides are applied. On campus, this would entail almost all streets. One solution to this is to utilize planters with salt-tolerant plant species and under-drains and liners that prevent the runoff from infiltrating into the groundwater. The plant roots absorb some of the stormwater through evapotranspiration and the soil medium helps filter the remaining runoff (TSS and metals), before it is discharged back to the storm sewer system (and ultimately the lakes). However it is important to note that dissolved chlorides have been shown to remain in the runoff even after flowing through a biofiltration practice.

Another issue to be addressed in design is accommodating pedestrian movements through Green Street spaces. Green street planters are typically suppressed below adjacent grades, making them potential trip hazards in areas where there is heavy pedestrian usage. Design details should be developed to strategically locate steps and curbs so they are visible and do not act as hazards.

Green Streets proposed for the master plan include Observatory Drive, N. Charter Street, N. Mills Street, W. Dayton Street, and Linden Avenue. Figure 5-31 shows the proposed extents. All but Linden Ave are City of Madison streets so these streetscape improvements would need to be designed in coordination with the city and implemented in accordance with their street reconstruction schedules. To date, conversations with the city have indicated that they are amenable to Green Streets as long as they are addressed to meet the concerns regarding infiltration of chlorides and other street construction standards.

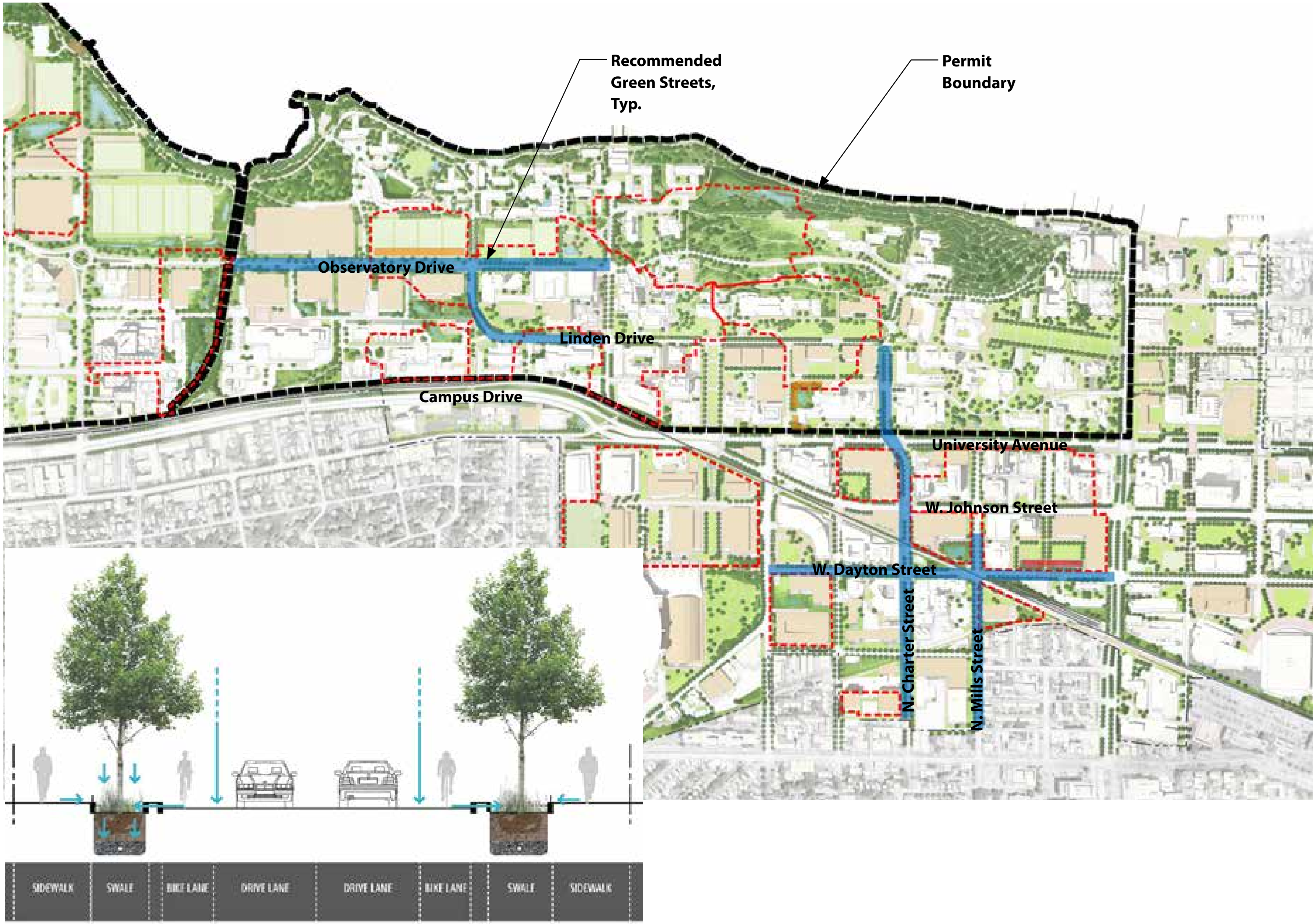


Figure 5-31 Recommended Green Street Locations & Example Green Street Cross Section

Figure 5-32 Permeable Paver Patio, Carson Gulley Commons

Permeable Pavement

There are a number of different permeable pavement applications on campus, and many have been installed within recent years. Most permeable pavement used on campus has been permeable pavers used in plaza areas such as around residence halls. Permeable concrete has been installed in a few locations such as bike parking and in Lot 92. Some permeable pavements have had less success. Permeable asphalt in Lot 34 for example was removed after it failed to perform.

Where there is low risk of failure (such as in non-traffic areas), it is recommended that UW–Madison investigate different types of pervious pavement to become more familiar with the costs and performance. Permeable pavement technology has advanced significantly since the first pervious asphalt was installed on campus, and permeable pavers come in many different forms now.

Surface parking lots and driveways, especially the parking stalls, should be considered for permeable pavement installations. UW–Madison typically has preferred to not use pervious pavements where there is vehicular traffic or where there are heavy sediment loadings due to maintenance and durability concerns. Permeable pavement is generally not recommended for loading docks or other areas experiencing point loads and excessively heavy vehicles, such as fire lanes.

Pervious pavements help achieve several stormwater management goals including a reduction in impervious surfaces, and TSS removal. When designed in accordance with WDNR Technical Standard 1008, permeable pavement with an underdrain can receive a TSS removal credit of 65% and a TP removal credit of 35%.

Snow removal can be more challenging when permeable pavers are used (as with any unit paver) however overall permeable pavement has been shown to cause less icing in the winter compared with normal pavement as snow melt infiltrates rather than ponds.

Maintenance recommendations for permeable pavements are described later in this chapter but in general require more maintenance than typical pavements. Installation costs are also higher.

Figure 5-33 Permeable Asphalt, Evanston, IL

Figure 5-34 Permeable Concrete, Evanston, IL

Green Roofs

Green roofs have been implemented on a variety of different building projects on campus including extensive (shallow) and intensive (deeper) systems. In keeping with Division of Facilities Development (DFD) policy, most green roofs on campus have been installed on accessible or visible roof areas (roofs that can be seen by other floors of that building or adjacent buildings). This policy recognizes that resources are often limited and the investment of a green roof is best made where the most benefits can be gained; not only stormwater management and heating/cooling benefits to the building but also visual green for building occupants or usable open space. Examples include green roofs at WIMR and the Education Building.

Green roofs can play a specific role when it comes to stormwater management. The DNR's stance on green roofs is that green roofs play a neutral role in management of TSS: green roofs can leach as much sediment and phosphorus from plant matter as than they help capture. However there is much evidence that shows that green roofs reduce runoff volumes over an average year of rainfall because the plant medium takes up small rainfall events. The majority of rainfall in Madison comes in small rainfall events, so the overall volume of runoff from campus would be reduced if the number of green roofs were significant enough.

While there are a dozen or so green roofs on campus currently, the impact of these is likely negligible relative to the amount of impervious area on campus. Volume reduction is important, however, for addressing issues such as increased flooding in the Yahara Lakes, so every little bit counts.

Whenever feasible, intensive rather than extensive green roof systems should be considered as they provide the most storage and volume reduction, as they allow for deeper rooted plants. They also have more soil medium to hold runoff and become saturated less frequently. A saturated green roof acts just like a regular roof as the holding capacity goes down to zero. Therefore for large storm events green roofs do not contribute to a significant reduction to peak flow rates.

In conclusion, green roofs should be considered and evaluated on all new building projects on campus, especially where there are visible or accessible portions of the roof which could double as visual or programmable open space. Intensive green roofs can be counted as "pervious surface" and may reduce the campus' share of city stormwater utility fees. However green roofs don't provide any reduction credits towards the TMDL or permit goals.

Green roofs typically cost more than standard roofs and require more maintenance.

Figure 5-35 Green Roof, University Square

Figure 5-36 Third Floor Green Roof, Education Building

Figure 5-37 Biofiltration Planter, University of Michigan, Ann Arbor, Michigan

Infiltration and Biofiltration

Infiltration and biofiltration practices are among the most prevalent types of BMPs on campus. Infiltration practices include depressed planters or swales which are designed to collect runoff and promote groundwater recharge and evapotranspiration through deep-rooted plants and engineered soil. Biofiltration practices are similar but may restrict infiltration and collect treated runoff at the bottom of the practice in an underdrain which is connected to the storm sewer system. Infiltration practices provide volume reduction as well as treatment of TSS and other pollutants, and peak flow reduction. Biofiltration practices provide a more limited volume reduction because much of the runoff is still collected and conveyed downstream.

Infiltration and biofiltration practices can be designed as traditional rain gardens with side slopes, or they can be incorporated into more urban and hard-edged planters. Planters allow for a larger footprint of treatment and may fit better into tight sites, such as between bike racks or in narrow beds where slopes aren't feasible. However they are more expensive to construct and may be more difficult to maintain. UW–Madison has installed several of these urban planter-style BMPs on campus and this is likely the form that most new BMPs on campus will take in the future due to other demands for open space.

In some areas of campus (such as West Campus) infiltration is limited due to poor infiltrating or hydric soils and high groundwater tables. In addition, infiltration practices may be restricted in wellhead protection areas.

Figure 5-38 Infiltration Planter Between Bike Racks, Wis. Institute for Medical Research

Bioswales and Vegetated Swales

Bioswales and vegetated swales are a form of green conveyance which also provide filtration and evapotranspiration of runoff. They can be very effective at removing TSS and other pollutants from street runoff. A bioswale is constructed with engineered soil and an underdrain system much like a biofiltration area, An example of a bioswale on campus is along University Bay Drive, which significantly reduces the TSS load from that area.

Bioswales and vegetated swales are most effective where there is ample green space along a parking lot or road . Most of campus has curb and gutter and hardscape adjacent to the street (sidewalks or small terraces) so there are limited opportunities but since bioswales and vegetated swales are a relatively inexpensive and effective BMP, they should be used whenever feasible to keep stormwater above grade rather than in a pipe.

Figure 5-39 Bioswale, University Bay Drive

Figure 5-40 Biofiltration Area, Lot 61

Figure 5-41 Co-Gen Ponds

Figure 5-42 Nielsen Pond

Wet Detention Basins

Wet detention basins like Nielsen Pond represent more traditional methods of treating stormwater. They are highly effective at treating TSS from large tributary areas. Nielsen Pond provides a significant amount of TSS reduction from the UW Hospital and surrounding area.

However there is limited potential for additional wet detention basins on campus due to their space requirements. Smaller footprint BMPs that treat pollutants at the source rather than the end of pipe better represent the green infrastructure approach that this plan recommends.

Some members of the campus community have expressed concern over mosquitos breeding in detention ponds. Research has shown that well maintained detention ponds do not contribute significantly to mosquito breeding grounds, and no evidence has been shown on campus that mosquitos preferentially breed in the detention ponds over other bodies of water such as nearby Lake Mendota. They typically prefer stagnant water and shady spots so these conditions should be avoided in the design of wet detention basins.

Constructed Wetlands

Constructed wetlands utilize natural ecosystem processes to treat stormwater and provide additional benefits such as habitat and wildlife viewing. The western area of campus features a number of natural and constructed wetlands that provide a great amenity to the university setting. Constructed wetlands are designed to filter and take-up pollutants in runoff, dampen peak flows, and reduce volume through evapotranspiration and infiltration.

Constructed wetlands are recommended as larger multi-site practices at two campus locations in particular: Observatory Hill (former Lot 34) and along Willow Creek. In both cases we recommend the creation of boardwalks and viewing areas for respite from daily activity, passive recreation, connection to nature, and as a living laboratory. Students and faculty could take advantage of the proposed wetlands for educational and curriculum opportunities. Interpretive signage is recommended for informing and educating visitors such as school children as well.

Figure 5-43 Wetlands at Sears Headquarters, Hoffman Estates, Illinois

Figure 5-44 Constructed Wetlands at Milliken State Park, Detroit, Michigan

Figure 5-45 StormTrap Underground Detention Chamber, Lot 45

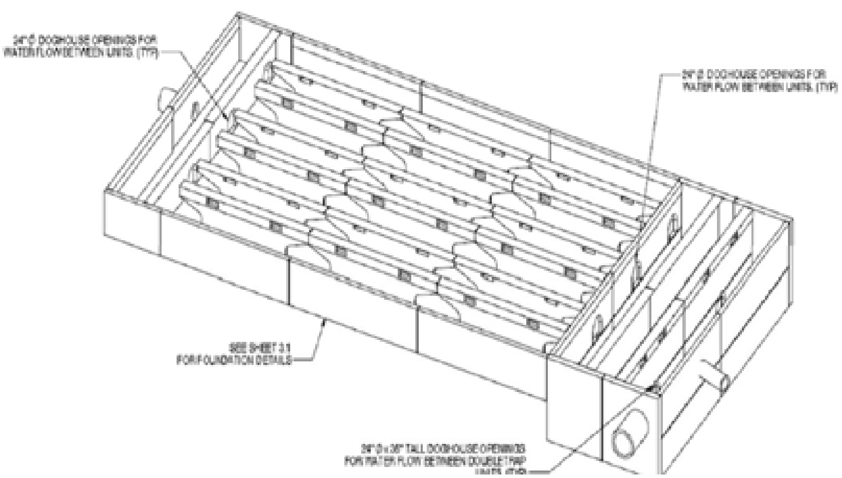


Figure 5-46 Sample Isometric Shop Drawing of a StormTrap Chamber

Underground Detention

In many areas on campus development density and demands on land space are extremely high and stormwater management features are not easily accommodated on the site. In addition, existing stormwater systems on campus which may drain fairly large areas are too deep to daylight for at-grade treatment. In these cases, underground detention and treatment chambers are an alternative to at-grade BMPs such as ponds or rain gardens.

Underground detention chambers act much like a detention pond as they are designed to hold and slowly release peak runoff volumes. This helps with peak discharge rates but can also be designed to settle out suspended solids and other particulates in sumps or baffled areas. On campus most underground detention chambers would be designed for TSS removal and would therefore be designed with wet or dry sumps (WDNR requires a 3-ft wet sump for TSS removal credit). Sizing of the underground chamber would be based on diverting a portion of the runoff from a site or pipe, typically the first flush which holds most suspended sediments.

There are downsides to using detention chambers below ground. One, they are one of the most expensive BMP options available. Two, there are typically no visible components of the underground detention and therefore the education value is limited. Three, they typically do not incorporate any ecosystem services or habitat opportunities as they are often concrete or polyethylene tanks. Four, maintaining underground tanks can be challenging and expensive, especially if they are not properly designed (it could involve trained confined-space entry workers and/or purchasing specialized equipment).

The primary benefits include the ability to use the land above them for things like parking, recreation fields, plazas, etc. They can also be incorporated into parking structures (but maintaining access to them for cleaning out sediment is critical). They can also be used in areas where deep pipes need to be intercepted and it is too difficult or infeasible to daylight the pipes for treatment purposes.

Recommended locations for the use of underground chambers (especially for multi-site practices) are under the Near West Recreation Fields, on the Superblock, and in the South Campus Quad. In each of these locations, large drainage areas drain to one particular storm sewer which could be intercepted to provide district-wide sediment treatment.

Sumps and Hydrodynamic Devices

Hydrodynamic devices or separators are stormwater management practices that use cyclonic or vortex separation to control TSS and other pollutants in runoff. They are designed as flow-through structures with a settling or separation unit and often integrate screens or baffles. Hydrodynamic devices are considered structural best management practices and are often proprietary (sold and patented by private companies).

These devices come in different configurations but often function in similar ways. However, from a TSS modeling standpoint, a large manhole with a sump provides the same results for soils in Southern Wisconsin. Therefore the additional cost for the proprietary device is not warranted and the results sometimes are not as good as the manufacturer's claims for fine-sediment soils such as those on most of the UW–Madison campus.

Many proprietary devices require maintenance techniques that can be difficult for maintenance personnel to implement on campus. Another downside with these units is that they don't easily offer educational opportunities or raise awareness of green infrastructure on campus since they are not visible to the public.

There are a number of these units installed and in use on campus currently, as shown on the figures in Chapter 2. Due to their costs and maintenance requirements, UW–Madison prefers the use of standard catch basin or inlets with sumps to capture TSS from paved areas where other BMPs are not feasible. WDNR requires a minimum 3-ft sump depth to provide credit for TSS removal.

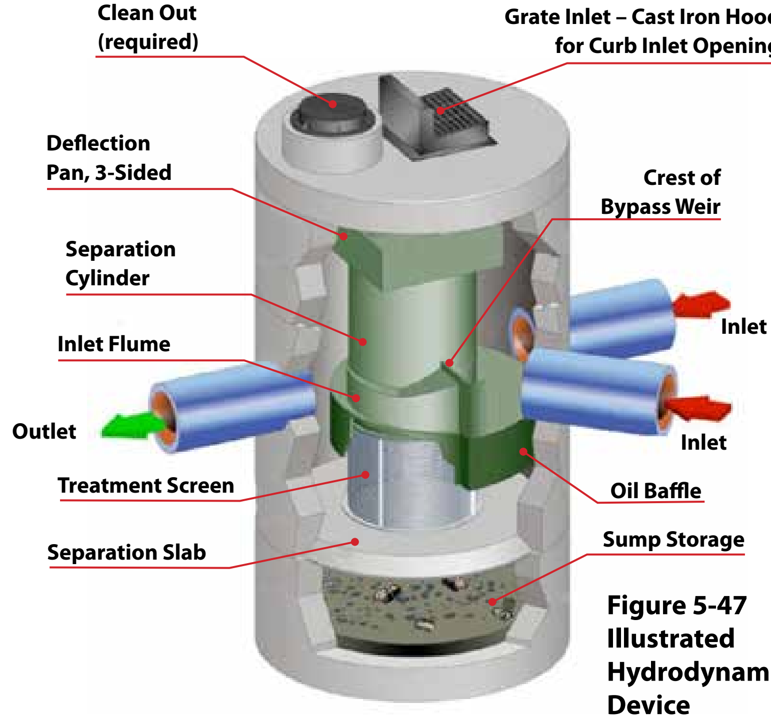


Figure 5-47 Illustrated Hydrodynamic Device

Figure 5-48 Installation of a Hydrodynamic Device, Butte, Montana

Figure 5-48 Asphalt Swale near Tripp Hall

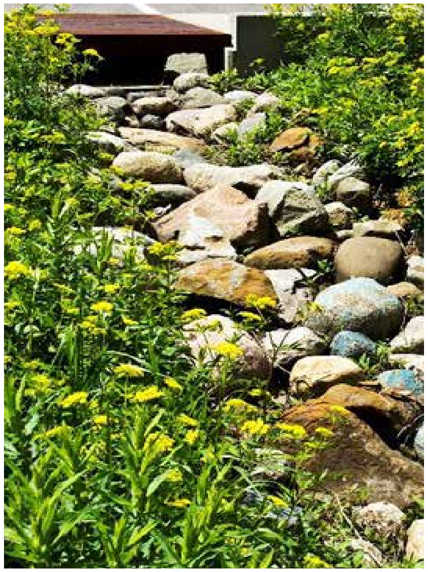


Figure 5-49 Stone Conveyance Channel

Alternative Conveyance Methods

Keeping stormwater at grade rather than in a pipe does several things: it slows down the runoff and lengthens the flow path (lengthening the time of concentration); increases the opportunity for infiltration or evapotranspiration; allows for the use of more shallow BMPs; and provides more awareness of the movement and treatment of stormwater. Conveyance methods promoted in green infrastructure practice includes stone lined or vegetated swales or channels, trench drains and flumes (with grates or plates for pedestrian or vehicle access), runnels, and other surface features. These can also be an opportunity for artful expression.

Figure 5-50 Stormwater Flume to Rain Garden with a Sidewalk Plate

Figure 5-51 Concrete Spillway

Figure 5-52 Modular Concrete Flume for Walks

Subgrade Storage and Urban Tree Canopy

Root enhancement zones or suspended pavement systems such as Silva Cell by DeepRoot allow trees to be planted in pavement areas such as in plazas and urban streetscapes without starving the trees of the soil capacity they need to thrive. The units are modular shelf-like structural units that transfer surface loads down to a compacted subbase below the root zone. Filled in the interstitial space is a planting mix that is high in sand and nutrient-rich soil for healthy growing trees.

Stormwater runoff can be directed to these systems below ground for filtration, infiltration, evapotranspiration, and detention. Directing stormwater to the root enhancement zone benefits the trees and reduces the need for supplemental irrigation.

The enhanced system results in trees that grow larger, faster and healthier than they would if planted in a typical structural soil or in a small planter with a traditional tree grate. Many studies have shown that urban trees contribute a significant amount to stormwater capture and volume reduction. The larger and healthier the tree, the more this benefit is achieved.

Suspended pavement systems have been installed with several projects on campus including Camp Randall North Lawn and on the Memorial Union Terrace.

Even where trees are not present, stormwater can be directed below grade to clear stone base layers below permeable pavement or recreational fields for added detention, infiltration and filtration.

Figure 5-53 Installation of Silva Cell Root Enhancement Zone

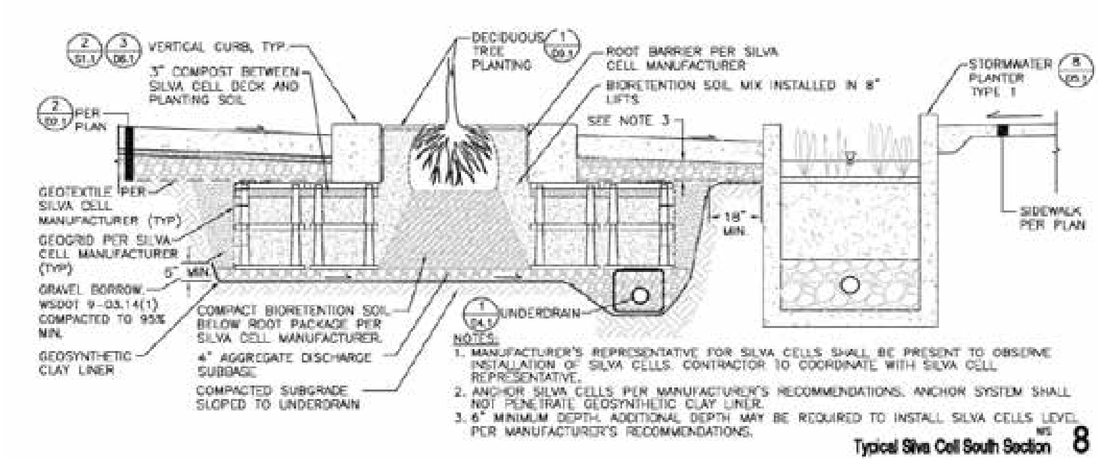


Figure 5-54 Details for a Suspended Pavement Silva Cell System with Stormwater Planters

BMP Matrix

To summarize the purpose and appropriate uses for certain BMPs a matrix of BMPs that are appropriate for urban settings such as UW–Madison's campus has been prepared (Table 5-4). The matrix is intended to summarize the primary and secondary stormwater management objectives for each BMP and their relative construction costs (low, moderate, high) as compared with their effectiveness. The matrix is intended to be a summary outlining the factors to be weighed when choosing site-specific BMPs. It is meant to be a quick reference guide to easily explain the purpose and function of many common urban BMPs.

Urban BMP costs can vary substantially. In Dane County, Yahara WINS (the group piloting Adaptive Management) collected data on urban BMPs that were constructed between 2005 and 2013 and calculated a median average of approximately $735 per lb of TP captured (the measure they are using to evaluate the costs of urban BMPs versus rural practices). The costs for urban BMPs ranged between $100 and over $10,000 per lb of TP.

The matrix in Table 5-4 includes different stormwater management objectives along the top row. The following summarizes in more detail what is meant by each of those objectives:

Runoff Rate Reduction:

These practices detain stormwater in ponds or chambers and slowly release the water through a control structure, pipe or orifice. These practices tend to be designed to treat large infrequent events (such as 10 or 25-year events) and help dampen peak flow rates that could lead to streambank erosion or flood urban storm sewer systems.

Runoff Volume Reduction:

These practices are typically designed to infiltrate or evapotranspirate runoff to reduce the total volume of water leaving a site (not just hold it and release it later). These practices are usually designed for smaller regular rainfall events. The volume reduction is often measured on an average annual basis using typical rainfall data (which consists of mostly small frequent events rather than large storm events). Volume reduction lessens the impact of lake floods, which are getting worse in the Yahara Lakes as the watershed becomes more urbanized according to UW–Madison published studies.

Groundwater Recharge:

These practices involve infiltration and contribute to groundwater recharge using relatively clean runoff (volume reduction is also achieved).

TSS Reduction:

These practices are designed to allow suspended solids to settle out in traps, sumps, engineered soil, or pervious pavement. Many pollutants in urban runoff such as heavy metals, nutrients, and pathogens are also often captured as they attach to sediments.

TP Reduction:

Total phosphorus is typically reduced through the same methods as TSS reduction; however dissolved phosphorus tends to stay in runoff and is harder to remove than TSS so biological processes such as plant uptake help contribute to TP reduction. However some practices have been found to leach phosphorus (such as decaying plant matter on green roofs). WDNR has issued specific guidance about the use of compost in infiltration practices, which can actually increase the amount of TP in runoff. A mostly sand soil profile is currently recommended to limit phosphorus leaching from the engineered soils.

Oil & Grease Control:

These practices use filters or baffles to trap oil and grease, which can be present in runoff from streets, driveways, parking lots, loading dock areas and fueling areas. Since these pollutants float, the baffles are typically trapping the surface water and the outlet draws from the bottom.

Impervious Area Reduction:

These practices, when incorporated to a project site, may reduce the overall impervious area that is included when calculating stormwater management metrics such as TSS loading or runoff quantity. Examples include pervious pavement and intensive green roofs, which can typically be counted as permeable areas in runoff calculations. Extensive green roofs, however, are not considered by WDNR as counting towards pervious surfaces because they have a very limited holding capacity and act similarly to regular roofs when saturated.

Table 5-4 Matrix of Urban Best Management Practices

Urban Best Management Practice (BMP)	Relative Cost	Stormwater Management Objective						
		Quantity			Quality			
		Runoff Rate Reduction(A)	Runoff Volume Reduction(B)	Groundwater Recharge	TSS (C) Reduction	TP (D) Reduction	Oil & Grease Removal	Impervious Area Reduction (E)
Architectural strategies								
Cistern, rain barrels (greywater use)	$$	X	1	X	X	X	X	X
Flow-through planter	$$	X	1	X	X	X	X	X
Green Roof (extensive)	$$	X	1	X	X	X	X	2
Green Roof (intensive)	$$$	X	1	X	X	X	X	1
Site strategies – non-vegetated								
Catch basin & inlet filters	$	X	X	X	1	2	1	X
Catch basin & inlet sumps	$	X	X	X	1	2	X	X
Infiltration Trench	$	1	1	1	X	X	2	X
Infiltration Basin	$$	1	1	1	1	1	2	X
Oil & grease trap	$$	X	X	X	2	2	1	X
Open graded base under parking or rec fields	$	2	1	1	2	2	2	X
Pervious/Permeable Pavement	$$	2	1	1	2	2	2	1
Proprietary sedimentation device	$$$	X	X	X	1	2	2	X
Underground vault with wet sump, closed bottom	$$$	1	X	X	1	1	2	X
Underground vault with infiltration	$$$	1	1	1	2	2	2	X
Site strategies – vegetated								
Bioswale (or vegetated swale)	$	2	2	2	1	1	2	X
Rain Garden (bioinfiltration)	$	1	1	1	1	1	2	X
Tree canopy	$	X	1	X	X	X	X	X
Wet detention pond	$$	1	X	X	1	1	1	X
Maintenance practices								
Street sweeping	$$	X	X	X	1	2	2	X

Legend:

1	Primary purpose of BMP, most effective at objective
2	Secondary purpose of BMP, less effective
X	Not effective for intended purpose
$	Relatively low cost
$$	Moderate cost
$$$	Relatively high cost

Notes:

A – Runoff rate reduction typically addressing larger storm events (greater than 2 yr)
B – Volume reduction looking at annual average (i.e. smaller, more frequent rainfall events)
C – TSS is total suspended solids
D – TP is total phosphorus
E – Strategy may reduce the total development impervious area, lowering requirements for treatment

5.5 Opportunities With Future Land Use Changes

Building and Site Improvements

The 2015 Campus Master Plan Update will direct campus development and reinvestment to meet the academic and campus needs and trends anticipated in the next 20 years. While the master plan is highly conceptual, it is intended as a road map to guide future development and provides an effective tool for use in planning future green infrastructure opportunities.

The 2015 Campus Master Plan Update suggests the following with respect to green infrastructure and stormwater management planning:

1. Substantial redevelopment is likely to occur in the vicinity of Lot 60 with the development of a new combined Track/Soccer facility. Surface parking will be replaced with a new parking structure flanked by new academic buildings and access road south of Marsh Lane near the existing marching band practice field. This work offers opportunities for pollutant reductions through the reduction in driving surfaces as well as opportunities for drainage reconfiguration and new green infrastructure facilities.
2. Also in the west campus area, it is anticipated that the campus physical plant grounds storage will be relocated. A primary focus area of the master plan is restoration of the Willow Creek corridor. These initiatives offer opportunities for reducing pollutant loading through land use modification and introduction of new green infrastructure practices.
3. Substantial modifications are anticipated in the near west campus area including expansion of the Veterinary Medicine building to the existing Lot 62, eventual removal and reconstruction of the Meat Science and Muscle Biology Lab, reconfiguration of Linden Drive, and other initiatives. A vision of the master plan is to develop this area as a "green" neighborhood offering opportunities such as addition of green street reaches on Linden and Observatory Drives as well as introduction of new biofiltration areas. In addition to pollutant reductions offered through new biofiltration and green street practices, replacement of Lot 62 with rooftop surfaces will substantially reduce pollutant loads from this district.
4. The Near East Athletic Fields and Natatorium are planned for reconstruction within the next 5 years. Because campus recreation space is at a premium, opportunities for surface stormwater treatment are limited However, subsurface stormwater treatment may be viable below a portion of the Near East Athletic Fields. Two major storm sewers serving a cumulative tributary area of over 40 acres intersect at the Observatory Drive/Elm Drive intersection, just southeast of the fields. Given the proximity of this intersection, and the potential area served, substantial reductions in pollutant loadings could be achieved through a large scale facility at this location.
5. Lot 34, located east of Tripp Residence Hall and near the base of Observatory Hill, is planned for removal as part of the master plan. The removal of Lot 34, in conjunction with planned Observatory Hill landscape enhancements, creates the opportunity for a highly visible stormwater treatment feature as described in Chapter 5.
6. A primary master plan goal is to improve north-south pedestrian and vehicular movements through the "superblock", bounded by Linden Drive to the north, Henry Mall to the west, University Avenue to the south, and North Charter Street to the east. The long term plan calls for replacement or major renovation of all buildings along Linden Drive as well as replacement of the Lot 20 Parking Ramp, Taylor Hall, and 445 Henry Mall. Introduction of open spaces and courtyards in this block will provide the opportunity for either surface or underground stormwater management features.
7. South Campus is currently a highly urban mix of campus buildings, private housing, and commercial areas. The master plan seeks to improve access to areas to the north, improve campus identity, and provide additional centralized social and recreational spaces. Due to the expected increase in density in this area, opportunities for district-wide practices may be limited. However, site-level practices such as green roofs, permeable pavement areas, green streets, and small biofiltration areas are expected to become more prominent features.

Figure 5-55 2015 Master Plan Primary Areas of Redevelopment

8. The master plan includes extensive utility and transportation improvements throughout campus. These projects are unique in that they often include in-kind surface replacement and are often not subject to post-construction stormwater permitting. Consequently, the feasibility of implementing green infrastructure practices such as replacement of impervious cover with permeable pavement or other BMP opportunities are rarely budgeted or explored. Future scoping and budgeting studies should include consultation with this document and consultation with FP & M staff to identify opportunities for implementation of practices such as green streets, biofiltration areas, permeable pavement or other related practices. These opportunities are described in more in Chapter 5.

Impervious Change

Building and site improvements identified in the proposed master plan will maintain or slightly reduce the amount of campus impervious area. As shown in Figure 5-56, master plan land use will reduce impervious traffic areas by approximately 14.2 acres and increase impervious non-traffic area by approximately 13.8 acres. This will reduce overall campus imperviousness by approximately 0.4 acres.

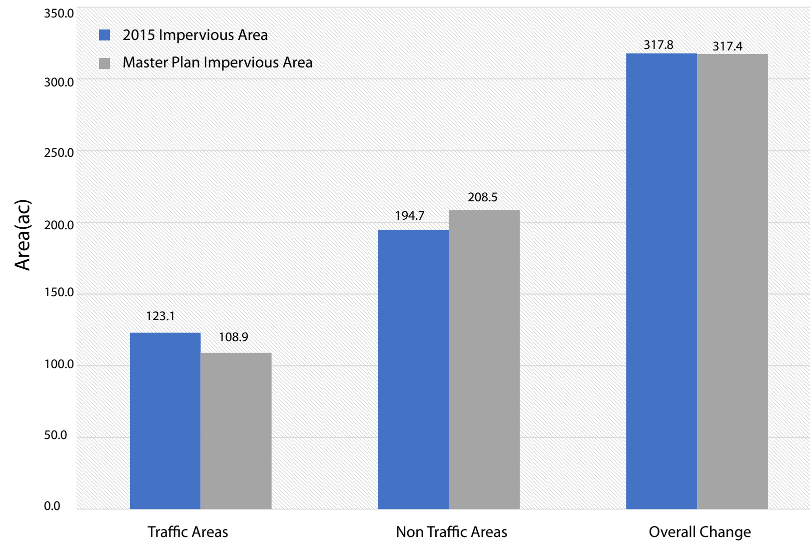


Figure 5-56 Anticipated Impervious Area Change – Permit Area

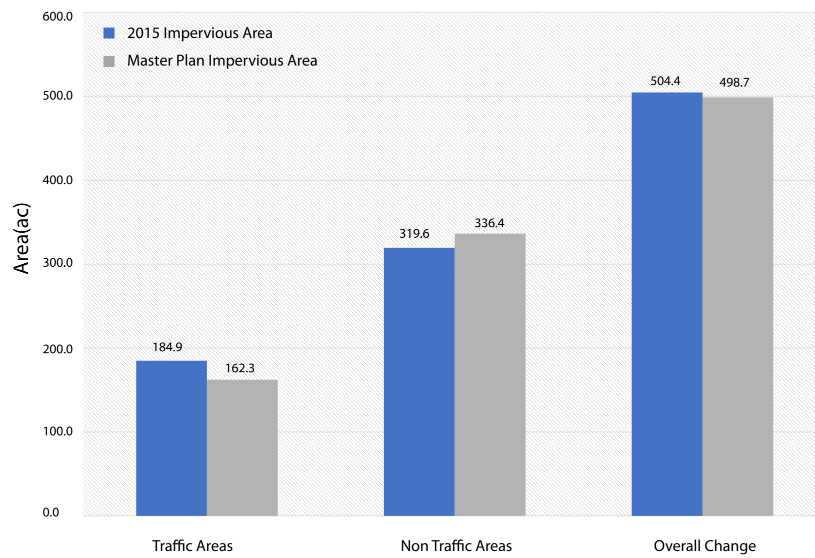


Figure 5-57 Anticipated Impervious Area Change – Total Campus

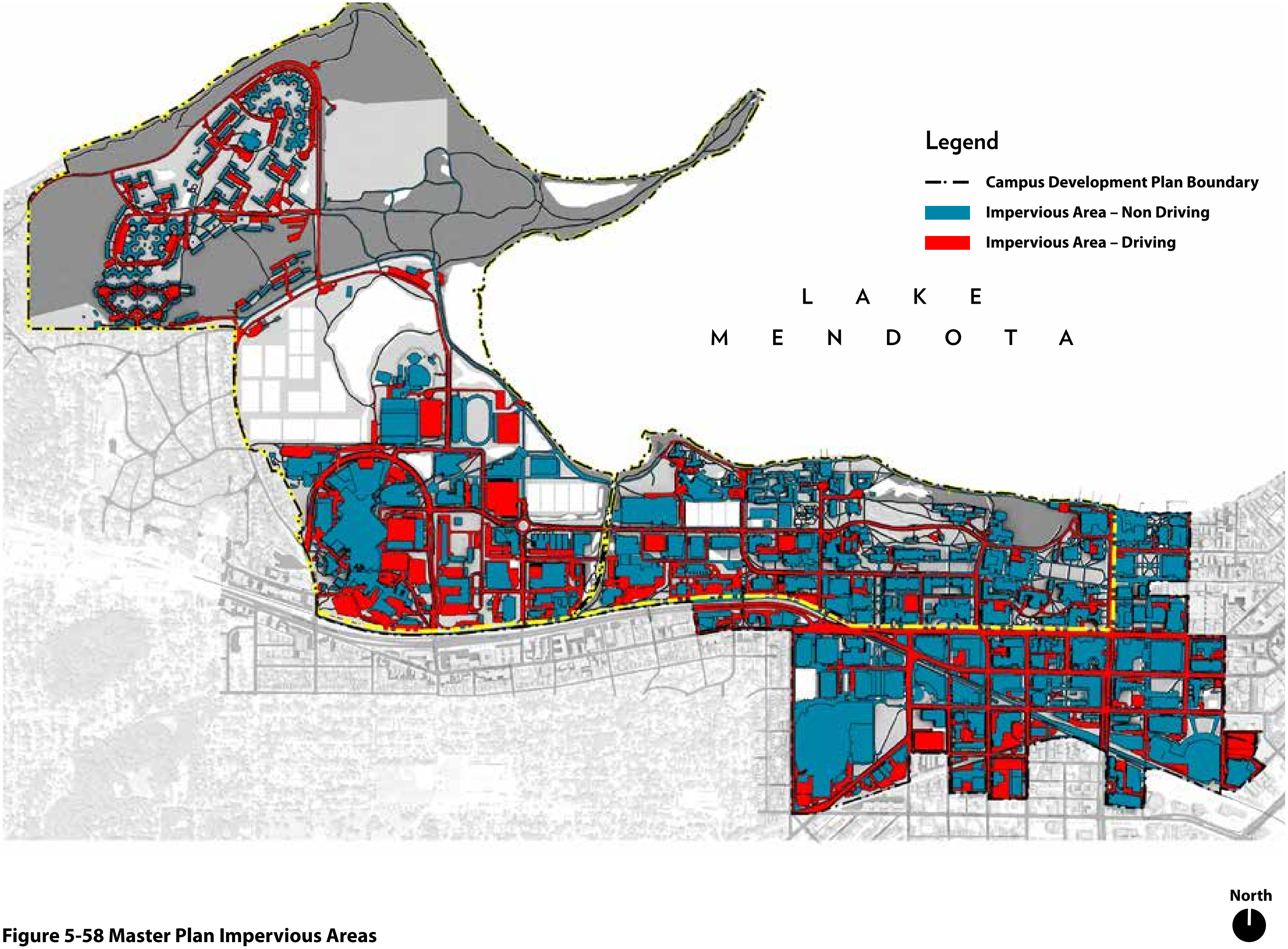


Figure 5-58 Master Plan Impervious Areas

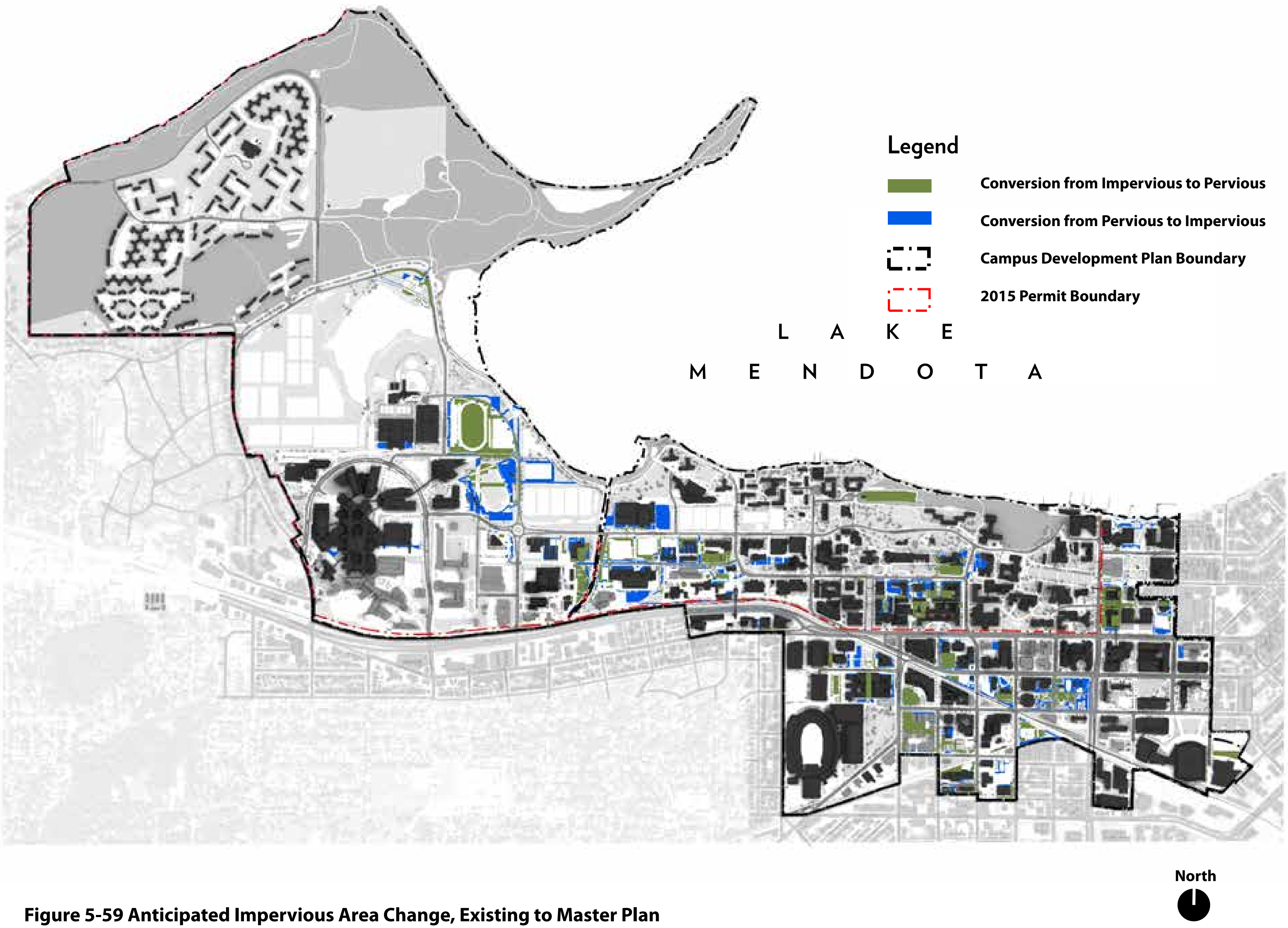


Figure 5-59 Anticipated Impervious Area Change, Existing to Master Plan

5.6 Opportunities with Utility Improvement Projects

The UW–Madison Master Plan update includes a variety of significant utility upgrade projects (primarily steam and chilled water). These projects will require disturbance of certain corridors on campus, which present opportunities for green infrastructure improvements to be planned in those areas. Unlike redevelopment projects for buildings, it is unlikely that stormwater management or green infrastructure would be mandated for any of the utility projects discussed here unless the surface land use changes substantially. However, every project that disturbs land on campus whether for utilities, street reconstruction, or new buildings should be studied as to whether green infrastructure can be included in the restoration to help UW–Madison achieve its overall campus permit and sustainability metrics.

The following project areas have been identified in the Utility Master Plan (see Appendix 4 of the Master Plan Document), including their locations and proposed project numbers. Potential green infrastructure improvements are described for each identified major project.

The extent of disturbance and therefore restoration that will be required for each project is not fully known, so there may be more opportunity in some projects than others. These recommendations are intended to spur discussion during the initial design phase of each project regarding the benefit and feasibility of each.

Lake Shore Residence Halls (1G and 1I)

The area around the Natatorium expansion and the residence halls on Willow Drive (Dejope, Phillips, and Goodnight) will be disturbed for a utility project in the first phase. Many new green infrastructure features were built in conjunction with Dejope. However, replacement of asphalt with permeable pavement should be considered where driveways/parking lots are reconstructed.

Lot 34 Removal/Stormwater (3B)

As described in the multi-site BMPs section, Lot 34 is planned for removal and a new constructed wetland will be built. Tripp Circle is planned for a utility project so this would provide an opportunity (depending on timing) for storm sewers in the Babcock Drive/Tripp Circle area to be rerouted to the new wetland.

Kohl Center Lawn (3D)

The front lawn of the Kohl Center (along W. Dayton Street) will be disturbed in Phase 3 for a utility project. The building roof drains appear to be directed to the south so drainage to the lawn area is limited. However, there may be future opportunities to route water draining to concrete gutters along walkways to rain gardens around the perimeter of the lawn. Primary benefit would be volume reduction. There is limited TSS and TP reduction potential since no driving surfaces would be treated. Also, this project is outside of the UW–Madison permit area so no credit would be granted toward the campus permit goals.

Bascom Hill (1AA)

Bascom Hill will be impacted by a major utility project in Phase 1. There was a lot of discussion among the Green Infrastructure Technical Coordinating Committee regarding the potential for green infrastructure practices on Bascom Hill due to its high profile status. The concern is to make sure we are exploring opportunities for this area while respecting the historical nature of the lawn and the surrounding buildings. There are also ten percent grades which impose challenges for designing surface features (minimizing velocities without walls/terracing). We do not recommend permanent surface modifications within the historic lawn area. However, opportunities for demonstration could include improved runnels/terraced planters along sidewalks or perched rain gardens in the areas outside of the center lawn. Additional investigations would be needed to determine impacts to subsurface structures/basements of historic buildings.

Marsh Drive and Future Gifford Pinchot Extension (4C)

Marsh Drive will be reconstructed for a utility project and also rerouted as the master plan is implemented. This presents a possible green street opportunity. However, Nielsen Pond and the future Marsh Drive wetland practice already provide a lot of stormwater treatment in this area so the green street would be driven more by aesthetics and educational opportunities.

Linden Drive and Elm Drive from Babcock Drive to Observatory Drive (1K)

As discussed previously, the Master Plan calls for green streets on Linden Drive and Elm Drive between Babcock Drive and Observatory Drive. The fact that these streets are slated for utility projects provides the catalyst for making those happen but can also pose some challenges. Steam tunnels in the terraces can create challenges for infiltration practices, so these green streets will need to be designed to work around existing and proposed utilities.

Linden Drive from N. Charter Street to Henry Mall (1JJ)

Most of this area would be treated by proposed “Superblock” underground chamber. However, a green street is feasible in this reach as well.

W. Johnson Street from N. Charter Street to East Campus Mall (2E)

W. Johnson Street is one of the streets identified as a future green street. Again, this will be required to be designed around utilities as the corridor is tight. This is also a city-owned street so the project would need to be coordinated with the City of Madison.

Observatory Drive/N. Park Street/Langdon Street from N. Charter Street to Lake Street (1Z)

The feasibility of green streets along this corridor is likely low due to very steep slopes, tight right-of-ways, and utilities. However there may be pocket opportunities for smaller practices in this corridor. It should be further studied when that project is in planning.

N. Mills Street from Capitol Court to W. Dayton Street (1W)

There is potential for a green street along N. Mills Street. However, this is outside of the permit area so the UW–Madison would not benefit in terms of meeting the permit requirements, and this is a city street so city buy-in is needed.

Figure 5-60 Utility Project on East Campus Mall

5.7 Green Infrastructure Practice Impacts

As discussed in Chapter 3, DNR has mandated that UW–Madison implement practices in the future to reduce the amount of phosphorus and total suspended solids discharging from campus surfaces to waters of the Rock River watershed. Specifically, UW–Madison must implement practices on campus or through participation in the regional Adaptive Management program to reduce TSS discharge by 73% and phosphorus discharge by 61% annually compared to baseline conditions. These reductions can be achieved through land use changes, implementation of new green infrastructure and best management practices, or a combination of the two. In accordance with inter-municipal agreements, UW–Madison must achieve at least a 40% reduction in TSS loading through on-campus measures. The remaining reductions can be achieved either on-campus or through adaptive management participation.

WinSLAMM modeling results suggest that current campus BMPs capture approximately 55,000 pounds of TSS and 143 pounds of phosphorus annually, resulting in current reductions of 33% and 25% of TSS and phosphorus per year respectively.

Land use changes anticipated by the master plan, along with potential implementation of "district-scale" and "site-scale" green infrastructure practices, will provide quantifiable reductions in TSS and phosphorus to waters of the Rock River watershed. Potential reductions achieved by future land use practices and green infrastructure projects are estimated below.

Land Use Change Impacts

Figure 5-61 shows locations of major land use changes identified by the master plan and indicates estimated annual changes in pollutant loading. For example, construction of the Track/Soccer complex at the current location of Lot 60 is expected to reduce pollutant loading by approximately 2,200 pounds of TSS per year. Conversely, reconfiguration of the Superblock may increase TSS loading by approximately 133 pounds per year due to increased building and pavement density. As noted previously, total campus imperviousness is expected remain relatively constant or be slightly reduced through the planning period with the amount of rooftop area expected to increase and the amount of driving surface, particularly surface parking area, expected to decrease. Because runoff from rooftops is cleaner than that from parking and driving surfaces, this change is expected to reduce pollutant source loading.

WinSLAMM estimates that master plan land use changes will reduce TSS loading from campus sources from approximately 168,000 lbs to approximately 160,000 lbs per year.

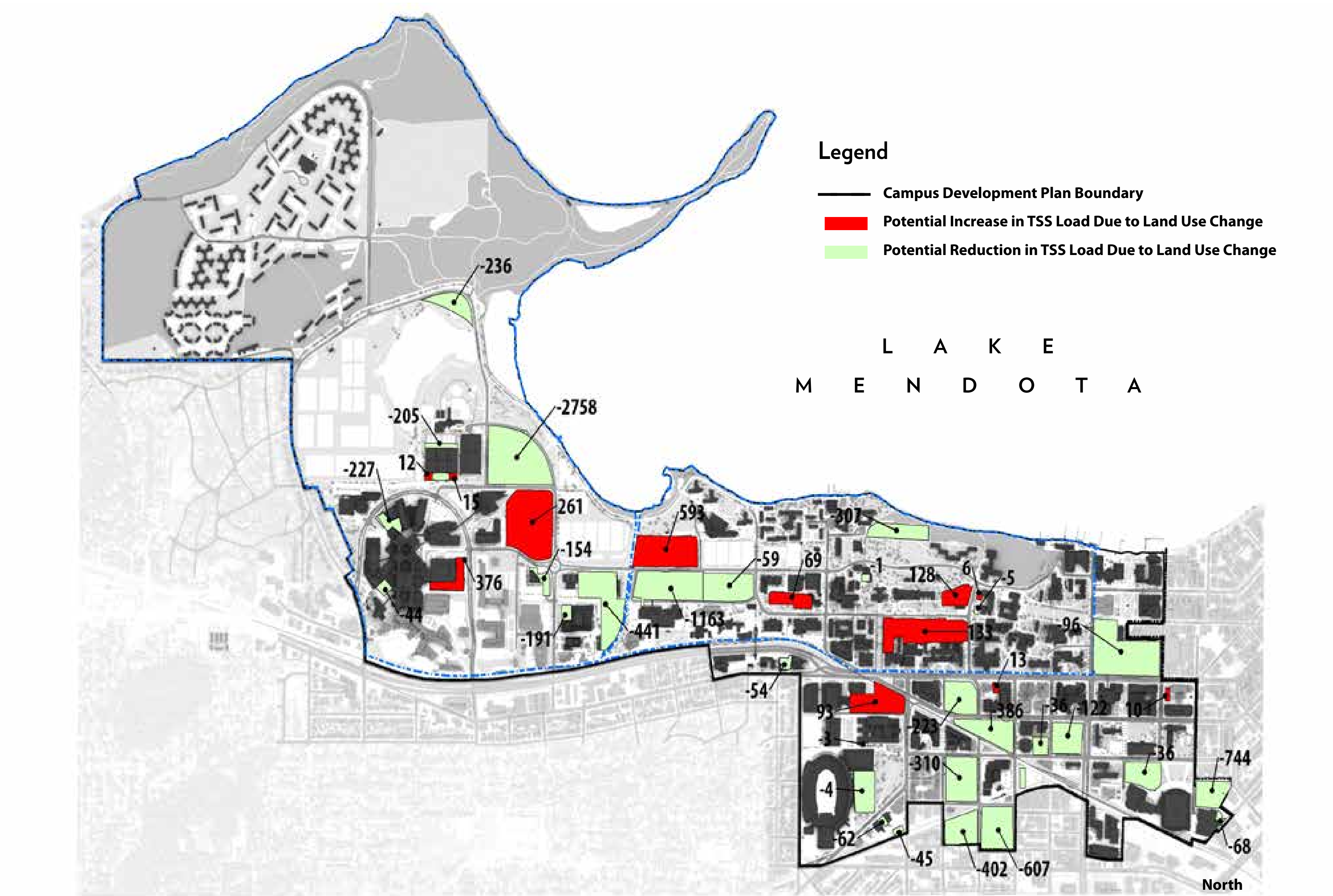


Figure 5-61 Locations of Anticipated Major Land Use Changes and Corresponding Change in TSS Loads

District-Wide Practices

Section 5.2 identified a series of potential district-wide practices for implementation during the planning period in conjunction with other campus projects. In addition to advancing campus sustainability objectives, implementation of these practices will help address UW–Madison permit responsibilities under the WPDES stormwater permit and Rock River TMDL initiatives. The compliance strategy is to implement on-campus practices intended to meet, at a minimum, MS4 permit limits (i.e., increase the current TSS capture within the permit area from 33% to 40% TSS reduction). Additional required reductions will be achieved through participation in the Adaptive Management program along with other regional partners.

Potential reductions for each district-wide practice was estimated using the WinSLAMM computer program based on conceptual surface area and discharge assumptions. Potential reductions for individual practices are included in practice descriptions in this chapter and summarized in Figure 5-63.

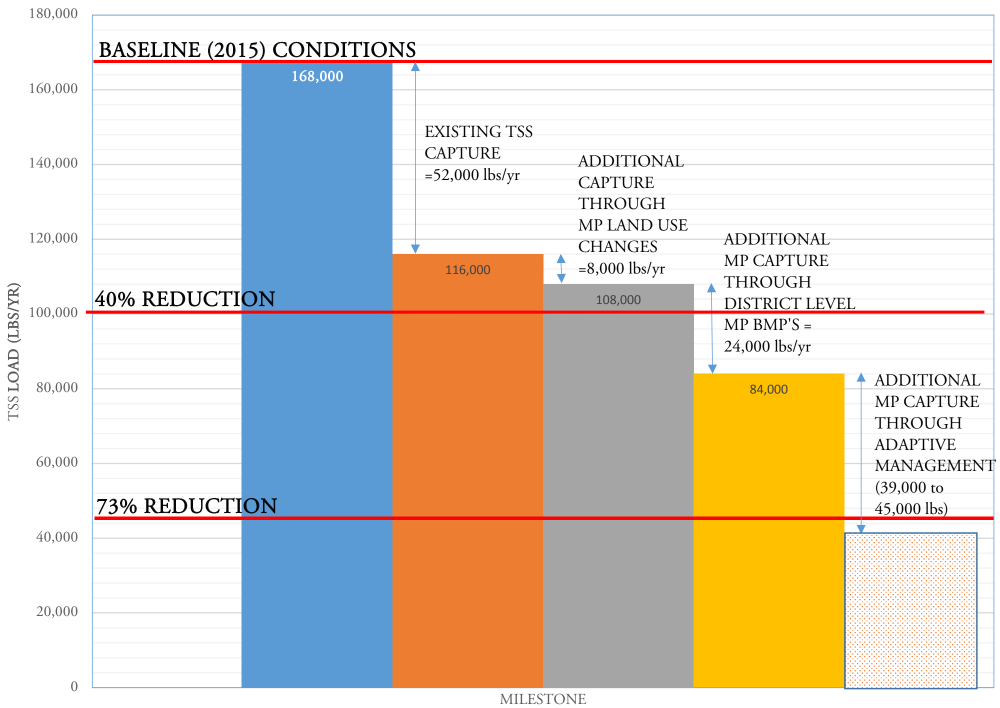


Figure 5-62 TSS Loads (Lbs/Yr) for Different Scenarios

Overall Reductions

WinSLAMM calculations indicate that implementation of all of these practices would reduce TSS loads within the campus permit area by approximately 24,000 pounds annually. This, combined with the 52,000 pounds captured by existing practices plus the estimated 8,000 pounds reduced through land use modifications would reduce loading from the permit area from the baseline level of 168,000 pounds to approximately 87,800 pounds, approximately a 45% reduction. This would exceed the UW–Madison commitment of achieving at least the WPDES MS4 minimum 40% reduction but would require reduction of 39,000 more pounds to meet UW–Madison's share of the TMDL reduction requirement (Figure 5-62). This must be achieved through participation in the Adaptive Management program.

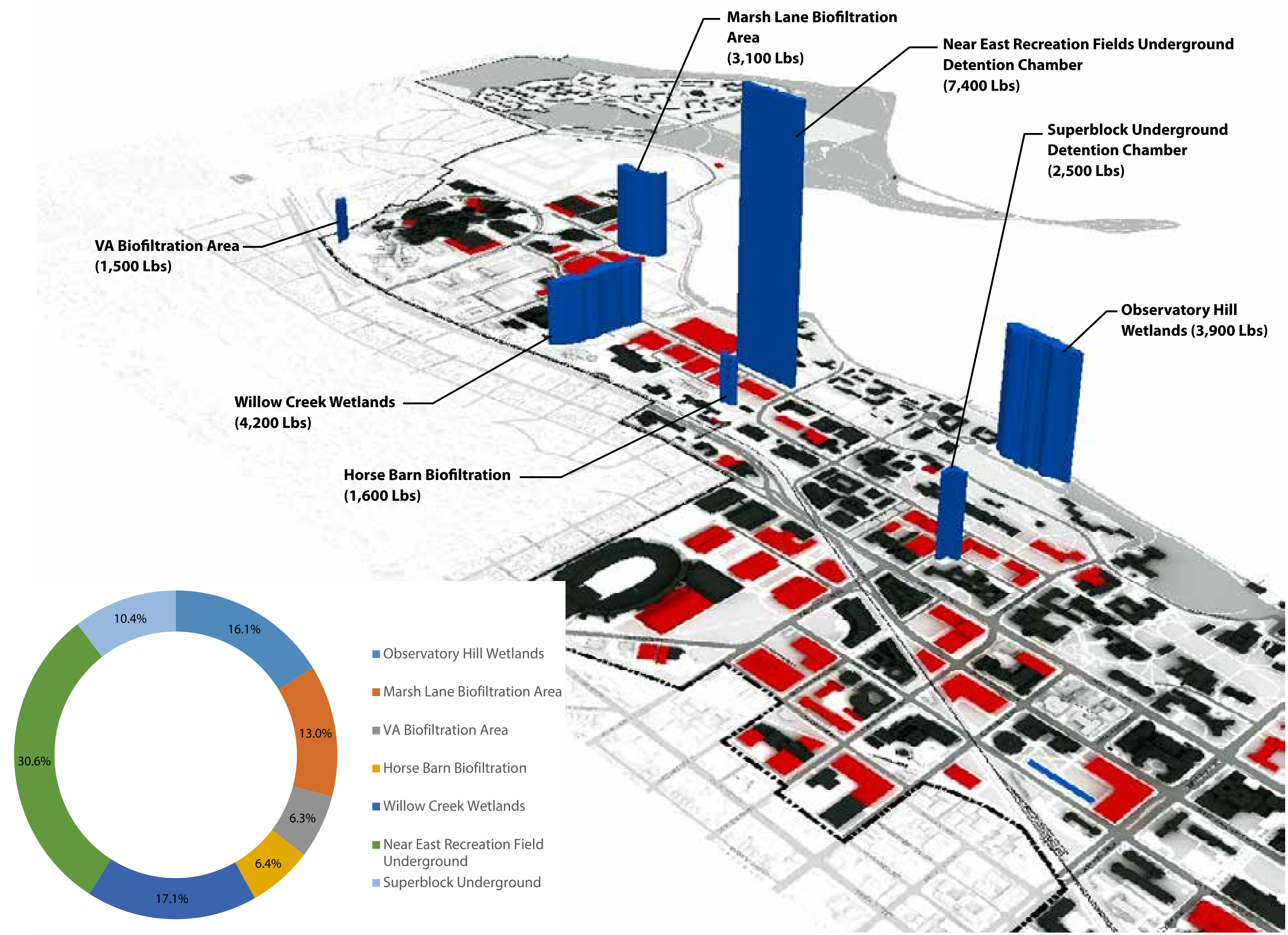


Figure 5-63 Estimated Annual TSS Reductions for Modeled Proposed District-Wide Practices

5.8 Implementation Sequencing of Recommended Practices

The 2015 Campus Master Plan Update sequences planned site and building improvements into Phase 1, Phase 2, and Phase 3 development windows. Phase 1 includes near term improvements anticipated for implementation between 2017 and 2023. Phase 2 includes mid-term improvements for implementation between 2023 and 2029. Phase 3 includes long term improvement anticipated for implementation between 2029 and 2035. The plan also includes “Future Capacity” projects expected after 2035.

Green infrastructure practices described in this report will not typically be constructed as stand-alone projects unless a unique funding source or other opportunity presents itself. Instead, these practices will be linked to one or more of the building or site improvements identified in the master plan. Site-based practices will most likely be constructed in conjunction with site improvements associated with individual building sites. Table 5-5 provides the anticipated implementation schedule for green infrastructure practices based on the overall master plan phasing schedule.

Figure 5-64 Rain Garden, Lakeshore Residence Hall

Table 5-5 Implementation Timeframes of Major Master Plan Projects

Master Plan Project	Linked Green Infrastructure Practice
Phase 1 (2017-2023)	
North Campus Loop/Bascom Hill	Bascom Hill Stormwater Conveyance/Infiltration Enhancements
South Campus Distribution Loop	N. Charter Street Green Street
Primate Center & Harlow Expansion	Capitol Court Subsurface BMP
Near East Rec Fields	Near East Recreation Field Underground Detention
Phase 2 (2023-2029)	
Convert Brooks Street to Ped Mall	South Campus Quad BMPs
WI Institute of Discovery, Phase 2	Campus/Orchard Street Surface BMP
Lot 45 Academic Building	Commuter Path Subsurface BMP
Phase 3 (2029-2035)	
E/W Road Access Road south of Linden Drive	Superblock Underground Treatment
Biological Systems Engineering	Horse Barn Biofiltration
Remove Lot 60	Marsh Lane Biofiltration Area
Zoology Research and Noland Hall	N. Mills Surface BMP
Art Building and Parking Structure	Bedford Surface BMP
Remove Lot 34	Observatory Hill Wetlands
Phase 4 (2035+)	
Reconstruction of Engineering Mall	Engineering Drive Surface BMP

5.9 BMP Inspection and Maintenance Recommendations

The following summarizes some basic recommendations regarding inspections and maintenance of some of the main BMPs that are included in this Green Infrastructure Master Plan. Actual frequency of inspections and cleanings will depend on the design of the specific BMP, but these are meant as general guidelines to follow.

As discussed in Section 5.1, currently inspection and maintenance of BMPs on campus are divided between the Plumbing Shop (for below grade structures) and Grounds (for above-grade features). This situation can function as long as there are well-defined checklists and logs for inspections, cleanings, and maintenance and communication between these groups to ensure that the work is being done efficiently and there aren't any gaps in the procedures. It is recommended that UW–Madison create a matrix of maintenance and inspection responsibilities and assign designated departments for each task.

In addition, UW–Madison should consider partnering agreements with the City of Madison to perform routine inspections and maintenance of underground facilities and permeable pavements on campus (especially in the South Campus) as the city has the equipment and trained personnel to most efficiently perform this work.

Underground Detention Chambers

Underground detention chambers, including the control structure, should be inspected at least two times per year, and cleaned as needed. Service should occur prior to and just after the snow season and during the summer rain season. Note that inspection and cleaning of underground chambers may require trained confined space entry personnel and equipment.

- The control structure orifice should be inspected after storm events of 1.5-inches or more, or at least quarterly to ensure there is no blockage from floating debris or ice. Any blockage should be removed immediately. Accumulated sediment in the sump should be removed.
- A well-designed underground chamber will have sumps designed to collect most of the debris accumulation. However, some sediment may settle in the main chamber, especially after a big rainfall. It is best to remove accumulated sediment in the chamber over time as the more that accumulates that bigger job it becomes. All removed sediment must be placed in an appropriate disposal site.
- Any other repair or maintenance needed to ensure the continued function of the chamber should be performed on an as-needed basis.

Storm Structure Sumps

Each sump should be inspected at least three times per year, and cleaned at least once per year. If inspections show that over half of the sump capacity is filled, cleaning should occur on a more frequent basis. Service should occur prior to and just after the snow season and during the summer rain season.

For maintenance, remove sediment and debris from stormwater structures, including the surface grates and the interior and sump of the structure. Routine cleaning reduces the amount of debris, chemicals, and sediment (including metals that bind to soil particles) that enter receiving waters. Debris left in catch basins can decompose; this reduces the amount of dissolved oxygen and may increase bacteria levels in a waterway. High levels of dissolved oxygen and low levels of bacteria are important to the health of aquatic ecosystems.

Catch basins can be cleaned manually or with specially designed equipment including tools and vehicles with vacuum pumps to remove pollutants. High-pressured water loosens compacted material and vacuums remove solids and liquids.

Biofiltration and Infiltration Practices

Biofiltration/infiltration areas should be inspected on a monthly basis. Maintenance should also be performed monthly or as needed based on inspections and as indicated below. Biofiltration/infiltration areas should be inspected for sediment build up and clogging; erosion; buildup of trash, debris, or organic matter; and plant health (where applicable).

- Water plants as necessary during the first growing season and as needed

during dry periods after the first year.
- Inspect plants for signs of disease monthly and treat as needed.
- Add additional mulch at least once per year and as needed.
- Inspect soil at least once per month and repair eroded soils as needed.
- Remove litter, debris, or buildup of organic matter monthly.

Permeable Pavement

Permeable pavement areas should be inspected at least once per year to evaluate the following:

- Pavement condition – inspect for signs of paver/pavement settlement, deformation and cracking.
- Drainage and Outfalls – Inspect underdrain outfalls for obstructions; inspect clean-outs 72 hours after a rain event of 0.5 inches or greater to verify that the storage reservoir is draining down effectively.
- Surface Infiltration – inspect for signs of surface clogging including sedimentation or evidence of ponding. Clean paver/pavement surface twice per year as outlined below.
    - Clean permeable paver surface twice per year, once during spring and once in fall. Additional cleaning should be performed if inspections show signs of clogging between cleanings. All cleanings should be completed using industry recommended methods such as regenerative air or vacuum sweeping.
    - Repair any surface settlement, deformations, or cracking that are significant enough to impact the system functionality.
    - Repair any blocked or restricted underdrain outfalls as needed based on inspection findings.

Suspended Pavement Systems (Silva Cells)

Silva Cell components including tree openings, and underdrain/distribution systems should be inspected regularly as outlined below:

- Tree openings – inspect twice per year in spring and fall and after major storm events for clogging, standing water, sediment, trash, and debris.
- Underdrains and Inlet/Outlet structures – inspect underdrain clean-outs and outlet pipe for clogging or blockages at least once annually and after major storm events.
- Remove sediment, trash and debris from tree openings as needed.
- Remove blockages from pipes as needed (e.g., jet clean, rotary cut roots/ debris).

Oil and Grease Chambers

Oil and grease chambers or traps should be checked periodically and at least once per year to determine if excessive amounts of solids and/or oils have accumulated. Solids accumulation in the lower sections of the chamber will reduce oil removal efficiencies. Regular inspection and maintenance will eliminate any compromise in performance due to solids build-up.

After the first six (6) months of operation, the inlet area should be inspected and cleaned (dispose of separated oil per regulatory procedures, flush the chamber, remove debris).

Figure 5-65 Lake Mendota Stormwater Outfall

5.10 Abbreviations, Acronyms, and Definitions

Abbreviations and Acronyms

ac	acre(s)
BMP(s)	best management practice(s)
COM	City of Madison
DFD	Department of Facilities Development
DNR	Wisconsin Department of Natural Resources
FEMA	Federal Emergency Management Agency
FP&M	Facilities Planning & Management
HSG	hydrologic soils group
HUC	hydrologic unit code
LEED	Leadership in Environmental and Energy Design
lb(s)	pound(s)
MAMSWP	Madison Area Municipal Stormwater Partnership
MMSD	Madison Metropolitan Sewerage District
MS4	municipal separate storm sewer system
NDPES	National Pollutant Discharge Elimination System
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USLE	Urban Soil Loss Equation
VA	Veteran's Administration
WHPA	wellhead protection area
WLA	waste load allocation
WPDES	Wisconsin Pollutant Discharge Elimination System
Yahara WINS	Yahara Watershed Improvement Network
yr	year

Definitions

Catchment area: The area from which rainfall flows into a body of water or storm sewer system; upstream area collecting flow that is routed to a BMP (routing of underground pipe networks may cause a catchment area of a storm sewer to differ from naturally occurring surface grades).

Detention: A practice that is designed to temporarily hold a designed volume of stormwater and release it (through an outlet, infiltration, or evapotranspiration) at a controlled rate. Used for peak flow reduction and settling out sediment and pollutants.

Ecosystem services: Benefits people and nature obtain from a BMP or feature in the environment such as habitat support, water filtering, heat island reduction as well as recreational and spiritual benefits.

Extensive green roof: A green roof which is constructed of shallow soil media (less than 6 inches in depth) such as tray systems with shallow-rooted plants.

Intensive green roof: A green roof which is constructed of greater planting mediums (greater than 6 inches in depth) to accommodate deeper rooted plants and more diverse plant species. Provides more stormwater benefit than extensive green roofs.

Interpretive signage: Plaques, graphics or signs which are mounted near a feature intended to provide information and education about that feature (usually related to historic, scientific, or cultural facts). Curated and designed with simple graphics and language to appeal to a broad audience.

Watershed: The drainage area of a body of water such as a lake or river. Typically defined by naturally occurring or man-made surface grades.

5.11 References and Resources

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