Grand Valley State University Stormwater Management Plan Allendale Campus

EGLE SAW Grant No. 1143-01

Project No. 191361
February 6, 2023

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Grand Valley State University
Stormwater Management Plan – Allendale Campus

Michigan Department of Environment, Great Lakes, and Energy
Stormwater, Asset Management, and Wastewater Grant
Grant No. 1143-01

Prepared For:
Grand Valley State University
Allendale, Michigan

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List of Abbreviations/Acronyms

AC	acres
AWRI	Robert B. Annis Water Resources Institute
BMPs	Best Management Practices
CFS	cubic feet per second
CFT	cubic feet
EGLE	Michigan Department of Environment, Great Lakes, and Energy
FPMG	Facilities Planning and Maintenance Group
GHM	Good Housekeeping and Pollution Prevention Program Manual
GIS	Geographic Information System
GVA	Grand Valley Apartments
GVSU	Grand Valley State University
GVMC	Grand Valley Metro Council
HSG	Hydrologic Soil Group
LGRW	Lower Grand River Watershed
LGROW	Lower Grand River Organization of Waters eds
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
PEP	Public Education Program
SAW	Stormwater, Asset Management, and Wastewater Grant
SWAG	Stormwater Advisory Group
SWDS	Stormwater Design Standards
SWMP	Stormwater Management Plan
TMDL	Total Daily Maximum Load
WMP	Lower Grand River Watershed Management Plan

1.0 Executive Summary

Grand Valley State University (GVSU) Allendale Campus is located in Allendale, Michigan, in Ottawa County, and has a total student population of 20,753 according to 2022 enrollment information. (GVSU has numerous satellite locations and extension centers; however, this report focuses on the Allendale Campus only.) Located approximately 12 miles west of Grand Rapids, in the Lower Grand River Watershed, the GVSU Allendale Campus is situated on 1,300 acres (AC). The east side of campus is bounded by steep ravines that formed over the last 15,000 years, connecting to the Grand River floodplain. All stormwater runoff from the campus discharges east to the Grand River, or north to Ottawa Creek, through Jacob's Drain and other unnamed tributaries. Both receiving water bodies support a diverse aquatic and wildlife population and offer residents a wide variety of recreational opportunities.

GVSU's stormwater management controls include approximately 114,000 lineal feet of campus storm sewer, 1,035 catch basins, 270 manholes, and 82 structural best management practices (BMPs). The BMPs found on campus include detention basins, vegetated swales, constructed wetlands, rain gardens, green roofs, permeable pavement, and underground detention.

Protection and restoration of natural resources impacted by stormwater is a priority for GVSU. In October 2019, GVSU was awarded a Stormwater, Asset Management, and Wastewater (SAW) grant from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for development of a Stormwater Management Plan (SWMP). This SWMP will assist GVSU in planning for improvement projects to enhance their stormwater management system and to protect and restore resources most impacted by stormwater. The SWMP will also facilitate digitizing and automating stormwater utilities and their associated maintenance schedules, inspection, and reporting.

During development of the SWMP, inspection of ravines and existing stormwater BMPs was conducted to evaluate impacts, impairments, and identify corrective measures, as necessary. Conceptual stormwater management plans for undeveloped parcels and areas deficient in stormwater management systems were also developed. In addition, stormwater assets were digitized, and BMP inspection and Municipal Separate Storm Sewer System (MS4) reporting were integrated into the campus work-order system. Public education and operation and maintenance plans found in the GVSU's MS4 were also considered during SWMP development.

The 2007 *Grand Valley State University Stormwater Management Plan*, the 2011 *Lower Grand River Watershed Management Plan* (WMP) and information from GVSU staff, were used to direct field investigations, identify impairments and water quality problems. The WMP identified 8 pollutants as impacting water quality in the Lower Grand River Watershed. The top 4 priority pollutants include pathogens and bacteria, sediment, nutrients, and unstable hydrology. In accordance with their MS4 permit, Total Daily Maximum Load (TMDL) for *E. Coli* (Grand River) and Phosphorus (Lake Macatawa (watershed)) are applicable to GVSU MS4 discharge.

Recommendations discussed in the SWMP include:

- Create a Geographic Information System (GIS) for storm water system components and incorporate with TMA Systems Software for inspection and maintenance scheduling and MS4 tracking and reporting.
- Reduce surface runoff and carry stormwater to toe of ravine slopes to the greatest extent practicable.
- Replace broken pipes and correct erosion issues at site-specific locations.
- Develop concept level stormwater management plans for undeveloped land north of Lake Michigan Drive and practice fields.
- Repair outlet control structures at north stormwater management complex.
- Incorporate appropriate maintenance techniques for vegetated BMPs.
- Continue active participation with Grand Valley Metro Council for reporting and coordinating MS4 permit requirement.

2.0 Introduction

The main campus of GVSU is located in Allendale, Michigan, and is widely recognized for the unique ravine system that exists on the east side of campus, Figure 1. The ravines formed approximately 15,000 years ago as a result of glacial activity in the area; they convey water from the campus to the Grand River and its floodplain. The ravines are a predominate natural feature of GVSU providing educational and recreational opportunities, as well as aquatic and wildlife habitat. Historic stormwater management did not provide for protection of the ravines, resulting in their significant erosion and degradation.

Originally built in 1960, the 1,300-acre campus has experienced substantial growth and development over the years. Natural areas, including but not limited to wetlands, floodplains, forests, and watercourses, have been removed or altered to accommodate pre-campus agricultural practices and subsequent campus development and growth. These alterations have also resulted in substantial changes in hydrology and increased stormwater runoff. Approximately 186 AC of the campus are developed and contain large areas of impervious surface, Figure 2. A variety of buildings and infrastructure now exist within close proximity to the steep ravine crests. An extensive network of pipes, catch basins and outfalls were built over the years to convey uncontrolled stormwater from buildings, parking lots, lawns/yards, and roads, directly to the ravines and streams leading to the Grand River.

Beginning in the early 2000s, GVSU recognized a significant transformation in stormwater management was necessary to prevent further degradation of the ravines and ensure integrity of structures. GVSU has undertaken several initiatives to improve stormwater management, but more is needed as the campus continues to increase in size and complexity.

As the campus has experienced substantial changes from pre-settlement conditions, and continued growth and redevelopment of existing areas is anticipated, proper management of stormwater is essential not only to protect resources, but also to ensure compliance with state and federal water quality discharge standards. Focus on proper stormwater management and incorporation of low impact development (LID) strategies are especially critical in areas where stormwater management BMPs are deficient. Preliminary site-specific stormwater management plans and strategies are needed for future redevelopment areas to improve design efficiency and reduce costs. As the number of stormwater BMPs continues to increase, quick access to design, construction, and maintenance records will be necessary. Tools are warranted to allow for efficient tracking, inspection, and reporting of stormwater assets. Use of sound maintenance protocol is essential to ensure function and integrity of BMPs. Understanding system capacity and opportunities for improvement, redevelopment, and future development is also critical.

3.0 Stormwater Management Background and History

3.1 Stormwater Management Timeline

GVSU Allendale Campus opened in 1960; for the next 20-30 years, stormwater management generally consisted of directing runoff to the ravine edges and piping to the ravine floor. As a result, historic drainage patterns were significantly altered, and uncontrolled stormwater adversely impacted the ravines and their delicate ecosystem and habitat. In 1998 and 2002, a new stormwater management plan and update were developed, which emphasized managing stormwater runoff onsite with controlled discharge rate to the ravines or away from the ravines. These plans established strategies for stormwater removal and flood control, while preventing erosion, and improving stormwater quality.

Failed stabilization measures in the Calder Ravine, Dec. 2021

As a result of the 2002 plan, several initiatives, such as: construction and consolidation of new storm sewers, piping to the ravine floor, streambank stabilization measures, rock armament and energy dissipators in the ravines, were implemented. Throughout the 2000's, numerous stormwater BMPs (i.e.: rain gardens, vegetative swales, detention, wetland construction, porous pavement, etc.) were incorporated into capital improvement projects. A significant ravine stabilization project to address erosion and storm outlet structure failures, was completed in 2002. However, after project completion, it was determined a more comprehensive approach for stormwater management was needed.

In 2004, the Stormwater Advisory Group (SWAG) was established, and its mission was to restore the 1960 campus drainage patterns, to "make the campus disappear". The SWAG consisted of faculty, staff, students, and consulting engineers to promote a campus-wide approach to stormwater management. Stormwater management focus shifted from "getting rid" of water, to reducing runoff and collecting/reusing in-campus irrigation systems. The SWAG oversaw development of the 2007 *Stormwater Management Plan* and developed BMP Benefits Calculator to help quantify hydrologic benefits resulting from implementation of onsite BMPs. Notable recommendation in the plan was the 80-acre Radio Tower Stormwater Management Complex, resulting in redirecting 60 AC of campus stormwater away from the east campus ravines. The plan also endorsed extended storage and slow release of stormwater, implementation of on-site BMPs, and storm water conveyance improvements with structural erosion control measures. Recommendations in the plan to address site specific areas of flooding have been implemented over the past 13 years and flooding is no longer a concern.

The following is a summary of green infrastructure projects implemented over the past 20 years:

- Multiple green roofs.
- Multiple rain gardens.
- Multiple vegetative swales.
- Zumberge Pond conversion for storm water reuse.
- Stormwater management complex at the broadcast tower.
- Porous concrete sidewalks.*
- Porous asphalt parking lots.*
- Constructed Wetland.
- Underground detention structures.

*These have largely failed and been replaced with asphalt. Failures stem from vehicular weight and damage caused from snow removal equipment.

In addition to the above noted projects, GVSU determined to restore the Little Mac Ravine; it had experienced extensive erosion from stormwater runoff and created structural integrity concerns for adjacent buildings. The restoration project was completed in 2017, implementing natural design techniques to mimic the ravines ecosystem. The project is currently being monitored and has been determined a complete success.

Little Mac Ravine – before

Little Mac Ravine – after

As previously noted, historic drainage patterns were significantly altered as majority of stormwater was traditionally directed to the east campus ravines. Figure 3 illustrates changes in the historic drainage divide and demonstrates the significant progress GVSU has made over the past 20 years to restore historic drainage patterns to the greatest extent possible. Notably, the 2022 drainage divide (red) is further east than the historic (green) in many areas. Today, GVSU remains committed to redirecting stormwater to the western stormwater complexes and implementing appropriate stormwater BMPs to the greatest extent practicable to continue making the campus disappear. For example, the recently completed Fieldhouse Arena expansion project rerouted roof water from the west side of the Arena to the detention basin SW of Lubbers Stadium, to reduce volume being discharged to the Ravine Apartments Ravine.

3.2 Stormwater Management – MS4/NPDES Compliance

Beginning in the 1980s, focus on stormwater management at both the federal and state level became a priority. As a result, discharges of stormwater to surface waters from an MS4 required a National Pollutant Discharge Elimination System (NPDES) Program permit. The NPDES Program safeguards waterways by assuring discharges comply with federal and state regulations. GVSU is located nearly equal distances from Grand Haven, Holland, and Grand Rapids, in an urbanized area and discharges all stormwater to the Grand River and Ottawa Creek. Presently, stormwater discharge from GVSU MS4 is authorized under NPDES Permit No. MI0059838.

The GVSU Stormwater Management Program (Program) was developed by Grand Valley Metro Council (GVMC), in cooperation with regulated communities within the Lower Grand River Watershed (LGRW), in accordance with NPDES permit requirements. The Program was initially approved in February 2013, amended in August 2013, with the most recent permit issued June 29, 2021. The Program provides GVSU with procedures and standards to reduce pollutant discharge from the MS4 to the maximum extent possible. The Program provides for leveraging and implementing both collaborative and campus-based policies, procedures, and initiatives for public participation and education, illicit discharge elimination program, construction and post-construction stormwater runoff control program, good housekeeping, and assesses progress in meeting the *E. Coli* and Phosphorus TMDL requirement.

3.3 Campus-Based Stormwater Management Program

The Facilities Planning and Maintenance Group (FPMG) are responsible for managing campus stormwater. Staff review all projects, and coordinate with design consultant, to ensure post-construction stormwater runoff design standards are met. FPMG is involved in evaluating impacts to the existing stormwater system as building expansions and redevelopments are considered. FPMG is also responsible for all maintenance, monitoring, and reporting of stormwater BMPs.

3.4 Post-Construction Stormwater Runoff

GVSU Stormwater Design Standards (SWDS) were prepared as part of the NPDES permit process. GVSU has adopted a formal resolution stating intent of the *Stormwater Standards Manual,* applies to any project falling under GVSU jurisdiction. The SWDS establish minimum stormwater management requirements for new or redevelopment projects. The FPMG reviews all proposed projects to ensure design standards are met. Design review works to achieve the following objectives:

- Ensure compliance with water quality treatment and channel protection standards set forth in the NPDES permit.
- Minimize degradation to the ravines.
- Minimize degradation to downstream waterbodies.
- Ensure BMPs adequately address stormwater management needs.
- Protect the campus from flooding and water quality degradation.
- Maintain pre-development hydrology to the greatest extent possible.
- Redirect stormwater to western wetland complexes as feasible.
- Identify opportunities for collection and on-campus use of stormwater.

3.5 Organization of Lower Grand River Watershed Communities

GVSU is an active participant with other MS4 communities in the LGRW. These NPDES Phase II communities work together to develop, guide, and leverage regional and collaborative initiatives to help implement stormwater management programs sufficient to meet NPDES requirements. Various communities within LGRW participate in the GLRC. The following committees have been established to lead the specific sections of the collaborative Phase II program.

- Public Education Program (PEP).
- Illicit Discharge Elimination Program.
- Best Management Practices.
- TMDL monitoring plan.
- Training programs.
- Good housekeeping procedures.

4.0 Project Purpose

The SWMP will serve as a roadmap for GVSU to plan for and implement key initiatives, to improve and enhance existing stormwater management policies, procedures, maps, and practices. Primary focus of the SWMP will be development of the storm water GIS system, strategies to reduce storm water discharge, and address erosion in the ravines, including recommendations for repair and maintenance of known areas of concern. The SWMP will prioritize drainage areas for implementation of recommendations and make recommendation for BMP maintenance protocol.

5.0 Project Objectives

Implementation of this SWMP will seek to accomplish the following objectives:

- Develop GIS system for storm water assets and storm water BMPs.
- Purchase TMA Software extension to link GIS database to TMA work order system.

- Ensure maintenance scheduling, tracking, and reporting is compliant with MS4 requirements.
- Evaluate ravine stability and assess erosion concerns.
- Update drainage area boundaries to reflect existing conditions.
- Prioritize drainage areas based on existing stormwater BMP coverage.
- Conduct survey and soil borings at high priority sites.
- Develop site-specific stormwater management plan with recommended BMPs for undeveloped area north of M-45.
- Develop recommendations for site-specific upland BMPs to reduce storm water runoff to ravines.
- Develop maintenance strategy for treating Zumberge Pond and wetland stormwater management complex.
- Develop recommendations for capital improvement projects and maintenance.
- Develop recommended stormwater BMPs by subcatchment/zones (i.e., for redevelopment, etc.).
- Prepare maintenance protocol for vegetative BMPs.

6.0 GVSU Characteristics

6.1 Drainage Area

GVSU is situated in the heart of the Lower Grand River Watershed, see Figure 4. The campus can be further delineated into six drainage areas, as shown in Figure 5, and described in in Table 1.

Table 1 – Drainage Area Boundaries

Drainage Area	Acres	Receiving Body
South Stormwater Management Area	32	Unnamed tributary to Ottawa Creek
North Stormwater Management Area	126	Unnamed tributary to Ottawa Creek
Golf Course	275	Unnamed tributary to Ottawa Creek
Ravine Apartments Ravine	66	Unnamed tributary to Ottawa Creek
Utilities & Services Building	18	Indirect to Grand River
Grand River Ravines	105	Direct to Grand River

6.2 Land Use

The 1,300-acre campus consists of open areas (golf course and stormwater wetland complexes) to the west, and high density developed areas to the east, Figure 6. Large areas of impervious surface exist throughout GVSU. Forest and wetland areas account for a very small portion of the campus. Review of pre-settlement conditions shows the campus was primarily a sugar maple and beech tree forest. The forest was converted to agricultural usage over time. A total of 617.6 AC of forested land has been lost since pre-settlement conditions due to agricultural practices, Figure 7.

6.3 Wetlands

Wetlands in the campus have been identified by the National Wetlands Inventory, conducted by the United States Fish and Wildlife Service, see Figure 8. Today, a total of 13 AC of wetland exists within campus property. Preservation and protection of wetland areas is important, as they provide a natural means for stormwater storage and water quality treatment.

In 2011, an 80-acre constructed wetland stormwater management complex was constructed. Although, this stormwater management complex is not considered a wetland for regulatory purposes, monitoring of the complex indicated their function and integrity has been sustained over the past 11 years.

6.4 Soils

The National Resource Conservation Service (NRCS) of the U.S. Department of Agriculture have classified the soils. A total of 18 mapped soils exist throughout GVSU and are shown in Figure 9. Soil types can be generalized as representing poorly drained clay, sand, and loam. Numerous soil borings conducted at various locations throughout the campus confirm stiff to hard clayey soils exist in the upper stratum, while leaner clay, sands and loams are encountered in lower stratums. All the soils in GVSU are known for being very poorly to poorly drained, due to their high-water storage capacity.

Understanding the hydrologic characteristic of soils is necessary to calculate potential stormwater runoff from an area and potential flooding. Clay soils have lower infiltration resulting in larger runoff volumes and higher flood discharges. Conversely, sandy soils have higher infiltration rates resulting in less runoff and lower flood discharge rates. Runoff potential for soil has been classified as A, B, C, or D by NRCS using the Hydrologic Soil Group (HSG) classification. Figure 10 depicts HSG data from the NRCS Soil Survey Geographic database. The HSG classification is based on the water infiltration capacity of the soil after wetting from long-duration storms and opportunity for swelling. Characteristics of the four HSG classifications are shown in Table 2.

Table 2 – HSG Soil Characteristics

HSG Group	Infiltration Rate	Soil Depth	Water Transmission Rate	Soil Texture
A	High	Deep	High	Sand, gravelly sand
B	Moderate	Moderately Deep	Moderate	Moderately fine to moderately coarse
C	Slow	Moderately Shallow	Slow	Coarse
D	Very Slow	Shallow	Very slow	Clay, clay pan

Most of the campus consists of Group C and D soils which have a low infiltrative capacity.

6.5 Hydric Soils

Hydric soils are soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation. Most of the campus consists of non-hydric soils. Areas of Sims Loam and Sloans Loam in wetland areas and the ravines are hydric, but these are isolated pockets.

6.6 Streams, Rivers, and Floodplain

The Grand River traverses approximately 1.25 miles along the eastern edge of GVSU. The Grand River floodplain is well established and is bounded by the river to the east and ravine system to the west. The river's floodplain is entirely natural and has not been substantially adversely impacted by development on the campus. The Grand River and its floodplain are shown on Figure 11.

6.7 Stormwater System

GVSU's stormwater conveyance system is comprised of a complex network of 21 miles of storm sewer pipes, 1,390 catch basins, manholes, and many BMPs for storage and/or controlled release of stormwater runoff. Stormwater for approximately 623 AC of developed area is conveyed via pipes ranging generally from 6 inches to 54 inches in size. A total of 28 storm sewer pipes discharge directly to the ravines. Stormwater is also conveyed via pipe system to the stormwater management complex which ultimately discharges into an unnamed tributary to Ottawa Creek, where it then discharges into the Grand River. The Grand River Ravines, Ravine Apartment Ravine, and golf course are the only drainage areas that discharge stormwater directly into an open channel system. The stormwater system is shown on Figure 12.

Several structural stormwater controls (BMPs) are part of the stormwater system and are summarized in Table 3, below, and shown in Figure 13. (Given the number, catch basin location can be found on Figure 12, Stormwater Collection System). GVSU owns and assumes responsibility for care and maintenance for all BMPs on the campus.

Table 3 – Structural Stormwater Controls

Structural Control	Quantity	Comment
Catch basins	1,035	Approximate number as quantity continually changes based on current construction projects.
Detention basins	15	
Oil/water Grit separators	1	Meadows Club House
Fueling Station	3	Double-walled with monthly monitoring, Service Building
Green Roofs	13	
Vegetated Swales	18	
Constructed Wetland Complexes	2	
Porous Pavement	3	Mackinac Courtyard, Connection East, and West entrances
Rain Gardens	12	
Stormwater Reuse Ponds	4	

7.0 State and Local Agency Collaboration

Faculty and staff at GVSU who are integral to various water-related activities, including but not limited to, water quality, stormwater management, watershed management, and low-impact development are active participants with a myriad of state and local agencies and groups, to protect and preserve surface waters of the state. GVSU collaborates with the communities of the LGRW as a watershed and regional partner to implement PEP and Illicit Discharge Elimination Plan, as approved by EGLE in February 2013, and June 2021, respectively. GVSU and MS4 communities work together to implement the six minimum measures, as appropriate, including shared operational and structural BMP procedures, good housekeeping procedures, training programs, and a TMDL monitoring plan. GVMC, LGROW, Ottawa County Water Resources Commissioner, EGLE, and local schools are just a few examples of organizations GVSU routinely collaborates and partners with to address water-related concerns and initiatives within the region.

The Robert B. Annis Water Resources Institute (AWRI) is a multidisciplinary research organization within GVSU's College of Liberal Arts and Sciences. Its mission is to integrate research, education, and outreach to enhance and preserve freshwater resources. AWRI has partnered with local watershed groups to assist in development of watershed management plans, including the 2011 *Lower Grand River Watershed Management Plan*.

8.0 Known Water Quality Issues

The 2011 *Lower Grand River Watershed Management Plan* (WMP) was a collaborative watershed planning process outlining goals and objectives to enhance, restore, maintain, and protect water quality in the LGRW. Staff, faculty, and students from various disciplines at GVSU, including but not limited to, the AWRI, partnered with consultants, local conservation districts, townships, and state and local agencies during WMP development. The WMP identifies pollutants and known water quality issues and offers specific tasks and BMPs to be implemented to address the same.

Eight priority pollutants were identified as impacting water quality in the LGRW and include: 1) pathogens and bacteria, 2) sediment, 3) nutrients, 4) unstable hydrology, 5) temperature, 6) habitat fragmentation, 7) chemicals, and 8) invasive species. The Direct Drainage to Lower Grand River subwatershed management unit, of which GVSU is a part, has the highest sediment and nutrient loading in the LGRW. Therefore, campus BMPs that address sediment and nutrient loading are critical.

The WMP identifies source and cause of water quality issues that are potentially associated with GVSU, shown in priority order in Table 4 below:

Table 4 – Water Quality Issues Potentially Associated with GVSU

Pollutant	Source	Cause
Pathogens and Bacteria	Wildlife – ducks, geese, etc.	High populations of wildlife; riparian management practices which encourage or attract wildlife
Sediment	Streambanks	Altered morphology and hydrology; erosion; loss of floodplain
	Rill and gully erosion	Concentrated flows
	Urban landscapes	Impervious surfaces; dense drainage network;
Unstable hydrology	Wetland loss	Historic drainage/filling for agricultural land use (prior to GVSU)
	Tiles and drainage networks	Urban land use practices
Habitat Fragmentation	Destruction of habitat, including wetland and floodplain	Urban development

The WMP recommends a wide variety of BMPs to address pollutants, and those most practicable for implementation at GVSU include:

- Low impact development practices (porous pavement, green roofs, rain gardens, bioswales, etc.).
- Stormwater system devices with pollutant separation capabilities.
- Detention or retention ponds.
- Sweeping of streets, parking lots, and other impervious surfaces.
- Capture and reuse of stormwater.
- Waterfowl management.
- Wetland preservation/creation.
- Ensure proper application of fertilizer, pesticides.
- Proper pet waste disposal.
- Public education and information – citizen's role in healthy watersheds.

9.0 Areas of Concern

As part of the SAW Grant, several potential areas of concern were reviewed; they are summarized below.

- Prioritize drainage areas based on runoff volume and existing BMP capacity and function.
- The Ravines were inspected to evaluate their overall stability, areas of erosion, and determine priorities for repairing impairments noted. Notably, Seidman House bank erosion was of greatest concern.
- Streambank erosion on the unnamed tributary to Ottawa Creek is compromising structural integrity of the most northern golf course footbridge crossing.
- Review of Zumberge Pond design and function was necessary to evaluate storm water management options required for the potential expansion of Kirkhof Center. Ensuring no significant increase of stormwater volume to Zumberge Pond is critical as the pond directly discharges into Little Mac Ravine.
- Detailed inspection of the stormwater management wetland complexes had not been conducted in recent years. Given the wetland complexes play a critical role in managing a large portion of GVSU stormwater,

ensuring proper function and integrity of the complexes is essential. The stormwater management wetland complexes were inspected to ensure their function, ensure structural integrity of outfalls, and make recommendations for maintenance activities.

- Visual inspection of all vegetated stormwater BMPs was conducted to assess their overall function, integrity, and identify required maintenance.
- Football practice field pipes are currently undersized and will not tolerate increases in storm water volume. Conceptual plan for improving storm water management in this area (practice fields, tennis courts, and Irwin Parking area) is desired to better accommodate future expansion.
- Lack of LID BMPs at the Fieldhouse arena require conceptual plans for improving storm water management and reducing runoff to the Calder Ravine.
- Future expansion of the campus north of M-45 is unknown at this time. However, a proactive approach to plan for proper management of stormwater in this area was desired.
- Stormwater runoff, erosion under boardwalks, and ponding of water at building egress doors at Maple, Pine, Oak dormitories required inspection and development of corrective measures.
- Stormwater runoff, erosion, and sidewalk integrity on east side of Copeland Robinson dormitories.
- Stormwater runoff and erosion at the northeast corner of Holton-Hooker dormitory.
- Digitized stormwater system data, including enclosed pipe, catch basins, outfalls, and structural BMPs, is desired to allow for automated maintenance scheduling, monitoring, and reporting, in accordance with MS4 requirements.

10.0 Stormwater System Assessment

Assessment of the stormwater system consisted of delineating and prioritizing stormwater drainage areas. Drainage areas were prioritized as high, medium, or low based on the type and capacity of existing stormwater BMPs, as shown in Figure 14. Drainage Areas rated "high" priority are those lacking adequate stormwater BMPs. Uncontrolled discharge of stormwater is generally associated with high priority areas. A "medium" priority drainage area has some stormwater BMPs, but improvements could be realized thru implementation of additional BMPs. Lastly, a "low" priority drainage area has sufficient stormwater BMPs. Evaluation of the stormwater wetland complexes was conducted to determine if design intent is being maintained. Assessment of Zumberge Pond was conducted to evaluate overall function and determine impacts from potential addition to Kirkhof Center. Ravines, which are situated primarily on the east side of campus and convey stormwater to the Grand River, were inspected to evaluate ravine erosion and identify areas of concern. Location and overall function (above ground BMPs only) of existing storm water BMPs was also conducted. Lastly, site-specific areas of known concerns were inspected. Corrective measures identified as a result of the stormwater system assessment are discussed in the Recommendation section of this report. Representative photos of site inspection are provided in Appendix 1.

10.1 Hydraulic Analysis

A comprehensive hydraulic analysis of the GVSU campus was not performed as part of this stormwater management plan. An EPA SWMM model of the GVSU campus was created by Fishbeck in 2011 and updated in 2016. An inventory of existing storm sewer infrastructure is maintained by Fishbeck on behalf of GVSU and is used to create project specific stormwater models when new projects are in the design phase. Since GVSU's stormwater improvements are generally constructed as part of new construction projects and hydraulic analysis is performed as part of these designs, an update to the campuswide model was deemed unnecessary.

A high-level analysis of the stormwater system was performed which mapped the outfall points for the entire campus and divided the campus into stormwater sub-basins. The subwatershed priority for these sub-basins was categorized as high, medium, or low priority based on the amount of impervious area and the stormwater BMPs managing runoff in each subbasin. Low priority subbasins are those that have minimal impervious area and adequate stormwater controls. Medium priority subbasins are those that have some stormwater controls and discharge directly to the ravine system. High priority subbasins are those without stormwater controls. These subbasin priority rankings should be used during the design phase of future construction projects to determine whether additional stormwater controls should be implemented along with those necessary for the project itself.

10.2 Stormwater Management Complex Analysis

An 80-acre constructed wetland complex exists on the west side of campus and serves as a stormwater management area for a large region of the campus. The complex was constructed in 2011, allowing for redirecting over 60 AC of stormwater runoff from the ravines and aided in restoring historic drainage patterns. The complex not only provides stormwater detention but improves water quality as vegetation uptakes pollutants and nutrients from stormwater. The stormwater management complex is divided into two sub-complexes. The south complex receives runoff from the South Living Center and the adjacent Parking Lot J. The north complex receives runoff from the majority of the remaining campus area bounded by West Campus Drive and South Campus Drive. See the Drainage Area Map, Figure 5 for more detailed boundaries. Field survey in December 2020, was performed in order to observe how the complex is functioning as a stormwater management area and make recommendation for corrective measures, as necessary.

In general, the south stormwater management complex is performing well. There was good coverage of bank vegetation with minimal invasives at the forebay and both the upper and lower cells. The water level appeared close to the design elevations in all three cells. Minor issues noted with the south complex include sedimentation in the lower cell and overgrown vegetation downstream of the complex clogging the outlet channel. Periodic dredging of constructed wetlands should take place once every 15 years. Since the stormwater management complex was constructed in 2011, they will be due for dredging maintenance in 2026. Vegetation in the outlet channel should be cut back to a height of six inches each spring to ensure that the outlet channel has appropriate hydraulic capacity in case of a major storm event.

The north stormwater management complex has more serious issues that should be promptly addressed. In the upper cell of the north complex, the water surface elevation is significantly below the design water elevation. The inlet from the forebay is perched, ten to fifteen feet of muddy banks are exposed, islands are forming on the interior of the cell, and the sound of running water is clearly audible in the downstream structure. Even with the water level below the design elevation, the basin outlet is still partially submerged. Based on the visual evidence, the likely cause of the low water level is the settling or subsidence of the basin outlet. Corrective maintenance is required to reset this structure to the design elevation. Likely as a result of the draining down of the upper cell, the middle cell of the north complex has an elevated water surface compared to the design elevation. The inlet is three-quarters submerged and bank vegetation is inundated even during dry periods. The outlet control structure for the middle cell is partially submerged. The outlet is tilted to one side, which is evidence of ongoing settling or subsidence here as well. Corrective maintenance is required for the middle cell as well, to reset the outlet structure to the correct elevation and address possible subsidence.

Field inspection notes that, overall, the wetland complex is adequately functioning as a stormwater management area. The vegetation around the perimeter is in good condition with numerous birds, insects, and aquatic wildlife observed during the field inspection. Regular maintenance needed at the stormwater management complex is the cutting of vegetation in the south complex outlet channel in early spring each year and the periodic dredging of the cells once every fifteen years, next scheduled in 2026. High priority corrective maintenance for the stormwater management complex are the repairs to the outlet structures for the north complex upper and middle cells that have fully or partially subsided, leading to significant deviations from the design water surface elevation. Photos of the stormwater management complexes are included in Appendix 1.

10.3 Zumberge Pond Analysis

Zumberge Pond is located between Kirkhof Center and Zumberge Hall; it was constructed in the early 1960's entirely for aesthetic purposes, and discharges to the Little Mac Ravine. The pond was reconfigured for stormwater reuse in 2010 and provides stormwater treatment for approximately 4 AC of contributing area. In addition to pond retrofit, aesthetic improvements were made along the pond edge.

The pond was inspected on December 7, 2020, to evaluate pond function, structural integrity and provide recommendations for corrective measures. In general, the pond is in good condition and functioning largely as intended. However, water surface elevation was observed to be approximately 4" above design, which reduces overall capacity for stormwater storage. The elevated water surface elevation is likely a result of the pond not being used at that time as a water supply for irrigation. Conversations with GVSU staff indicated that previous complaints had been lodged about the appearance of the pond when the water level was at the design elevation which discouraged its use as originally intended. In addition, aluminum edging between limestone banks and landscape has been compromised and is failing. Aluminum edging is only 1/8" thick and not able to withstand heavy load from heavy equipment that traverses the area (lawn mower). Areas of erosion were noted on the north bank and are contributing sediment to the pond, which reduces overall capacity. Lastly, dislodged stone at the main outlet channel was observed.

Impacts to the pond by increasing stormwater contributing area or conversion of pervious to impervious areas as a result of the proposed Kirkhof Center addition was also assessed. Concern for long-term stability of the Little Mac Ravine is the greatest threat, and adequate stormwater controls will be necessary should the volume of water discharging from pond increase. Detailed summary memo for Zumberge Pond from December 2020 can be found in Appendix 2.

10.4 Ravine Analysis

10.4.1 Overall Ravine Analysis

As previously noted, GVSU is widely recognized for the ravine system that was formed as a result of glacial activity approximately 15,000 years ago. Majority of the ravines exist on the east side of campus, albeit one is situated on the north. The ravines play an important role in conveying both storm and surface runoff from the campus. Historically, uncontrolled stormwater was allowed to discharge into the ravines, resulting in severe erosion, slumping, fracturing, and downcutting. Over the past 15 years, significant portion of stormwater has been redirected away from the ravines and natural processes have allowed ravines to achieve some levels of equilibrium and stability.

Ravines were inspected in December 2020 to assess their overall condition, and identify areas of impairment, including but not limited to erosion, fracturing/slumping, downcutting, and integrity of structures previously installed. Inspection also assessed potential threats to buildings or structures resultant from ravine impairments.

Geotechnical analysis was conducted by MTC, respectively, at three high priority sites in the Au Sable, Calder, and Grand Valley Apartments (GVA) ravines to further evaluate impairments and slope stability. This information was also used to develop preliminary restoration designs. The geotechnical report is found in Appendix 3.

There are seven significant ravines on the campus, including GVA, Calder, Au Sable, Little Mac, Copeland Robinson, Lot D, and Ravine Apartment, Figure 15. In general, the ravines exhibit very similar characteristics with varying degrees of impairment. However, there are unique features that make ravines slightly different in character and overall stability and function.

Inspection notes the ravines are comprised of very steep slick clay slopes that descend from the campus floor approximately 1,000 to 2,000 lineal feet to the Grand River floodplain area. Large mature trees are found in the upper portion of the ravines. Fallen trees and woody obstructions were commonly observed in the upper reach areas. Several small tributaries flow into the middle reach of many of the ravines. From the middle area, the ravine then discharges into vegetative open areas where open streams convey water to both the Grand River and its floodplain. This area of the ravine is marked by vegetation typically found in floodplains and wetlands. Given the time of year when the inspection was conducted, identifying specific vegetative species was not possible. However, one could reasonably expect Joe-Pye weed, Swamp milkweed, Jack-in-the-pulpit, Stinging nettles, Skunk cabbage, and wildflowers to be found in the floodplain/wetland areas.

In general, all ravines exhibit signs of degradation from historic uncontrolled stormwater runoff. Historic fractures and slumps were commonly observed but appeared to have somewhat stabilized. New areas of minor to severe erosion, fracturing, and undercutting and falling trees were also observed in all of the ravines. Fallen trees and displaced stone are providing critical grade control in many locations. On the other hand, flow is being redirecting around some in-stream obstructions, resulting in channel bank erosion. Historic stabilization measures, including placement of riprap armor, gabion baskets, and vegetated mats have either failed or are in poor condition. Several areas of the ravine channel's beds and banks have exposed clay, indicating little to no further erosion is anticipated. Sediment bars have developed where ravine slope flattens out and/or in the vicinity of woody obstructions.

Storm outfalls were observed at the crest, middle and toe of steep ravine slopes, and are generally stable or no longer functional. An enclosed elevated pipe system exists in both the Au Sable and Copeland Robinson ravines and conveys stormwater from the campus floor to the toe of steep slopes. Pipes are supported on wooden braces and range in size from 12" to 24". Pipes originate at the campus floor and extend 300-500 lineal feet, or to where ravine grade begins to flatten out. Fewer impairments and greater stability of the ravines were observed in areas where enclosed pipe systems exist. Concerns with the Au Sable pipe system include site specific areas of rusting/deteriorating pipe, broken braces, and trees on top of pipe. One broken brace was noted in the Copeland Robinson pipe system.

Copeland Robinson Pipe System

Outfall of Au Sable pipe system at toe of ravine

Tree and broken brace – Au Sable

Deteriorating pipe – Au Sable

10.4.2 Impairments and Observations Unique to Individual Ravines

10.4.2.1 Au Sable Ravine

Localized erosion, slumping, and fracturing of the steep ravine slopes east of and approximately 10-25 feet from the Seidman House was observed. A 12" clay tile discharges on the face of the slope and is contributing to slope instability. Geotechnical report notes the steep slopes are not likely to have a massive failure; however, erosion will continue to intensify based on soil composition. Previously placed riprap is not adequately protecting slopes. Left unchecked, structural integrity of Seidman House could occur. Au Sable Ravine receives stormwater from high priority drainage areas.

10.4.2.2 Calder Ravine

Historic stabilization measures in the upper reach of the ravine near O-25 outfall have failed. Significant erosion and instability exist primarily in the upper reach of the ravine where steepest grades carry stormwater from the campus floor. An approximate 10-foot drop was also observed in one location. Geotechnical report indicates erosion and downcutting will continue and intensify, although catastrophic slope failure is not anticipated. The lower reach of the ravine is stabilized with gabion baskets that aid in providing grade control. Flow is being diverted around the baskets in site-specific areas but is not problematic. The lower reach of the ravine is more stable given flatter grade. Calder Ravine conveys stormwater from high and medium priority drainage areas.

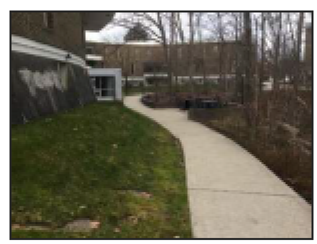
10.4.2.3 GVA Ravine

A failed 12-inch diameter CMP has rusted and failed where stormwater discharges from O-27 to the open ravine. The 12-inch CMP discharges water into a concrete energy dissipation structure. Although installed with good intent, this structure does not provide adequate grade control and directs water to ravine side slopes. The dissipation structure is cracked and failing as well. Significant erosion, downcutting and numerous fallen trees were observed in the GVA ravine. Similar to other areas, geotechnical report notes no imminent threat to catastrophic failure of the ravine or nearby structures. However, repair of the failing 12-inch CMP and adequate grade control measures are needed to ensure long-term stability in this area. GVA Ravine receives water from a medium priority drainage area.

10.4.2.4 Ravine Apartments Ravine

Evidence of extensive historic erosion, channel downcutting and undercutting of trees was observed throughout the east branch of the ravine. Channel bank height averages 15-25 feet. Banks are vertical and generally lack vegetative cover. Mature trees on top of banks are severely undercut, as evidenced by exposed root systems, and situated within very close proximity to edge of channel bank. Weight of these heavy trees places stress on top of the fragile channel banks which may result in their dislodgement into the main channel. Several log jams and woody obstructions were noted in the upper reach of the east branch. Channel has down-cut to clay throughout most of the area. A stormwater detention basin and underground detention discharges to the ravine's west branch. The west branch also has constructed grade control features (rock check dams). The west branch has significantly less erosion and undercutting of trees due to controlled discharge from the detention basin and grade control structures. The northern (lower end) of the ravine is most stable due to presence of wetland/floodplain area. Historic stabilization measures at outfalls appear to remain intact. This ravine receives stormwater from high and medium priority drainage watersheds.

10.4.2.5 Copeland Robinson Ravine



Surface runoff has resulted in embankment erosion along on the backside of the sidewalk, resulting in sidewalk heaving at the top of the ravine. Due to the enclosed pipe system, few areas of active erosion exist in the ravine channels. There was some scour at the toe of enclosed pipe system, however. MTC's October 7, 2021, stability analysis indicates slopes are in a stable condition and do not present a threat to the living areas. Report also notes that embankment erosion will continue, should corrective measures not be implemented. Copeland Robinson ravine is situated in a medium priority drainage watershed.

10.4.2.6 Lot D Ravine

Overland runoff from sidewalks, Lot D parking area, and groundwater seepage have resulted in erosion and loss of vegetation on ravine side slopes. Several fallen trees were noted throughout this ravine. Lot D Ravine conveys stormwater from a medium priority drainage area.

10.4.2.7 Little Mac Ravine

A comprehensive restoration project was completed in 2017 to restore the Little Mac Ravine in an effort to, not only protect the ravine from further degradation, but protect buildings and infrastructure in close proximity to the ravine. Restoration efforts included reestablishing the historic channel bed and installing grade control structures. Inspection notes restoration work is performing as anticipated and is stable. No erosion or dislodgement of stone within the channel bed or in-stream structures were observed. The project should be considered a complete success. It should be noted, however, a comprehensive restoration project, such as this, may not be practicable for other ravine areas. Little Mac is in a high priority drainage area.

10.5 Jacobs Drain and Unnamed Tributary – Golf Course

Jacobs Drain (Drain) is a designated county drain, under the jurisdiction of the Ottawa County Water Resource Commissioner. The Drain parallels 48th Avenue and outlets into an unnamed tributary on the north end of the Meadows Golf Course. This tributary also receives stormwater from the south and north stormwater management areas and ultimately discharges north into Ottawa Creek. Inspection notes the Drain is in fair condition; however, channel instability, as evidenced by erosion, mid-channel bars, and fallen trees, exists throughout majority of the unnamed tributary. Notably, erosion of golf cart bridge footings is occurring on the most northern crossing. Integrity of this channel is paramount to providing a stable outlet for the stormwater management complexes.

10.6 Existing Stormwater BMP Analysis

Visual inspection of existing stormwater BMPs was conducted in December 2020 to evaluate function, structural integrity, and identify corrective measures that may be necessary. The inspected BMPs include rain gardens, vegetated swales, wetland complexes, detention basins, and remaining areas of porous pavement. Underground detention, oil/water separators, porous pavement, and green roofs were not inspected due to inaccessibility.

The majority of the rain gardens, bioswales, and other vegetated BMPs are located on the southern portion of campus as well as around the Kelly Family Sports Center. The most common issue among the inspected vegetated BMPs was poor vegetation management. In many of the inspected rain gardens, the installed vegetation had been removed entirely. Vegetation in rain gardens, bioswales, and other similar BMPs should receive biannual maintenance in the fall and early spring. Fall maintenance should consist of weeding and the renewal of the mulch layer as necessary, to prepare the beds for winter. Vegetation should be allowed to remain over winter to provide resources and habitat for wildlife as well as to prevent erosion of the BMP bed. In the early spring maintenance should consist of weeding and cutting dead vegetation back to a height of three to six inches to allow for new growth.

Almost all of the permeable pavements that were included on GVSU's original MS4 permit have since been removed, except for the permeable pavements at the interior courtyard of Mackinac Hall. In addition, many of the rain gardens and other vegetated BMPs that had been included on GVSU's MS4 permit, have been removed or converted to grass swales. The removal of stormwater BMPs should be avoided whenever possible, however, when it is necessary to remove a BMP, compensation should be made elsewhere in the system in order to avoid adverse impacts such as increased runoff.

Additional areas that needed maintenance include the detention basins serving Lots B and D. These detention basins have been allowed to become overgrown with vegetation, which reduces the capacity of the basin. The outlet structure for the Lot D basin is in good condition; however, the emergency overflow channel for the basin at Lot B is in poor condition and has been undermined and eroded. Corrective maintenance is needed at both basins to remove overgrown vegetation and restabilize or repair the outlet control structures, as necessary.

10.7 Undeveloped Parcels – North of M45

Field verification of GVSU owned parcels (178 AC total) north of M45 was conducted in December 2020 to assess natural features, development potential, and identify potential stormwater management options for the area, should future development occur. Several regulated features, including wetlands, floodplain, and streams were observed during the inspection, Figure 16. Non-regulated features noted include steep slopes and ravines. Given location and size of regulated features and steep slopes, approximately 59 of the 178 AC can be considered for development.

11.0 Recommendations and Implementation

Addressing known impairments in a timely manner will protect and restore natural resources and campus infrastructure to the greatest extent possible. A proactive approach to stabilize and care for the ravines and protect infrastructure adversely impacted by stormwater is needed to assist GVSU to plan for and implement improvement measures. Implementing automated inspection, tracking and maintenance requests of stormwater BMPs will ensure their integrity and function. Drainage areas with no or few stormwater BMPs should be given priority consideration for their design and installation. Opportunities to divert stormwater to the western detention areas should continue to be evaluated and pursued where practicable. Implementing and maintaining green infrastructure to the greatest extent possible (bioretention, green roofs, pervious pavement, etc.) will work to effectively reduce peak flows in areas where underground detention or routing stormwater to western stormwater management complexes is not practicable. Proper maintenance techniques must be utilized to ensure design intent and function is maintained for vegetative BMPs.

At a minimum, ravines should be inspected every two years to identify areas of significant erosion, fractures, and slumps. Inspection should also evaluate fallen trees and obstructions to ensure that flows are not being redirected and causing erosion of side slopes. Removal of obstructions should be carefully considered to not disturb grade control that the woody material may be providing. Inspection of overland pipes should occur routinely as well to ensure braces are intact and trees have not fallen on top of pipes. Vegetative native buffers and deep-rooted vegetation at ravine crest will also aid in slope stability. Continued installation of upland BMPs and redirecting stormwater from ravines will remain the most effective means to protect the ravines.

It should be noted that comprehensive restoration of ravines is not strongly recommended, given large amounts of stormwater have been directed away from ravines, natural processes have work to stabilize ravines, and there are no threats to buildings or infrastructure. In addition, restoration of the ravines will be a costly endeavor with potential low cost-benefit. Based on existing conditions, Ravine Apartment Ravine would likely be the only ravine to consider for a comprehensive restoration project.

As previously noted, digitizing stormwater BMP infrastructure was desired as an outcome of the project. Recommendations for developing the GIS database and integrating data with the existing work order system is desired and recommended to allow for efficiency in maintenance tracking, inspection, and reporting.

Summary of recommendations for improvements include:

- Re-establishing existing stormwater BMPs that have been removed or altered.
- Instructing grounds crew on proper maintenance techniques for vegetative BMPs.
- Regular maintenance and inspection of existing stormwater BMPs.
- Routing stormwater to the toe of ravine slopes.
- Inspecting ravines every two years.
- Repairing failed infrastructure.
- Removing channel obstructions to maintain stormwater conveyance.
- Redirecting surface runoff to catch basins.
- Installing BMPs in high priority drainage areas.
- Inspecting and maintaining all stormwater BMPs, including overland pipes in ravines.
- Stormwater management planning for undeveloped areas.
- Redirecting stormwater to western stormwater management complex where feasible.
- Developing a stormwater GIS database and integrating with current work order system.

Recommendations were broken out into three categories: 1) new project, 2) maintenance and 3) future. New projects are those projects that have cost estimates exceeding $50,000, require significant design, and should be included in GVSU Capital Improvement Plan. Conversely, recommendations not meeting that criterion are considered maintenance. Prioritizing and implementing recommendations for maintenance or a new project was based on the following:

- Drainage area priority.
- Potential for negative impacts to campus infrastructure, buildings, or natural resources.
- Potential for negative public health and safety impacts.
- Severity of stormwater system infrastructure degradation (i.e., broken over land pipe braces, failed inlet/outlet structures, etc.).
- Cost benefit.
- Implementation timeline for recommendations have been prioritized as high, medium, or low and are subject to change, at GVSU's discretion based on campus-wide input, available funding, and as new concerns arise; however, priority activities should generally be given consideration as follows:
  - High priority – 1-2 years
  - Medium priority – 3-10 years
  - Low priority – 15 years

New project (P), maintenance (M) and future (F) recommendations are briefly described below and shown in Figure 17. Some areas have both project and maintenance recommendations, based on extent and cost of work. Preliminary design plans for select project recommendations can be found in Appendix 4. Summary table of recommendations can be found in Appendix 5. Future projects are those areas where future development may occur, but details are not yet known or finalized. General stormwater management recommendations are provided for these areas and no preliminary design work has been prepared.

11.1 Unnamed Tributary on Golf Course (M&P)

Erosion and stream instability in the vicinity of the northern golf course crossing presents concern with bridge integrity and public health and safety. Fallen trees and stream instability may adversely impact stormwater conveyance from the south and north stormwater management complexes. Priority bridge stabilization measures include installation of Redi-Rock wall and realigning portions of the watercourse. These are shown on Figure C-101 in Appendix 4. Consideration for stream restoration throughout the 1,000 lineal foot channel, including removal of obstructions and creating stable pattern and profile, should be given to ensure long-term stability and continued conveyance for the stormwater management complexes. Preliminary design was not prepared for stream restoration, as it is **lower priority**. However, repair of the eroding bridge piers is a **high priority** recommendation. It is anticipated that repair of the bridge piers will be conducted in either 2023 or 2024.

11.2 Fieldhouse Arena and Lot C (P)

The eastern half of the Fieldhouse Arena and Lot C do not have adequate stormwater management. To address this deficiency, underground detention is strongly recommended, shown on Figure C-107 in Appendix 4. Preliminary design estimates a 76,000 cubic foot detention facility could be constructed, which would significantly reduce volume to the Ravine Apartment Ravines. This is a **medium priority** recommendation, as stormwater from the western half of the Fieldhouse was recently diverted to western detention areas.

11.3 Calder Ravine (P)

Active erosion and downcutting are occurring in the vicinity of storm outfall O-25 and are anticipated to accelerate if left unchecked. Historic stabilization measures (riprap) have reached end of life cycle. Recommendations include piping stormwater to the toe of the ravine via a series of catch basins and storm sewer, shown on Figure C-102 in Appendix 4. Proposed work activities are a **medium priority**, as no threats to infrastructure exists.

11.4 Au Sable Ravine and Seidman House (M & P)

Preliminary design concepts were developed to address erosion and slope failures by Seidman House, which is a **high priority**. Design concepts, shown on Figure C-104 in Appendix 4, were further refined and constructed summer 2022, outside auspices of this grant. Two additional recommendations to improve stormwater management in the Seidman House and Lake Huron building area include construction of underground detention areas. Alternative 1 considers 2,200 cubic feet of underground detention for Seidman House and the adjacent lawn area. An additional 3,600 cubic feet of underground detention could be achieved for the area located between Lake Huron Hall and Seidman House, Alternative 2. Consideration of underground detention in this area is recommended as very few stormwater BMPs exists in this area and this practice will provide the most protection for long-term stability of the Au Sable Ravine. Considerations for underground detention are a **medium priority**. The deteriorating pipe and broken pipe brace for the overland pipe in the Au Sable Ravine should be repaired and is a **high priority**.

11.5 GVA Ravine (P)

Storm outfall is compromised, and insufficient energy dissipation has resulted in erosion and scour of ravine channel banks and bed. Recommendations include replacing the failed 12" CMP and removing the existing concrete dissipation structure. Design concepts include creating an approximate 150 lineal foot cascading rock channel with grade controls, similar to the Little Mac Ravine concept, shown on Figure C-103 in Appendix 4. This is a **high priority** project given poor condition of the 12" CMP and failing concrete dissipation structure. It is anticipated that this design concept will be further refined and implemented during the 2023 or 2024 calendar year.

Consideration for implementing bio-retention in this area were determined not cost-effective. Relatively small, isolated pockets for bio-retention exist, and would only provide minimal improvements. Construction costs would be significantly higher than benefit, given large areas of impervious surface in this drainage area and limited ability to construct bio-retention.

It is also recommended that underground detention be implemented when, and if, buildings are razed and reconstructed. Installing underground detention prior to site redevelopment would not be practical or cost-effective.

11.6 Copeland Robinson Ravine (M)

Recommendations include repair of broken overland pipe braces, and repair of upheaved sections of sidewalk, construction of straight edge curb along sidewalk to prevent surface runoff to ravine slopes, Figure C-105. Design concepts, shown on Figure C-105 in Appendix 4, were further refined and constructed summer 2022, outside auspices of this grant. (It should be noted that brace repair is not shown on Figure C-105). Shade-tolerant vegetation is recommended to stabilize soil on ravine side slopes. It is anticipated that additional stormwater management BMPs will be incorporated as building razing and reconstruction in this area is refined. Recommendations are a high priority given support for overland pipe and sidewalk stability cannot be compromised.

11.7 Ravine Apartment Ravine (M&P)

Recommendations for the east branch include selective tree removal to reduce weight on top of steep eroding banks and open cut of woody obstructions in the channel to ensure uninterrupted conveyance. (The open cut method will allow flows to be centralized without adversely impacting the grade control that the woody obstructions are providing). Additionally, a comprehensive (approximately 1,200 lineal feet) restoration project *could* be considered for this area to address historic erosion and downcutting. Stabilization measures would be similar to those employed on the Little Mac Ravine. However, a stream restoration project will be a costly endeavor and cost-benefit is likely low. No survey or detailed preliminary designs were prepared for these recommendations, given priority. These are **low priority** recommendations as no threats to infrastructure exist. No work is recommended for the west branch of the ravine, given previously installed grade control structures are stable and discharge is regulated through the stormwater detention basin and underground detention area.

Corrective maintenance is required to remove overgrown vegetation and repair the outlet control structure and overflow channel at the Lot B detention basin which discharges into the west branch of the Ravine Apartments Ravine. This is a **medium priority** recommendation as the benefit to cost ratio is high.

11.8 Lot D Ravine (M&P)

Surface runoff is adversely impacting ravine slope stability in several areas. Recommendations include drop structure and overland piping of stormwater to ravine toe to reduce erosion. French drains are proposed along edge of Lot D parking area to intercept and manage surface runoff. See preliminary design Figure C-108 in Appendix 4. This is a **low priority** area but should be monitored to determine if conditions worsen.

In addition, corrective maintenance is required to remove overgrown vegetation at the detention basin at the eastern edge of Lot D. Overgrown vegetation reduces the capacity of the basin and increases discharge during large storm events. This is considered a **medium priority** recommendation as the benefit to cost ratio is high.

11.9 Maple, Pine, Oak Dormitories (M)

Slope grading, underdrains, catch basins, and shade-tolerant vegetation are recommended to address site-specific areas of erosion under existing boardwalks and ponding of water near ingress/egress areas and next to buildings. See Figure C-106 in Appendix 4. This is a **high priority** recommendation given ponding of water near building structures. It is anticipated that this design concept will be further refined and implemented during the 2023 or 2024 calendar year.

11.10 Holton Hooker Dormitory (M)

Surface runoff is causing erosion on ravine side slope and installation of concrete curbing is recommended to redirect water to catch basins. This is a **low priority** area and detailed preliminary design plans were not prepared for this site.

11.11 Zumberge Pond (M)

Maintenance recommendation at Zumberge Pond include repair of pond edge. This is a **medium priority** recommendation since the benefit to cost ratio is high. Adjustment of the outlet control structure and the establishment of native plantings to improve aesthetics at a range of water surface elevations are possible improvements. These aesthetic improvements are a **low priority** and detailed plans were not prepared. It is anticipated design concepts will be prepared and implemented during the 2023 or 2024 calendar year.

11.12 South Stormwater Management Area (M)

Gravel drive between the upper and lower cells has eroded and new gravel should be installed to raise the vehicular maintenance access path. Vegetation in the downstream receiving channel should be cut back to a height of six inches each spring in order to maintain the appropriate hydraulic capacity. This is a **medium priority**. Dredging of the cells of the stormwater management complex should be scheduled once every fifteen years. The next scheduled dredging is in 2026.

11.13 North Stormwater Management Area (M)

The outlet control structures in the upper and middle cells of the north stormwater management complex have settled or subsided leading to significant deviations from the design water surface elevation. This reduces the capacity of the basins, exposes or inundates different areas of the banks, and could lead to total failure of the outlet structures if left unresolved. Resetting the outlet structures and preventing future subsidence is a **high priority**. It is anticipated that this design concept will be further refined and implemented during the 2023 or 2024 calendar year. Dredging of the cells of the stormwater management complex should be scheduled once every fifteen years. The next scheduled dredging is in 2026.

11.14 Existing Vegetated BMPs (M)

Regular maintenance should take place for the existing vegetated BMPs located primarily around the residential areas on the south side of campus. Maintenance should take place biannually in the fall and in early spring. Fall maintenance should include the placement of new mulch as necessary and the removal of weeds and dying or diseased vegetation. Healthy growth should not be cut back in the fall and should be allowed to remain over winter. In the early spring, vegetation should be cut back to just above ground level to allow for new growth and weeding of invasive weeds should take place. This is an ongoing maintenance priority.

11.15 Meadows Maintenance (P)

Uncontrolled stormwater runoff from parking/drive areas, and in the vicinity of the fueling station, is of concern as untreated stormwater is being discharged to downstream areas. Installation of a concrete containment pad, curb and environmental catch basin will provide needed protection from inadvertent leaks or spills around the fueling station. A hydrodynamic separator is also recommended for this site to remove sediment and pollutants prior to discharge to open channel areas. This work is a **high** priority and should be implemented concurrent with proposed parking and driveway paving. Preliminary design is shown in Sheet C-110. It is anticipated that this design concept will be further refined and implemented during the 2023 or 2024 calendar year.

11.16 Irwin Parking, Football Field, Tennis Court (F)

Consistent with Fishbeck's memo dated April 5, 2018, increasing pipe size and additional stormwater management structures will be necessary for any future development in these areas. No further preliminary design of this area was completed, given its very low priority.

11.17 Undeveloped Parcels North of M-45 (F)

As noted previously, 179 AC of undeveloped land is owned by GVSU north of M-45 of which 54 AC is considered developable. A conceptual stormwater management plan was developed to aid in future planning and design of the area, Figure C-109. Recommendations include establishing a 50-foot buffer from top of ravine slopes to ensure no adverse impacts and designing the stormwater management system to accommodate a 25-year 24-hour storm, using low-impact development and green infrastructure. If retention cannot be achieved, design should include extended detention with staged releases at a rate no greater than 0.13 cubic feet per second/acre (CFS/AC). Conceptual design results in 725,000 cubic feet (CFT) and 350,000 CFT of retention and detention, respectively. Use of constructed wetlands, rain gardens, and bioswales is suggested to mimic existing natural features while aiding in stormwater management.

11.18 GIS Database and Work Order System Integration

Developing GIS is crucial for having accurate location information for routine and preventative maintenance. A GIS database was created by converting existing stormwater utility data from CAD. Additionally, BMP locations were mapped with assistance from GVSU's facilities personnel. ArcGIS Online (AGOL) was deployed for web and mobile mapping capabilities. GVSU Facility staff have access to the mapping applications to aid in maintenance and completing work orders. Currently, GVSU uses TMA Systems for their computerized maintenance management system. Leveraging GVSU's existing workorder software, a GIS extension was purchased to allow the GIS data to be linked directly to the assets within TMA and their respective workorders and preventative maintenance tasks. Having the ability to link the GIS with TMA allows GVSU facilities personnel to accurately locate and inspect their stormwater assets in an integrated platform. Fishbeck developed maintenance schedules and procedures for stormwater assets within TMA. Workorders will be automatically generated based on their inspection schedule. In addition, TMA can generate annual reports and summaries of worked performed allowing GVSU to efficiently submit required records to the State. Moving forward it is recommended that GVSU maintains their GIS dataset by updating assets regularly to reflect changes on campus. Electronic data standards should be developed for contractors to submit as-built records in a typical format for GVSU to update their GIS.

11.19 Public Education and Involvement

Practicable and meaningful ways to protect water quality and the Lower Grand River Watershed are primary goals of GVSU's PEP program. Message content and distribution methods (i.e., brochure, signage, website, etc.) have been carefully selected to ensure target audiences are reached to the maximum extent possible. As previously noted, MS4 communities participating in LGROW have developed a collaborative and regional PEP, which was approved by EGLE on July 8, 2020. The collaborative PEP allows MS4 communities to leverage resources, materials, and funding to publicize, promote, and facilitate education, creating citizen awareness and inspiring the public to reduce discharge of pollutants to stormwater to the greatest extent possible. It is recommended that GVSU continues participating in the PEP program and serving as a member of the LGROW, which is responsible for implementation of the PEP.

The PEP strategy is structured to ensure target audiences are reached and adequately convey messages for the following 11 topics areas, as required in the NPDES permit. GVMC staff and LGROW Public Engagement Committee (PEC) have develop key messages, conveyance strategies, target audiences, and evaluations measures for each category listed below:

1. Promote public responsibility and stewardship in the applicant's watershed.
2. Inform and educate the public about the connection of the MS4 to area waterbodies and the potential impacts discharges could have on surface waters of the state.
3. Educate the public on illicit discharges and promote public reporting of illicit discharges and improper disposal of materials into the MS4.
4. Promote preferred cleaning materials and procedures for car, pavement, and power washing.
5. Inform and educate the public on proper application and disposal of pesticides, herbicides, and fertilizers.
6. Promote proper disposal practices for grass clippings, leaf litter, and animal wastes that may enter the MS4.
7. Identify and promote the availability, location, and requirements of facilitates for collection or disposal of household hazardous waste, travel trailer sanitary wastes, chemicals, yard wastes, and motor vehicle fluids.
8. Inform and educate the public on proper septic system care and maintenance, and how to recognize system failure.
9. Educate the public on, and promote the benefits of, green infrastructure and Low Impact Development.
10. Promote methods for managing riparian lands to protect water quality.
11. Identify and educate commercial, industrial, and institutional entities likely to contribute pollutants to stormwater runoff.

PEP implementation is closely coordinated with the Information and Education strategy of the *Lower Grand River Watershed Management Plan* (2011) to further leverage resources, promote reduction of nonpoint source pollution, and ensure consistent messages are conveyed throughout the LGRW. PEP initiatives, documents, and relative information are provided on LGROW's website to share information with the public. Social media, such as Twitter and Facebook, are also used to communicate and share information.

11.20 Operation and Maintenance Plan

The Good Housekeeping and Pollution Prevention Program Manual (GHM), which is part of the MS4 permit, serves as the guide for inspecting and maintaining stormwater facilities within the campus. Procedures for inspecting and maintaining both structural and operational BMPs are provided in the GHM, and it is recommended GVSU continue with current maintenance practices. Structural BMPs are constructed to protect, convey, treat, control or infiltrate stormwater, including but not limited to rain gardens, vegetative swales, bio retention, detention ponds, porous pavement, and underground storage. Activities that have the potential to impact stormwater quality, such as cutting lawns or cold weather operations, are considered an operational BMP.

The following initiatives are in place for structural BMPs and should continue:

- **Catch basins**: free from trash, debris, vegetation, sediment, and sound structural integrity.
- **Vegetative (swales, raingardens, etc.)**: proper protocol for weeding, invasives, trimming, and mowing.
- **Constructed wetlands and detention basins**: removing sediment, trash, and debris; maintaining outlet integrity; maintaining appropriate vegetation; banks free from rodent holes/damage; side slope stability; periodic dredging.
- **Porous pavement**: vacuuming lots; removing blockages to underdrains and repairing damaged surfaces.
- **Underground storage**: free from sediment, contaminants, and pollution.
- **Infiltration basins**: removing sediment; managing vegetation; underdrain integrity.

The following initiatives are in place for operational BMPs and should continue:

- **Sweeping**: streets, parking lots, sidewalks, and bridges.
- **Pavement repair and maintenance**: proper protocol for application, timing, and safety.
- **Vegetated properties**: proper protocol for mowing, trimming, irrigation, and weeding; pesticide and fertilizer storage, handling, and application.
- **Cold weather operations**: appropriate sand, salt and brine application and storage.

- **Fleet maintenance**: appropriate protocol for fueling, washing, and maintaining vehicles.
- **Waste**: ensuring trash receptacles are sound and have lids.
- **Spill and response**: polluting materials are kept away from drains and surface waters (storage and during work).
- **Employee training**: online stormwater training program for staff.

It is also recommended that the BMP inspection and maintenance schedules set forth in the MS4 Stormwater Management Plan continued to be followed. As such, all BMPs and their appropriate maintenance schedule have been included in the GIS/TMA database to create automated maintenance inspection tracking and reporting.

11.21 Regulatory Considerations

Work activities impacting streams, wetlands, floodplain, and other regulated resources will require permits pursuant to the Natural Resources and Environmental Protection Act, Act 451, 1994, including but not limited to Part 301 Inland Lakes and Streams, Part 303 Wetlands, and Part 31 Floodplains and Floodways. Noteworthy regulatory changes have recently been implemented for work activities impacting regulated waterbodies. Many of these changes have potential to increase project costs. As some of the recommended work in this plan involves work within wetlands and watercourses, it is strongly recommended that regulatory considerations are thoroughly understood early in project development, as costs and project timing can be significantly impacted. Early coordination with EGLE will aid in developing a plan that address concerns and meets regulatory requirements.

12.0 Cost and Funding

12.1 Costs

Table 5 depicts approximate capital cost estimates for recommendations. Cost estimates include engineering, permitting and construction. Estimates were prepared in December 2022 and reflect conditions at that time. It is recommended that estimates are confirmed and updated prior to bidding and construction, as costs are likely to increase. Priority ranking (H,M,L) and project designation, either maintenance (M) or project (P), are also included. Two high priority projects (highlighted in green) were constructed in 2022. Four priority projects (highlighted in yellow) are scheduled for construction in either 2023 or 2024. All final design and construction activities were or will be funded outside the auspices of the SWMP grant.

Table 5 – Cost Estimate

Site	Cost	Description	Priority	Project Designation
Unnamed Tributary to Golf Course	$100,000	Footbridge stabilization – Redi-Rock wall	H	M
	$300,000	Comprehensive stream restoration	L	P
Fieldhouse Arena and Lot C	$1.3 Million	Install underground detention	M	P
Calder Ravine (O-25)	$110,000	Install catch basins and pipe to toe of ravine	M	P
Au Sable Ravine and Seidman House	$37,500	Stabilize ravine slopes by Seidman House and repair deteriorating pipe and broken pipe brace	H	M
	$87,500	Alternate #1 – Underground detention	M	P
	$107,500	Alternate #2 – Underground detention	M	P
GVA Ravine	$100,000	Replace failed 12" CMP; install cascading rock channel with grade control	H	P

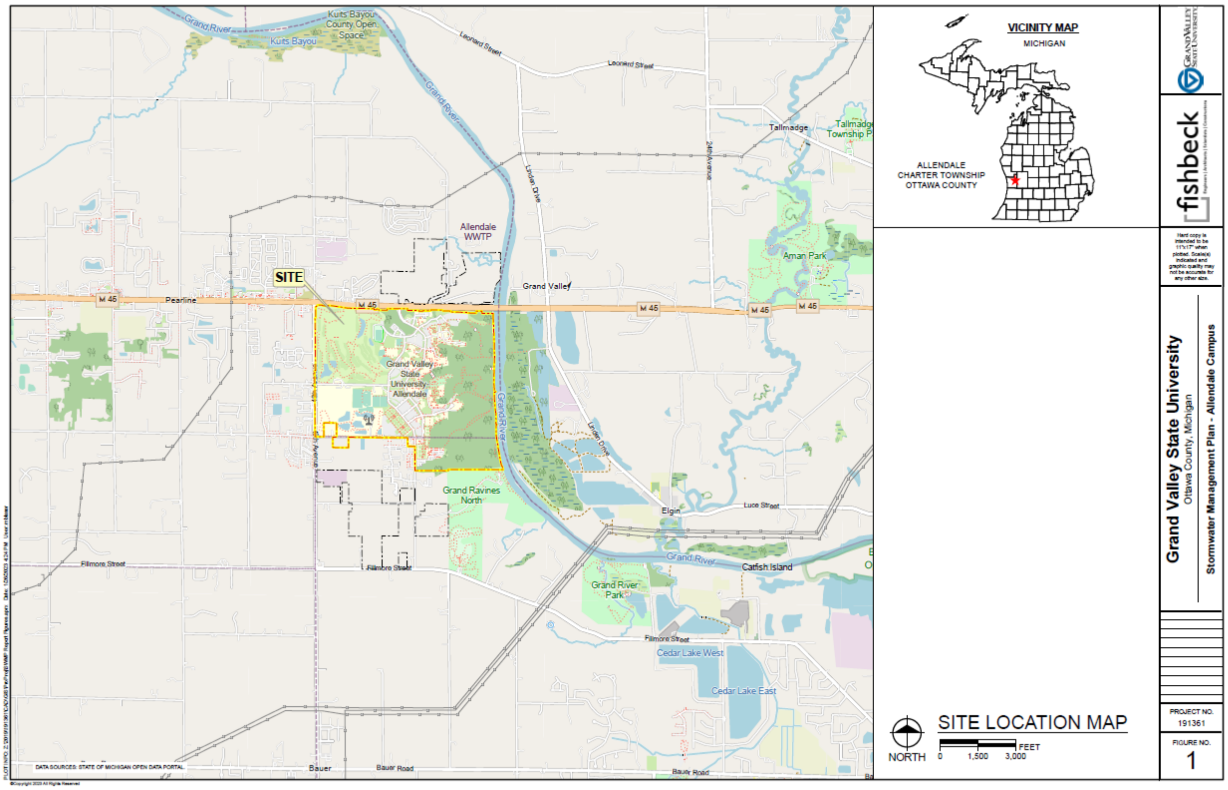
Table 5 – Cost Estimate

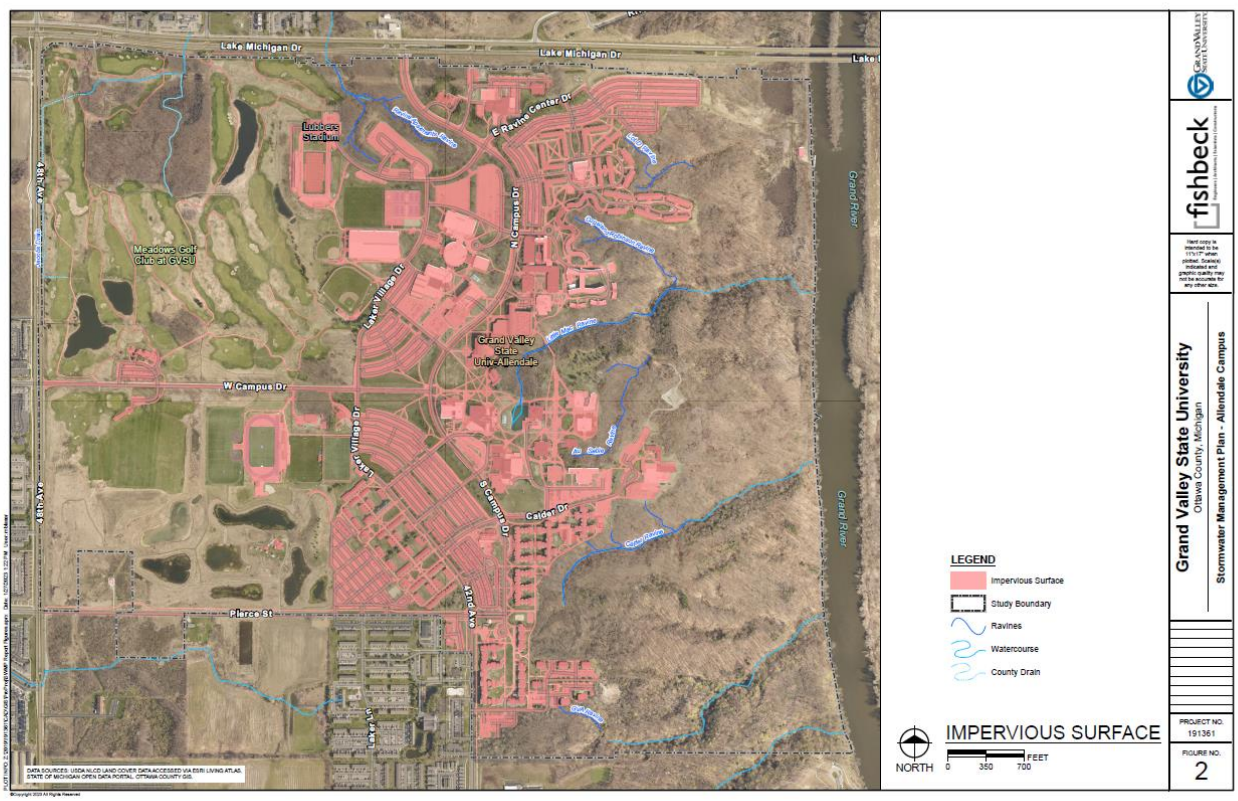
Site	Cost	Description	Priority	Project Designation
Copeland Robinson	$12,500	Repair failed sidewalk; concrete curbing; vegetative plantings; repair broken overland pipe brace	H	M
Ravine Apartment Ravine	$5,000	Selective tree and obstruction removals	L	M
	$400,000	Stream restoration	L	P
	$20,000	Remove overgrown vegetation and repair outlets in Lot B detention basin	M	M
Lot D Ravine	$110,000	Drop structures and pipe to toe of ravine; French drains to intercept parking lot runoff	L	P
	$20,000	Remove overgrown vegetation in Lot D detention basin	M	M
Maple, Pine, Oak Dormitories	$20,000	Grading, vegetative plantings and underdrains	H	M
Holton Hooker Dormitory	$25,000	Concrete curbing and vegetation	L	M
Zumberge Pond	$6,000	Repair pond edge	L	M
South Stormwater Management Area	$50,000	Cutting of vegetation in outlet channel, periodic dredging.	M	M
North Stormwater Management Area	$50,000	Repair of settled outlet control structures	H	M
Meadows Maintenance	$130,000	Install environmental catch basin; hydrodynamic separator; concrete pad	H	P

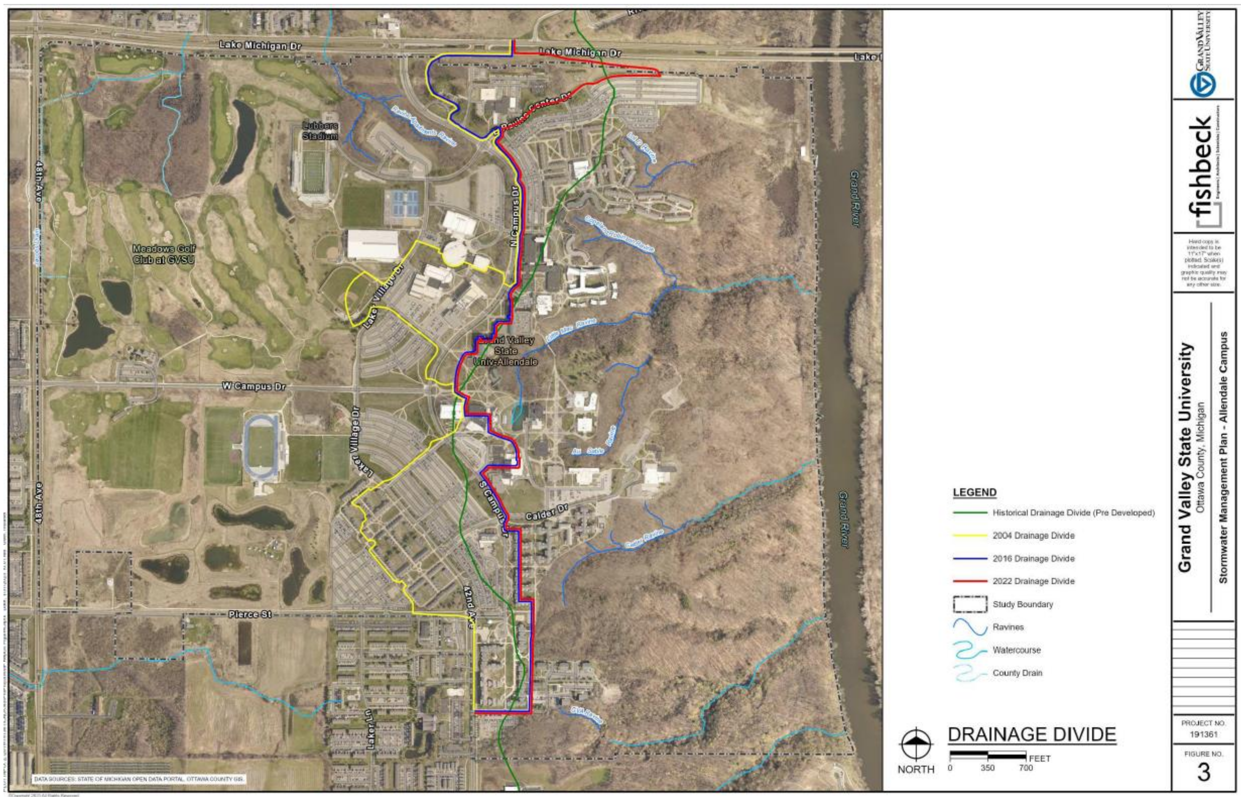
12.2 Funding

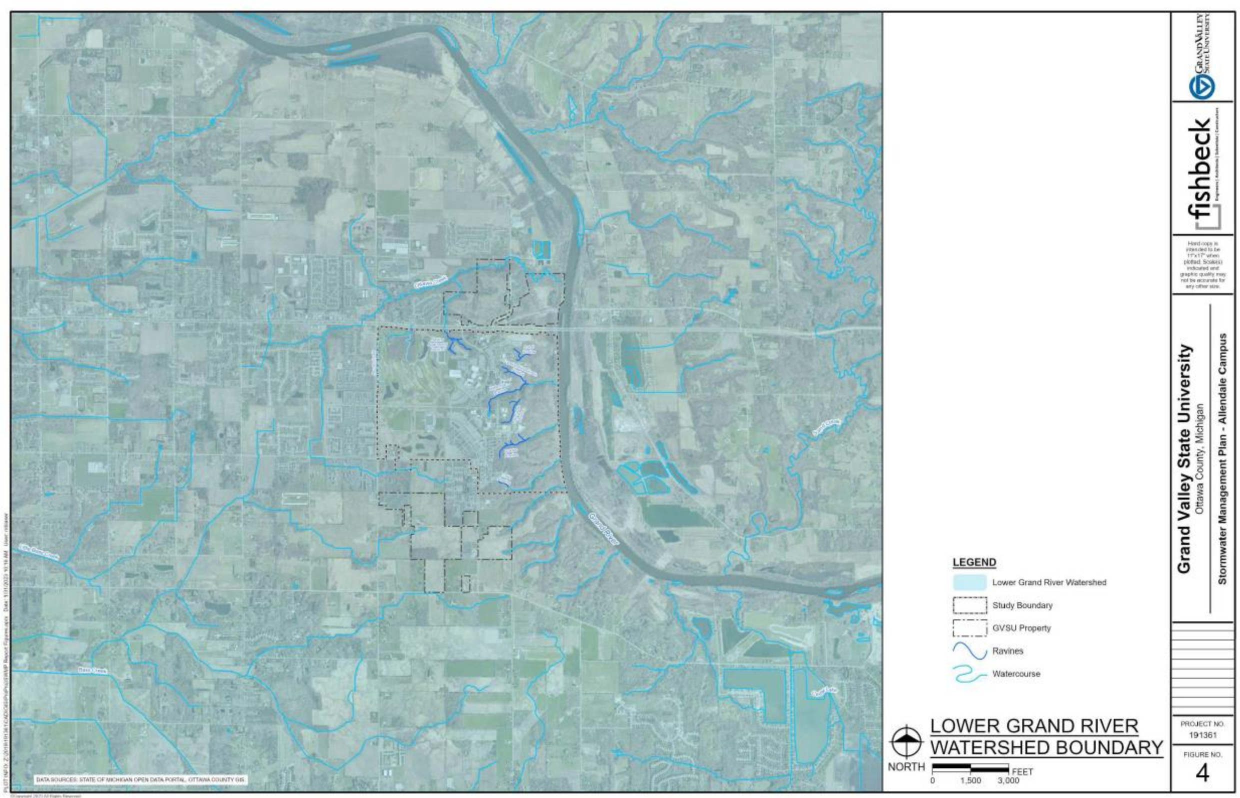
GVSU will be responsible for all costs associated with implementing storm water initiatives. However, grant opportunities, such as 319 or other storm water associated grants, will be explored to provide additional funding where applicable.

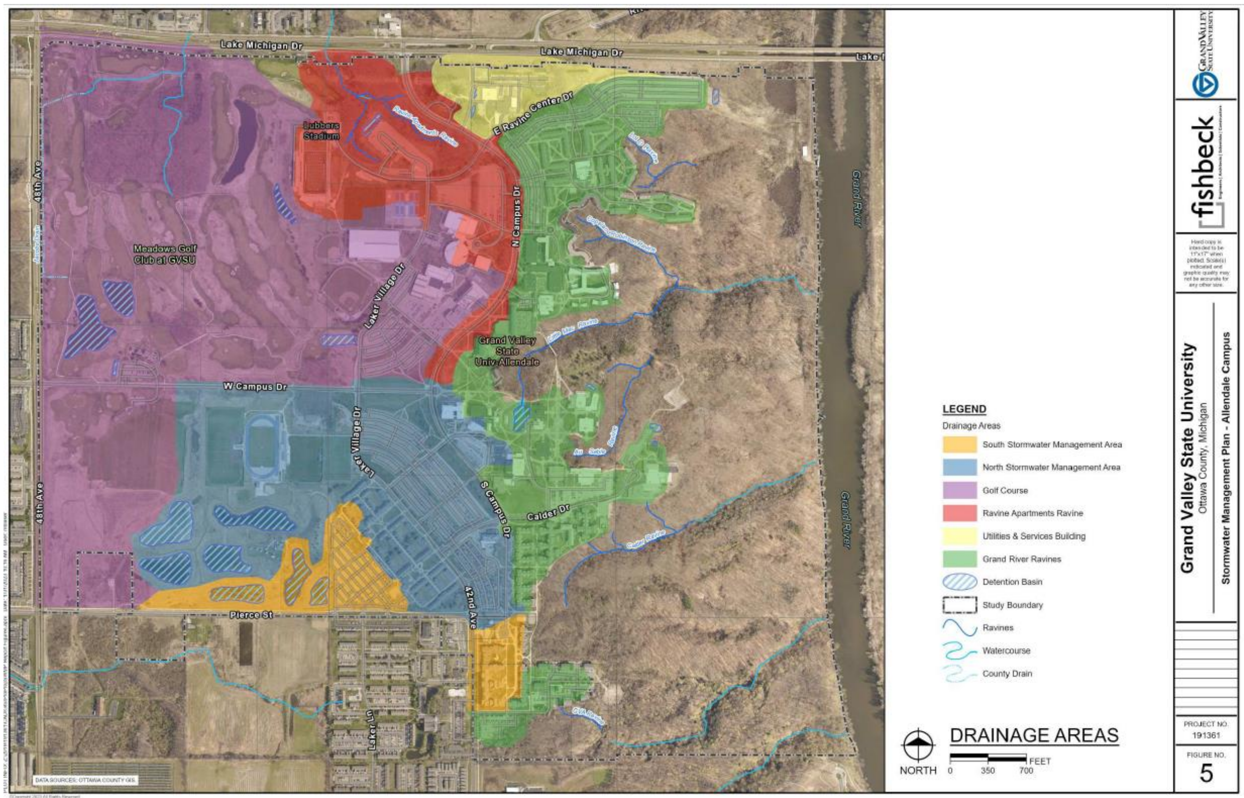
Figures

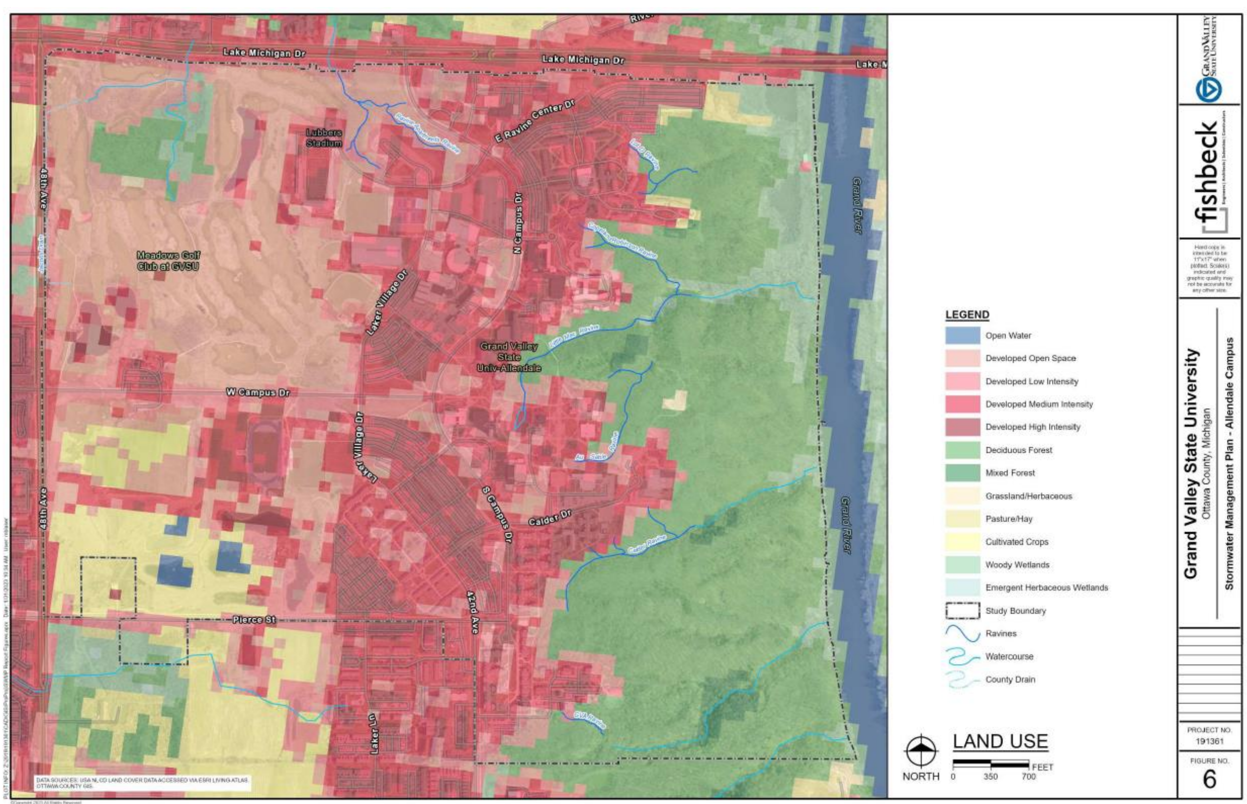

Grand River
Kuits Bayou County Open Space
Kuits Bayou
Leonard Street
Tallmadge
Aman Park
Allendale WWTP
SITE
M 45
Pearline
Grand Valley
Grand Valley State University Allendale
Grand Ravines North
Elgin
Luce Street
Catfish Island
Fillmore Street
Grand River Park
Cedar Lake West
Cedar Lake East
Bauer Road
DATA SOURCES: STATE OF MICHIGAN OPEN DATA PORTAL
VICINITY MAP
MICHIGAN
ALLENDALE CHARTER TOWNSHIP OTTAWA COUNTY
fishbeck
Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
SITE LOCATION MAP
NORTH
FEET
0 1,500 3,000
PROJECT NO. 191361
FIGURE NO. 1


Lake Michigan Dr
E Ravine Center Dr
Lubbers Stadium
N Campus Dr
Meadows Golf Club at GVSU
Laker Village Dr
Grand Valley State Univ-Allendale
W Campus Dr
48th Ave
S Campus Dr
Calder Dr
42nd Ave
Pierce St
Laker Ln
Grand River
DATA SOURCES: USDA NLCD LAND COVER DATA ACCESSED VIA ESRI LIVING ATLAS, STATE OF MICHIGAN OPEN DATA PORTAL, OTTAWA COUNTY GIS.
LEGEND
Impervious Surface
Study Boundary
Ravines
Watercourse
County Drain
fishbeck
Hard copy is intended to be 11"x17" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
IMPERVIOUS SURFACE
NORTH
FEET
0 350 700
PROJECT NO. 191361
FIGURE NO. 2


Lake Michigan Dr
Lubbers Stadium
Meadows Golf Club at GVSU
48th Ave
W Campus Dr
Lake Village Dr
N Campus Dr
S Campus Dr
Calder Dr
Pierce St
42nd Ave
Laker Ln
Grand Valley State Univ-Allendale
Grand River
LEGEND
Historical Drainage Divide (Pre Developed)
2004 Drainage Divide
2016 Drainage Divide
2022 Drainage Divide
Study Boundary
Ravines
Watercourse
County Drain
NORTH
DRAINAGE DIVIDE
FEET
0 350 700
DATA SOURCES: STATE OF MICHIGAN OPEN DATA PORTAL, OTTAWA COUNTY GIS
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
fishbeck
PROJECT NO.
191361
FIGURE NO.
3


LEGEND
Lower Grand River Watershed
Study Boundary
GVSU Property
Ravines
Watercourse
NORTH
LOWER GRAND RIVER WATERSHED BOUNDARY
FEET
0 1,500 3,000
DATA SOURCES: STATE OF MICHIGAN OPEN DATA PORTAL, OTTAWA COUNTY GIS
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
fishbeck
PROJECT NO.
191361
FIGURE NO.
4


Lake Michigan Dr
Lubbers Stadium
E Ravine Center Dr
N Campus Dr
Meadows Golf Club at GVSU
Laker Village Dr
Grand Valley State Univ Allendale
W Campus Dr
48th Ave
S Campus Dr
Calder Dr
42nd Ave
Pierce St
Laker Ln
Grand River
LEGEND
Drainage Areas
South Stormwater Management Area
North Stormwater Management Area
Golf Course
Ravine Apartments Ravine
Utilities & Services Building
Grand River Ravines
Detention Basin
Study Boundary
Ravines
Watercourse
County Drain
DRAINAGE AREAS
NORTH
0 350 700 FEET
DATA SOURCES: OTTAWA COUNTY GIS.
fishbeck
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
PROJECT NO. 191361
FIGURE NO. 5


Lake Michigan Dr
Lubbers Stadium
E Ravine Center Dr
N Campus Dr
Meadows Golf Club at GVSU
Laker Village Dr
Grand Valley State Univ Allendale
W Campus Dr
48th Ave
S Campus Dr
Calder Dr
42nd Ave
Pierce St
Laker Ln
Grand River
LEGEND
Open Water
Developed Open Space
Developed Low Intensity
Developed Medium Intensity
Developed High Intensity
Deciduous Forest
Mixed Forest
Grassland/Herbaceous
Pasture/Hay
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands
Study Boundary
Ravines
Watercourse
County Drain
LAND USE
NORTH
0 350 700 FEET
fishbeck
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
PROJECT NO. 191361
FIGURE NO. 6

DATA SOURCES: HISTORIC AERIAL PHOTO ACCESSED VIA USGS EARTH EXPLORER, 1947. STATE OF MICHIGAN OPEN DATA PORTAL LAND COVER CIRCA 1800.

LEGEND

Study Boundary

OTTAWA COUNTY, 1947

NORTH

PRE-SETTLEMENT CONDITIONS

0 350 700 FEET

Grand Valley State University
Ottawa County, Michigan

Stormwater Management Plan - Allendale Campus

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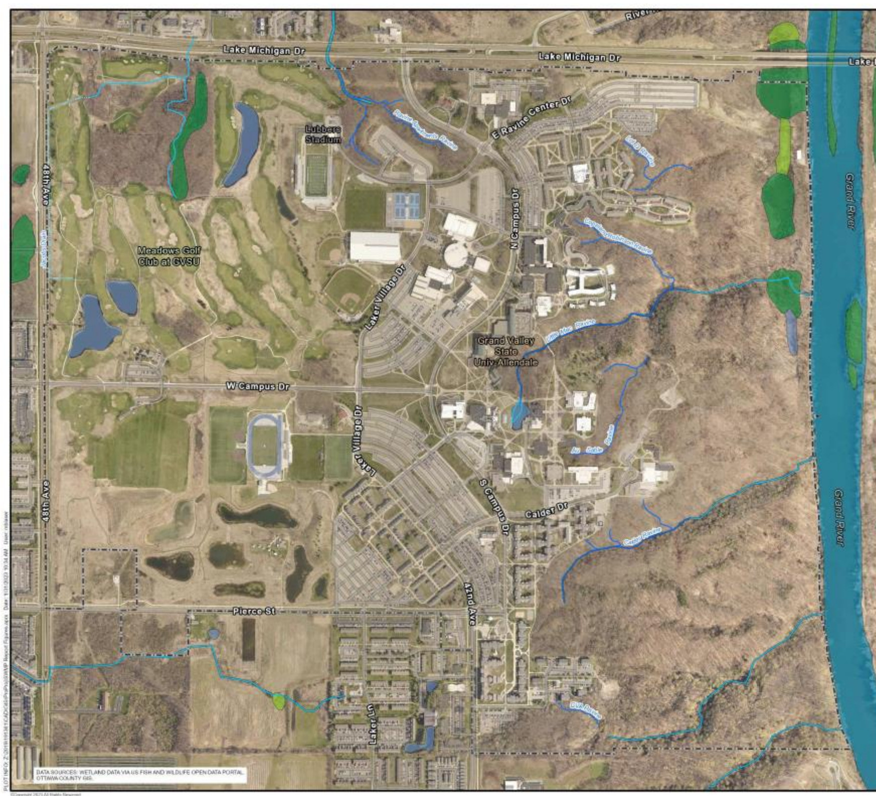
GRAND VALLEY STATE UNIVERSITY

PROJECT NO. 191361

FIGURE NO. 7



DATA SOURCES: WETLAND DATA VIA US FISH AND WILDLIFE OPEN DATA PORTAL, OTTAWA COUNTY GIS.

LEGEND

National Wetland Inventory

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine
- Study Boundary
- Ravines
- Watercourse
- County Drain

NORTH

WETLANDS

0 350 700 FEET

Grand Valley State University
Ottawa County, Michigan

Stormwater Management Plan - Allendale Campus

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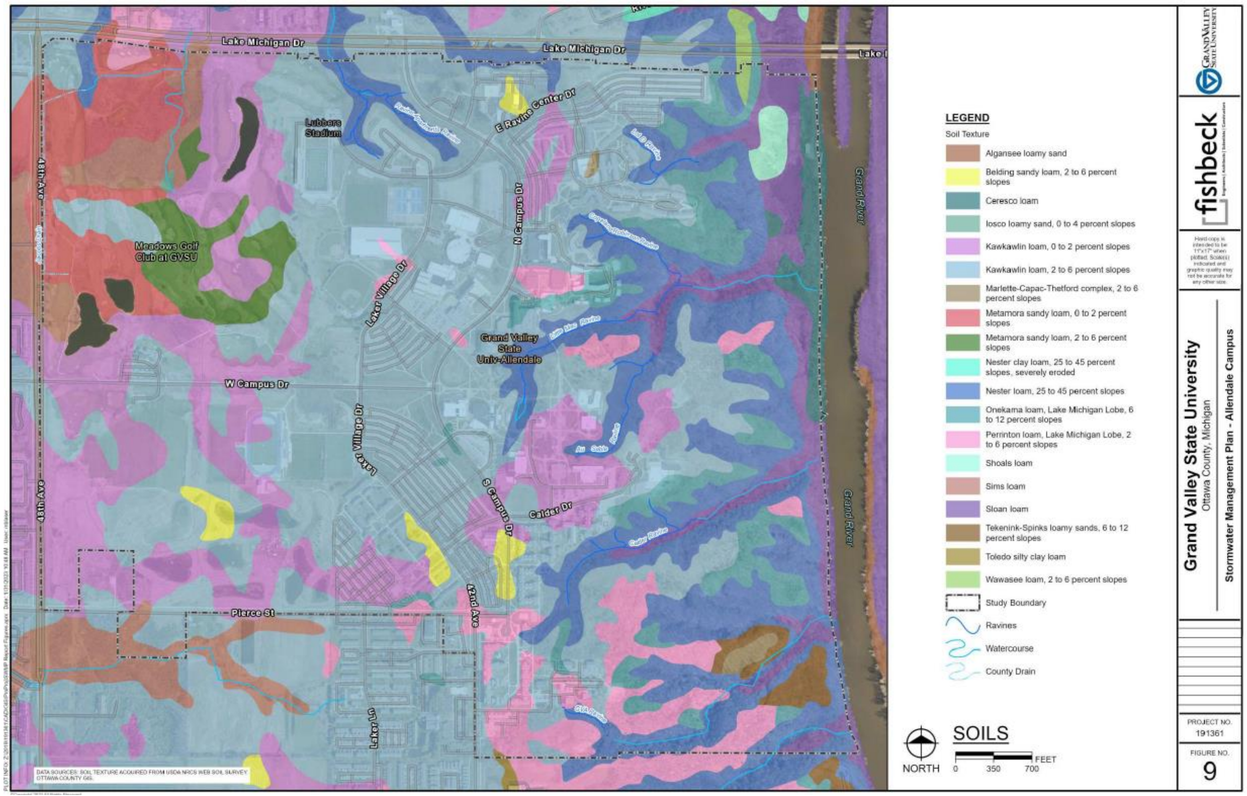
GRAND VALLEY STATE UNIVERSITY

PROJECT NO. 191361

FIGURE NO. 8



Lake Michigan Dr
Lubbers Stadium
E Ravine Center Dr
N Campus Dr
48th Ave
Meadows Golf Club at GVSU
Lake Village Dr
Grand Valley State Univ-Allendale
W Campus Dr
S Campus Dr
Calder Dr
42nd Ave
Pierce St
Laker Ln
Grand River
DATA SOURCES: SOIL TEXTURE ACQUIRED FROM USDA NRCS WEB SOIL SURVEY, OTTAWA COUNTY GIS.
LEGEND
Soil Texture
Algansee loamy sand
Belding sandy loam, 2 to 6 percent slopes
Ceresco loam
Iosco loamy sand, 0 to 4 percent slopes
Kawkawlin loam, 0 to 2 percent slopes
Kawkawlin loam, 2 to 6 percent slopes
Marlette-Capac-Thetford complex, 2 to 6 percent slopes
Metamora sandy loam, 0 to 2 percent slopes
Metamora sandy loam, 2 to 6 percent slopes
Nester clay loam, 25 to 45 percent slopes, severely eroded
Nester loam, 25 to 45 percent slopes
Onekama loam, Lake Michigan Lobe, 6 to 12 percent slopes
Perrinton loam, Lake Michigan Lobe, 2 to 6 percent slopes
Shoals loam
Sims loam
Sloan loam
Tekenink-Spinks loamy sands, 6 to 12 percent slopes
Toledo silty clay loam
Wawasee loam, 2 to 6 percent slopes
Study Boundary
Ravines
Watercourse
County Drain
NORTH
SOILS
0 350 700 FEET
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
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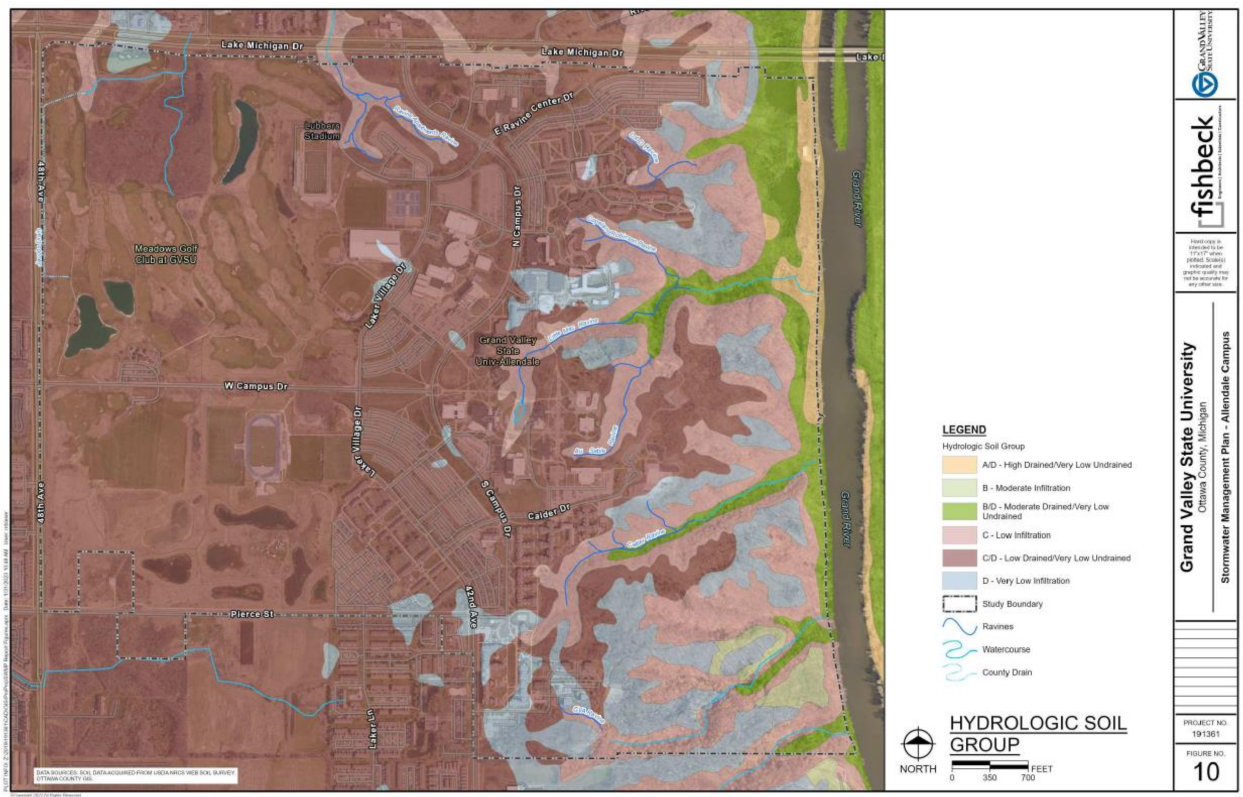
PROJECT NO.
191361
FIGURE NO.
9



Lake Michigan Dr
Lubbers Stadium
E Ravine Center Dr
N Campus Dr
48th Ave
Meadows Golf Club at GVSU
Lake Village Dr
Grand Valley State Univ-Allendale
W Campus Dr
S Campus Dr
Calder Dr
42nd Ave
Pierce St
Laker Ln
Grand River
DATA SOURCES: SOIL DATA ACQUIRED FROM USDA NRCS WEB SOIL SURVEY, OTTAWA COUNTY GIS.
LEGEND
Hydrologic Soil Group
A/D - High Drained/Very Low Undrained
B - Moderate Infiltration
B/D - Moderate Drained/Very Low Undrained
C - Low Infiltration
C/D - Low Drained/Very Low Undrained
D - Very Low Infiltration
Study Boundary
Ravines
Watercourse
County Drain
NORTH
HYDROLOGIC SOIL GROUP
0 350 700 FEET
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
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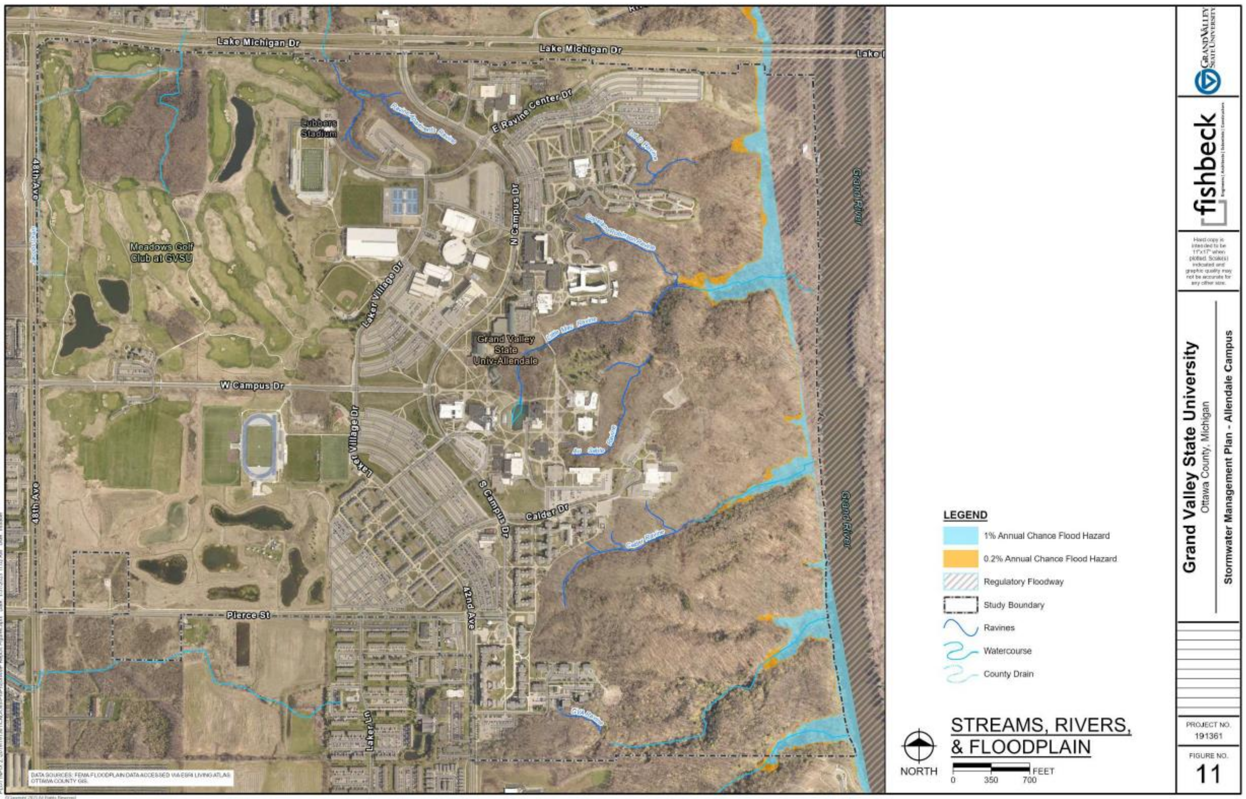
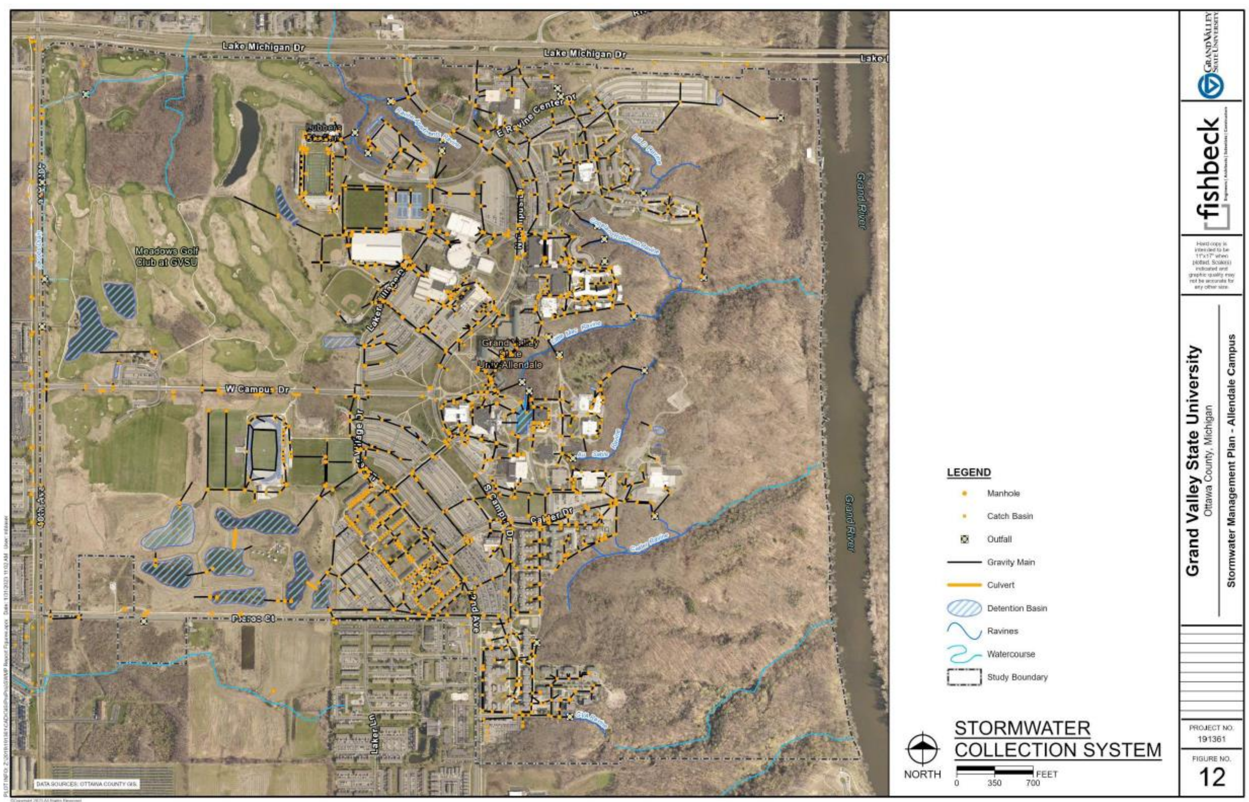
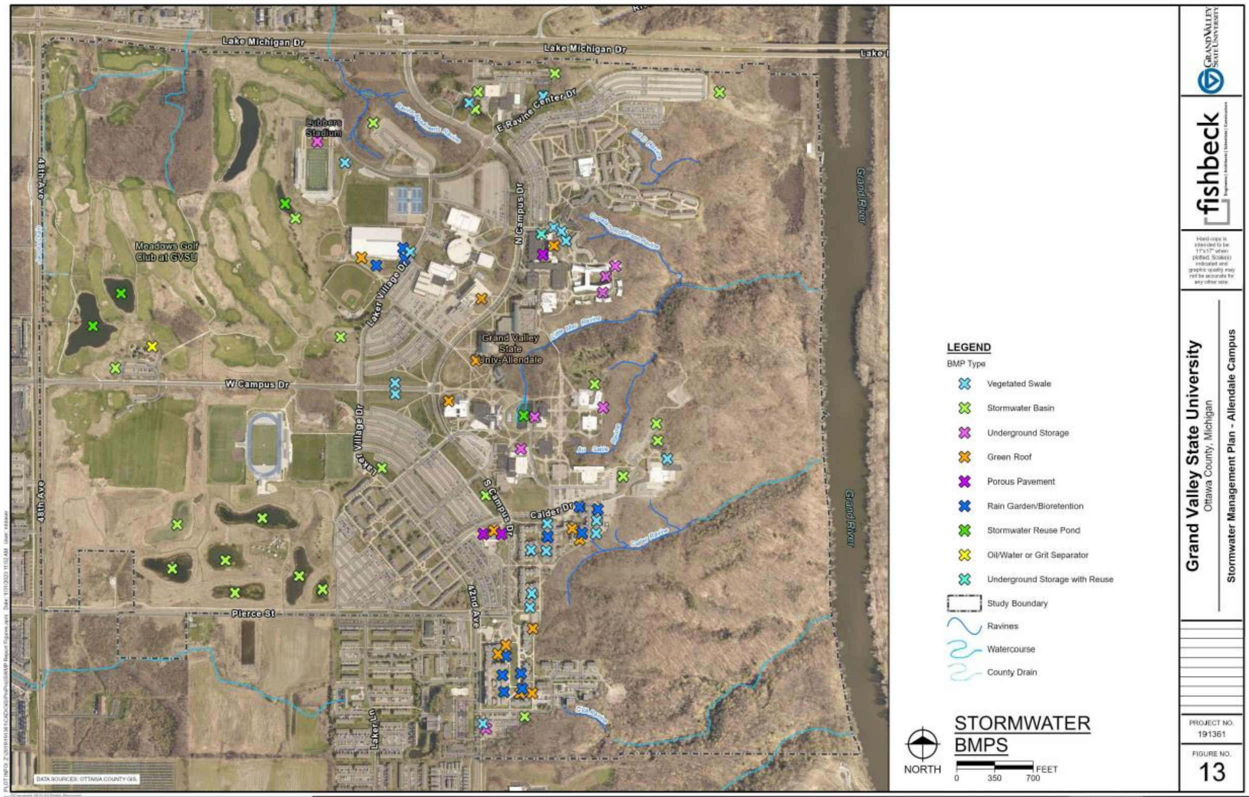
PROJECT NO.
191361
FIGURE NO.
10



STREAMS, RIVERS, & FLOODPLAIN



STORMWATER COLLECTION SYSTEM


Lake Michigan Dr
Lake Michigan Dr
48th Ave
Lubbers Stadium
E Ravine Center Dr
N Campus Dr
Meadows Golf Club at GVSU
Laker Village Dr
Grand Valley State Univ-Allendale
W Campus Dr
S Campus Dr
Calder Dr
42nd Ave
Pierce St
Grand River
LEGEND
BMP Type
Vegetated Swale
Stormwater Basin
Underground Storage
Green Roof
Porous Pavement
Rain Garden/Bioretention
Stormwater Reuse Pond
Oil/Water or Grit Separator
Underground Storage with Reuse
Study Boundary
Ravines
Watercourse
County Drain
NORTH
STORMWATER BMPS
FEET
0 350 700
DATA SOURCE(S): OTTAWA COUNTY GIS
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
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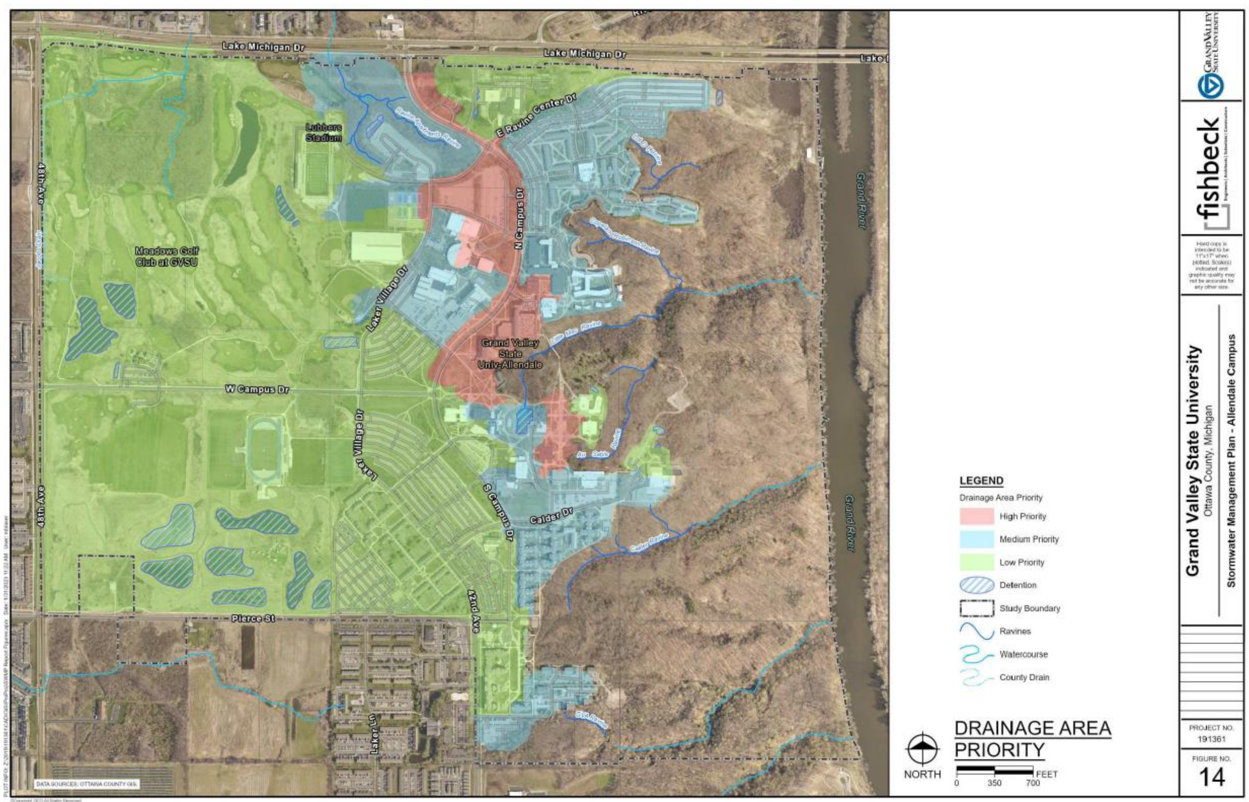
PROJECT NO. 191361
FIGURE NO. 13


Lake Michigan Dr
Lake Michigan Dr
48th Ave
Lubbers Stadium
E Ravine Center Dr
N Campus Dr
Meadows Golf Club at GVSU
Laker Village Dr
Grand Valley State Univ-Allendale
W Campus Dr
S Campus Dr
Calder Dr
42nd Ave
Pierce St
Grand River
LEGEND
Drainage Area Priority
High Priority
Medium Priority
Low Priority
Detention
Study Boundary
Ravines
Watercourse
County Drain
NORTH
DRAINAGE AREA PRIORITY
FEET
0 350 700
DATA SOURCE(S): OTTAWA COUNTY GIS
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
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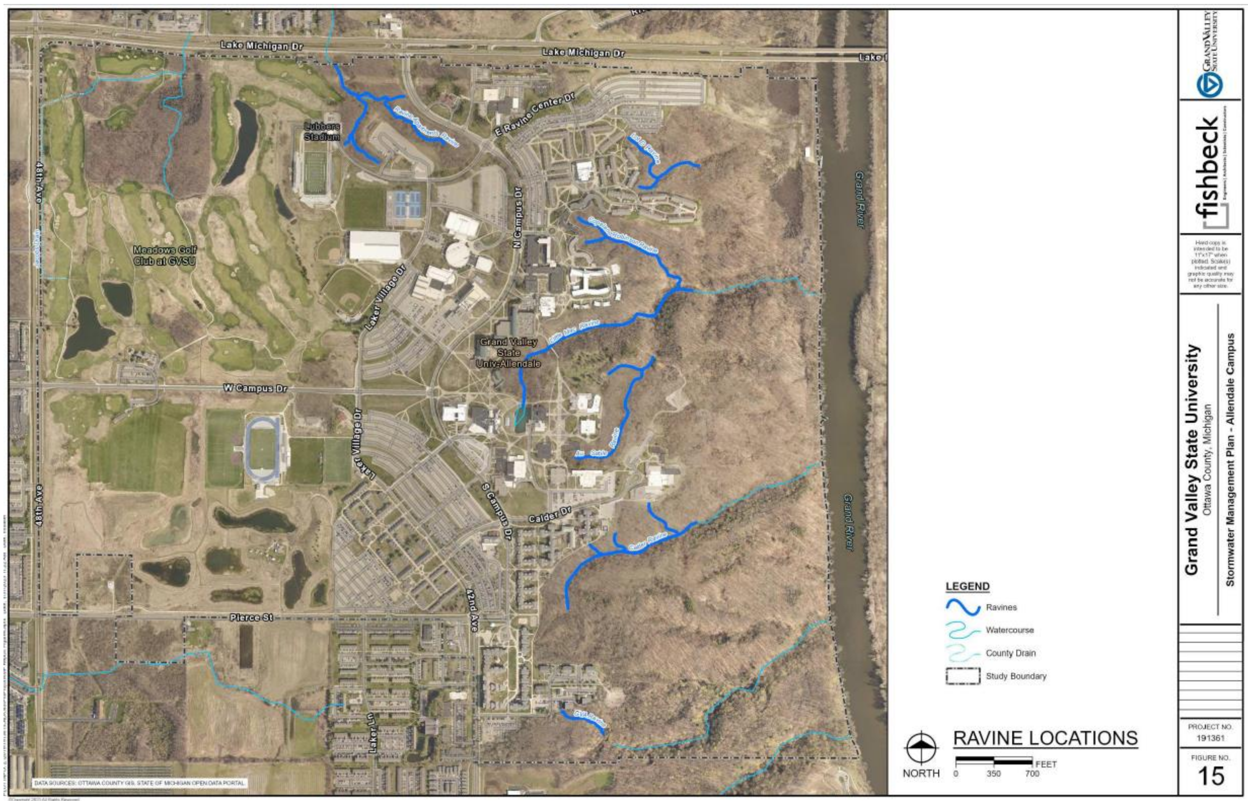
PROJECT NO. 191361
FIGURE NO. 14


Lake Michigan Dr
Lubbers Stadium
E Ravine Center Dr
Meadows Golf Club at GVSU
48th Ave
N Campus Dr
Laker Village Dr
Grand Valley State Univ-Allendale
W Campus Dr
S Campus Dr
Calder Dr
Pierce St
42nd Ave
Laker Ln
Grand River
LEGEND
Ravines
Watercourse
County Drain
Study Boundary
RAVINE LOCATIONS
NORTH
FEET
0 350 700
DATA SOURCES: OTTAWA COUNTY GIS, STATE OF MICHIGAN OPEN DATA PORTAL
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
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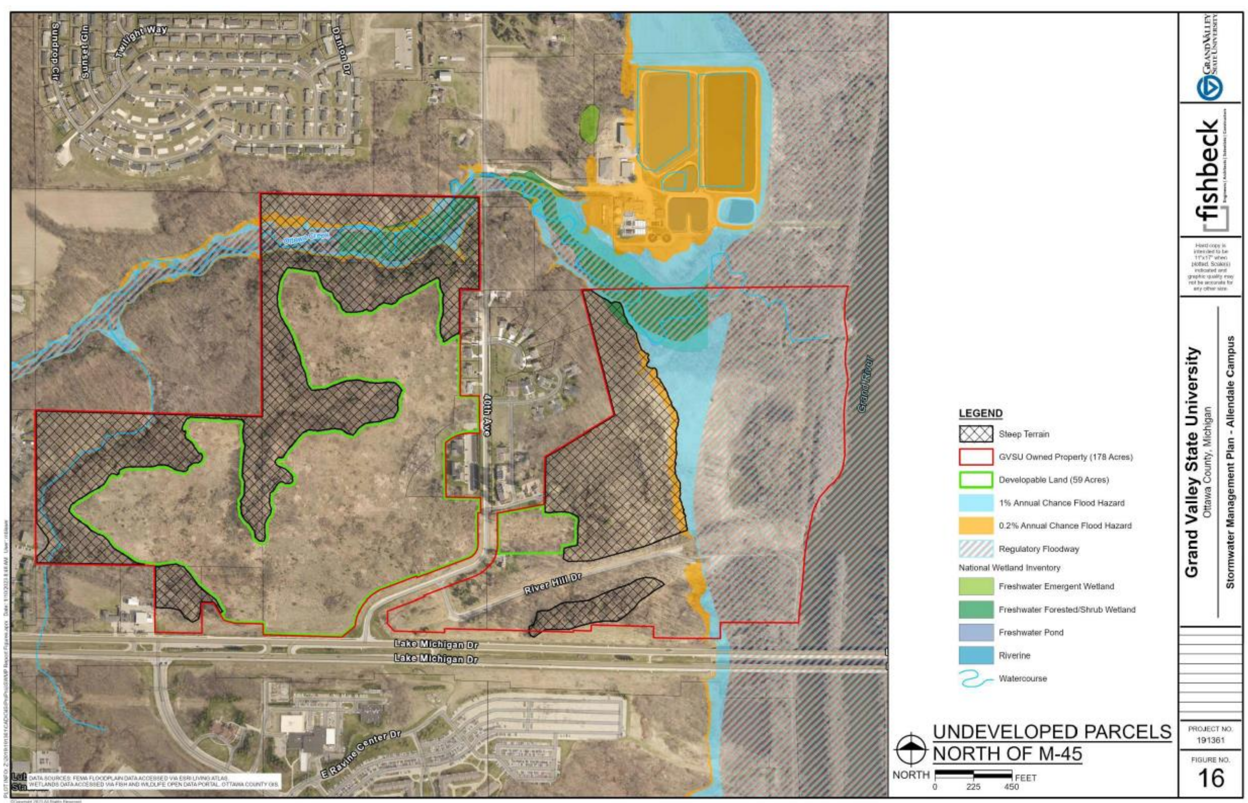
PROJECT NO.
191361
FIGURE NO.
15


Twilight Way
Sunset Gln
Dalton Dr
40th Ave
River Hill Dr
Lake Michigan Dr
E Ravine Center Dr
LEGEND
Steep Terrain
GVSU Owned Property (178 Acres)
Developable Land (59 Acres)
1% Annual Chance Flood Hazard
0.2% Annual Chance Flood Hazard
Regulatory Floodway
National Wetland Inventory
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Riverine
Watercourse
UNDEVELOPED PARCELS NORTH OF M-45
NORTH
FEET
0 225 450
DATA SOURCES: FEMA FLOODPLAIN DATA ACCESSED VIA ESRI LIVING ATLAS, WETLANDS DATA ACCESSED VIA FISH AND WILDLIFE OPEN DATA PORTAL, OTTAWA COUNTY GIS
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
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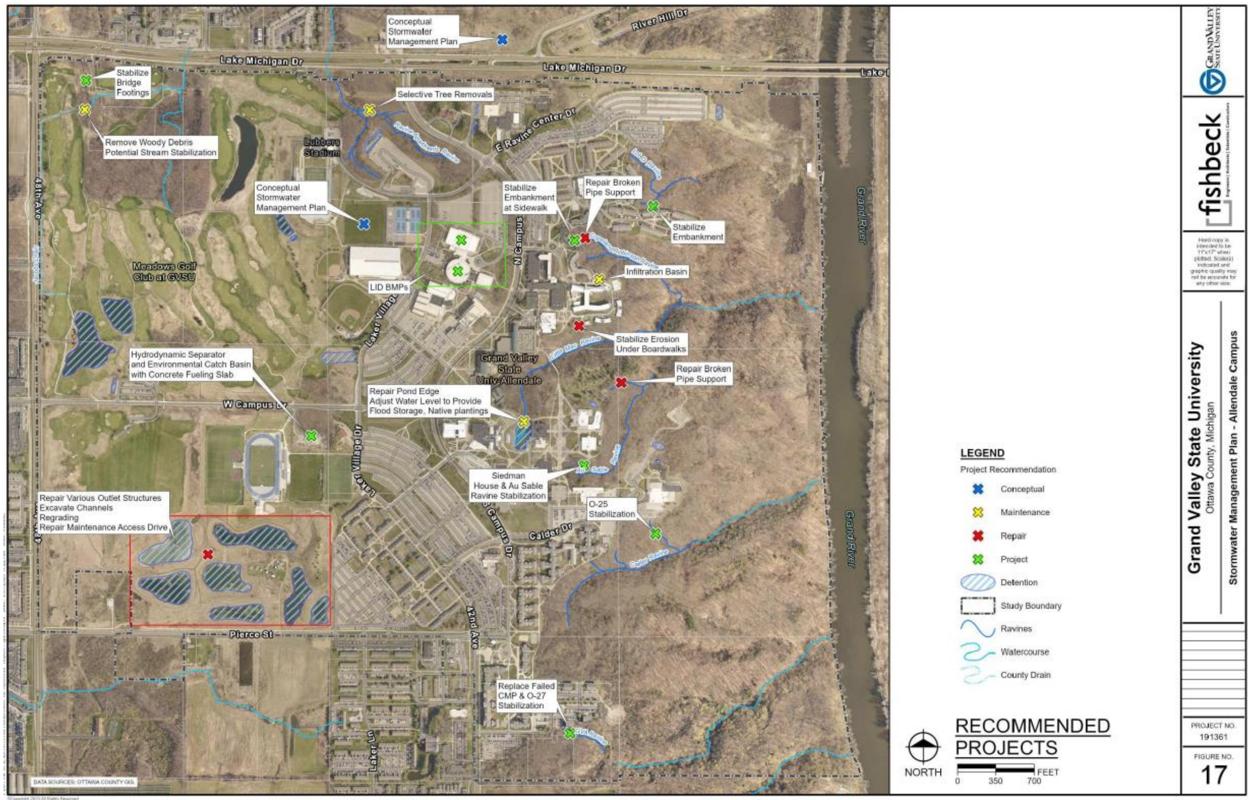
PROJECT NO.
191361
FIGURE NO.
16


Conceptual Stormwater Management Plan
River Hill Dr
Lake Michigan Dr
Lake Michigan Dr
Stabilize Bridge Footings
Selective Tree Removals
Remove Woody Debris Potential Stream Stabilization
E Ravine Center Dr
Lubbers Stadium
Conceptual Stormwater Management Plan
Stabilize Embankment at Sidewalk
Repair Broken Pipe Support
Stabilize Embankment
48th Ave
N Campus
Meadows Golf Club at GVSU
Infiltration Basin
LID BMPs
Lake Village
Stabilize Erosion Under Boardwalks
Hydrodynamic Separator and Environmental Catch Basin with Concrete Fueling Slab
Grand Valley State Univ Allendale
Repair Broken Pipe Support
W Campus Dr
Repair Pond Edge Adjust Water Level to Provide Flood Storage, Native plantings
Grand River
Siedman House & Au Sable Ravine Stabilization
Repair Various Outlet Structures Excavate Channels Regrading Repair Maintenance Access Drive
O-25 Stabilization
Calder Dr
42nd Ave
Pierce St
Replace Failed CMP & O-27 Stabilization
DATA SOURCES: OTTAWA COUNTY GIS
LEGEND
Project Recommendation
Conceptual
Maintenance
Repair
Project
Detention
Study Boundary
Ravines
Watercourse
County Drain
NORTH
RECOMMENDED PROJECTS
0 350 700 FEET
Grand Valley State University
Ottawa County, Michigan
Stormwater Management Plan - Allendale Campus
Grand Valley State University
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PROJECT NO. 191361
FIGURE NO. 17