

Background

Michigan State University's (MSU) Bioretention Basin was designed in 2008 and was completed in 2010. This site is intended to manage stormwater on campus and is located at the northeast corner of Farm Lane and Service Road. It is maintained by MSU's Infrastructure Planning and Facilities (IPF) team.

Block A receives stormwater, where it is sent to Block B and Block C for treatment. Block D acts as an overflow. Figure 1 shows the location in relation to campus, and how the site is labeled.

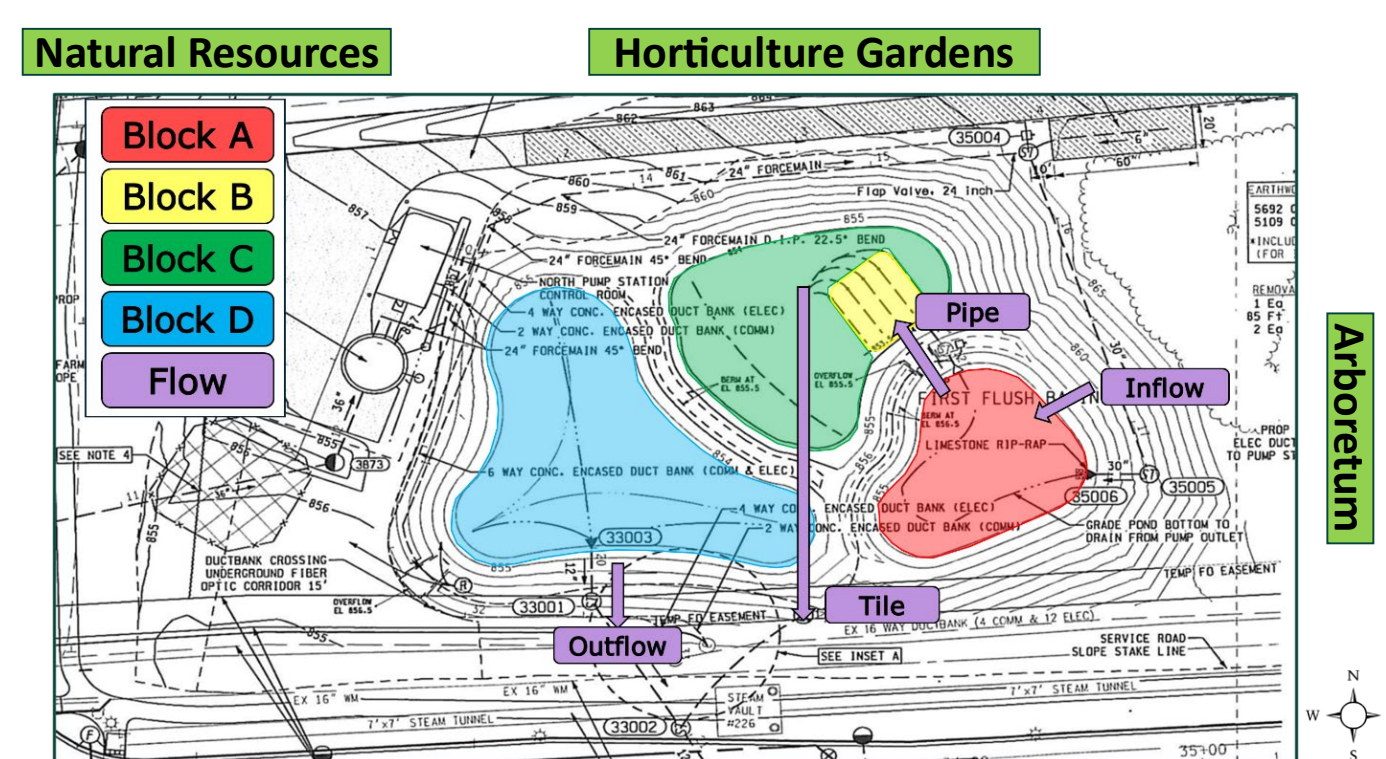
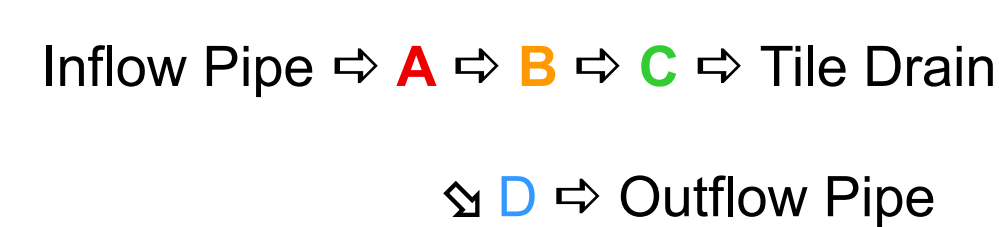


Figure 1 Farm Ln and Service Rd Bioretention Site's original site plan and location on campus

The site is intended to flow in the following order, with water from Block A only entering Block D as a last resort:



However, the pipe between Blocks A and B is broken, meaning water is not entering the treatment basin. A short-circuit pipe to the overflow block was installed in 2015 to prevent flooding.



Figure 2 (A) Short-circuit pipe on side of Block A, (B) Manhole connecting Blocks A and B, (C) Broken Pipe covered in sediment and biomass

The current flow is:



The MSU Bioretention Team aims to restore flow to the entire site to successfully treat stormwater.

Objectives

To address the problem at the site the team hopes to accomplish the following:

Project Objectives

- Understand issues present at the site
- Estimate the current lifespan
- Model hydrologic flow in STELLA to raise utilization from 33% to 90% or greater

Design Objectives

- Restore the basin to hydraulically functional conditions by returning:
 - Drawdown requirements
 - Hydraulic Retention Time
 - Treatment Volume
- Raise biodiversity by a minimum of 50%

Constraints

- Minimize cost to IPF for improvements.
- Keep maintenance at a minimum
- Follow Municipal Separate Storm Sewer System (MS4) permit held by Michigan State University (issued by EGLE).¹
- Comply with MSU's Stormwater Management Program to ensure discharge conditions are met (<80 mg/l TSS from up to 1 in of rainfall).²

Design Alternatives

The team considered three design alternatives. All replace the broken pipe. The amount of soil to dredge was determined by surveying results.

Table 1: Survey results and 2008 elevations

Block	2025 Average Elevation (ft)	2008 Estimated Elevation (ft)	Difference (in)
A	855.2	855.0	2.0
C & B	854.2	854.0	1.9
D	854.3	854.0	3.5

Designs include:

- **2008 Restoration Plan (2008):** Surface removal of soils to original elevations, pre-determined seed mixes
- **Replace and Restore Plan (RRP):** Surface removal and replacement of soils to original elevations, pre-determined seed mixes
- **Specialized Improvements Plan (SIP):** Additional surface removal and replacement of soils, adding mulch and individually selected plants

All designs increase biodiversity and ecosystem services by adding native wetland plants from Stantec.³ Table 2 shows the original composition of the basin.

Design Alternatives

Table 2 Biodiversity Index results

Category	Permanent Grasses	Forbs	Weeds
# of Unique Species	3	12	28
% of Blocks B and C	2.4%	39.7%	58.0%

Each alternative was evaluated based on the following criteria:

- Cost (15%)
- Level of Maintenance (15%)
- Effectiveness of treatment (55% total)
 - Hydraulic Performance (30%)
 - Pollutant Removal (25%)
- Ecosystem Services (15%)

Table 3 Decision matrix scoring based on design criteria

Decision Options	Cost	Level of Maintenance	Effectiveness of Treatment		Ecosystem Services	Total
			Hydraulic Performance	Pollutant Removal		
Weighted Number	0.15	0.15	0.30	0.25	0.15	1.00
2008	8	4	7	4	4	5.5
RRP	5	5	8	6	4	6.0
SIP	3	6	9	7	6	6.7

Selected Design

The **Specialized Improvements Plan** scored the highest and was selected. It includes:

- Replacement of the broken connector pipe with a 12-inch HDPE pipe
- Excavation of accumulated media, installation of fresh sandy loam media in Blocks B and C
- Addition of 2 inches of mulch
- Replant specialized species selected to improve treatment and biodiversity

Final elevations are 2 inches below the 2008 design elevation, increasing available storage and improving performance in the case of large inflow events to address flooding concerns.

Figure 3 shows a diagram of the design's excavation depths along with the replacement media included in the design.

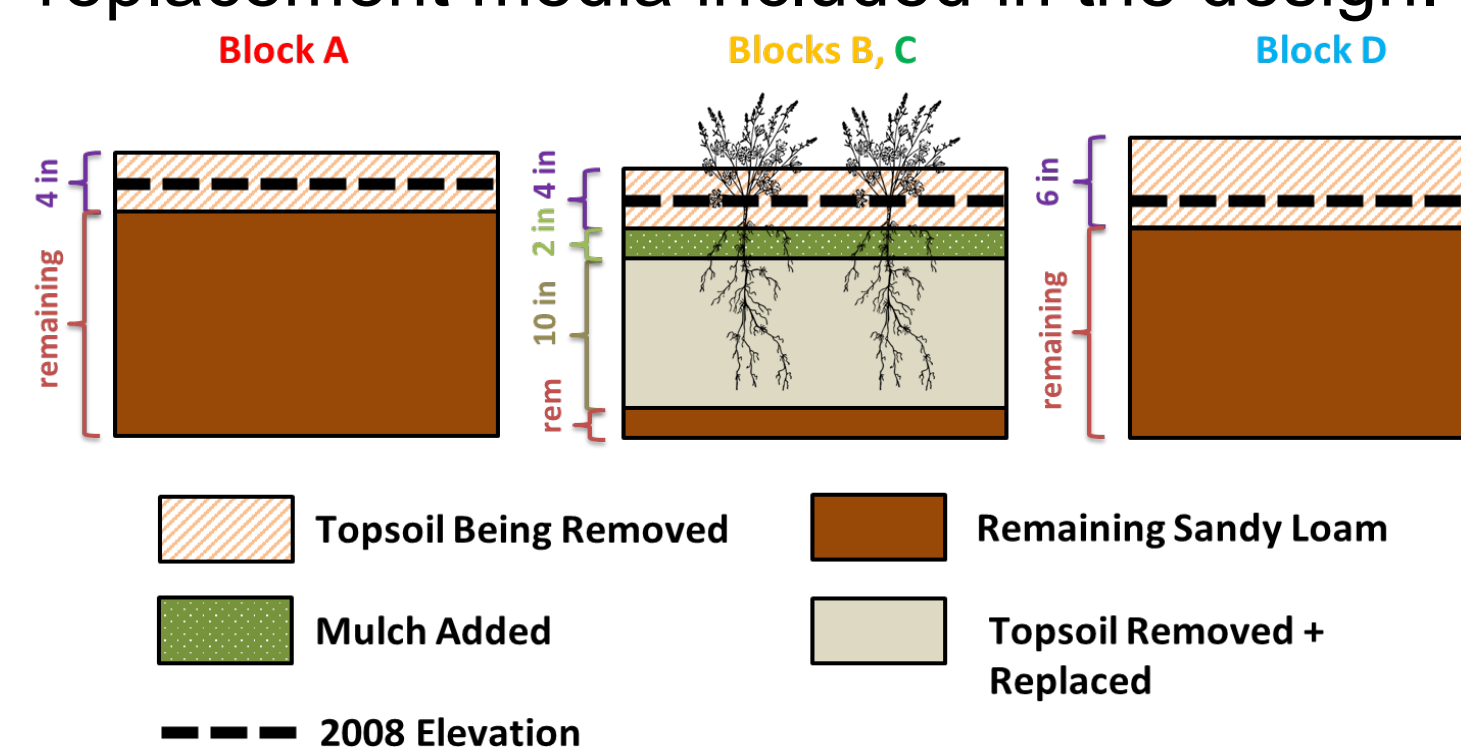


Figure 3. Specialized Improvements Plan for Soil Removal and Replacement

The design restores proper flow and increases residence time in the treatment basin, improving filtration and pollutant removal. Added soil media, mulch, and plantings enhance treatment, while increased storage volume allows more stormwater to be effectively treated.

Modeling

This plan is supported by the STELLA model's output, displayed in Figure 4 and Figure 5.

- Following pipe replacement and excavation, the modeled surface volume in Block D drops substantially and only spikes during large storm events (meeting drawdown requirements), returning to its role as an overflow rather than storage basin.
- Sustained water volumes in the subsurface of Blocks B and C, showing that flow is returned through the primary treatment media as intended, increasing HRT in these blocks.
- The Specialized Improvements Plan restores flow distribution, increases effective treatment volume, and improves overall site performance.

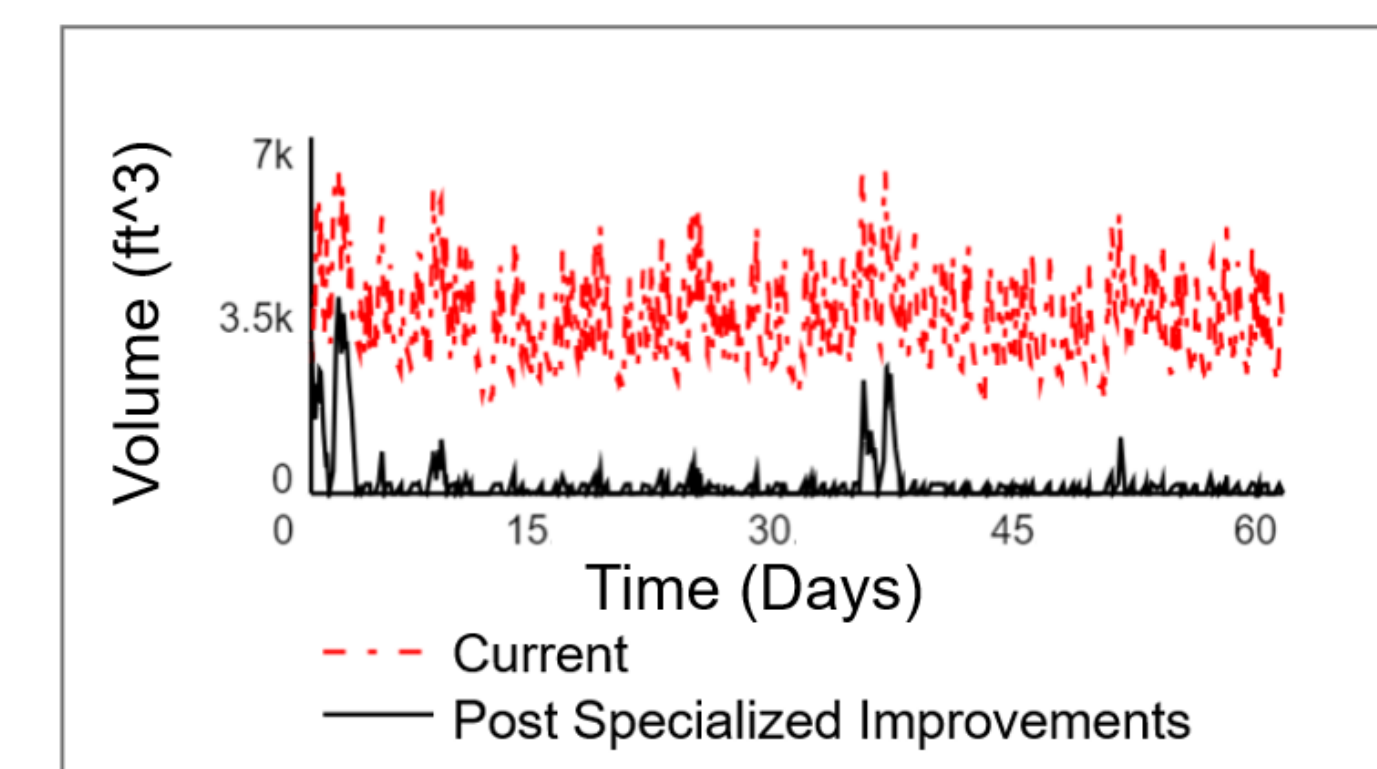


Figure 4: Surface Ponding in Block D Under Current and Improved Conditions

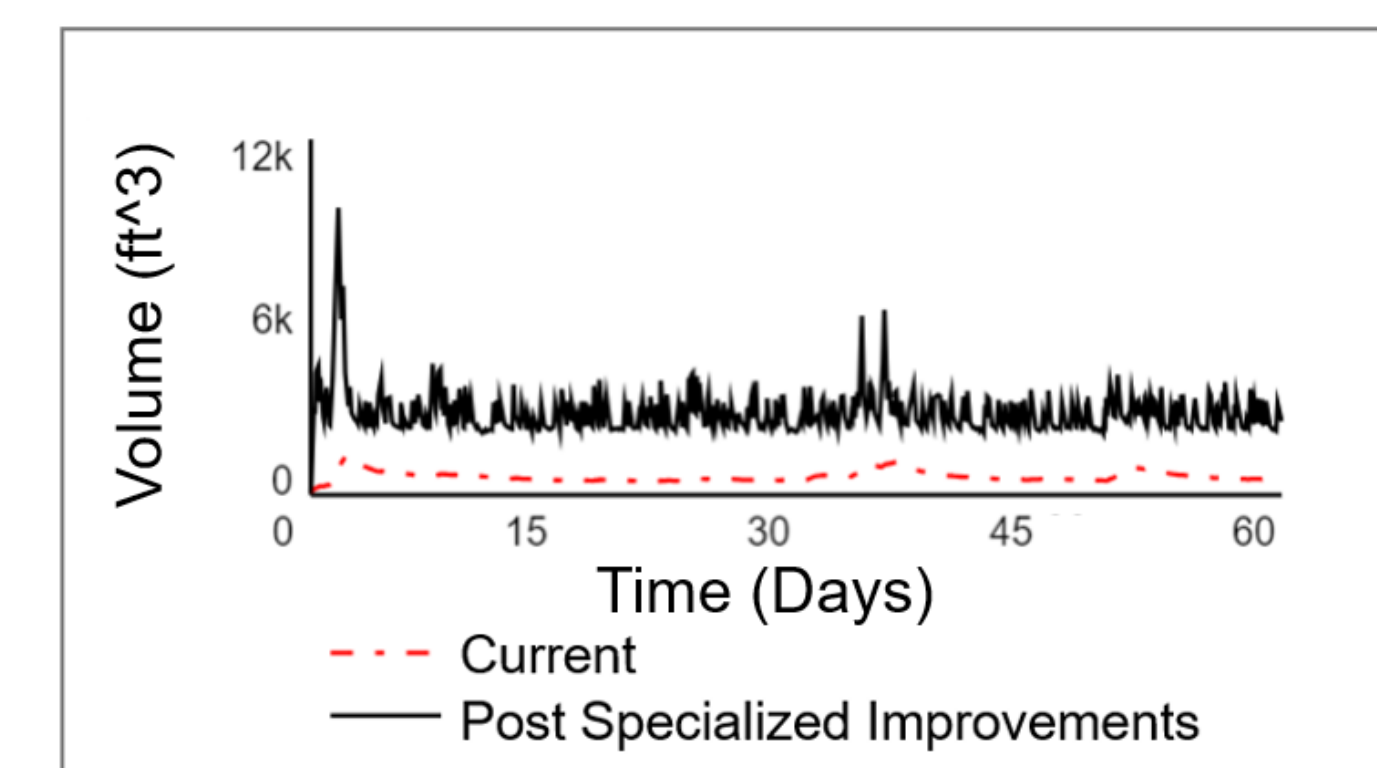


Figure 5: Subsurface Treatment in Blocks B and C Under Current and Improved Conditions

Pipe sizing sensitivity was evaluated in Figure 6. The STELLA results show that a 12-inch and a 16-inch replacement scenario does not produce a strong deviation in subsurface volume patterns in Block B and C.

- A larger pipe is not projected to provide a meaningful treatment benefit.
- This is also compared to higher costs with new larger infrastructure.

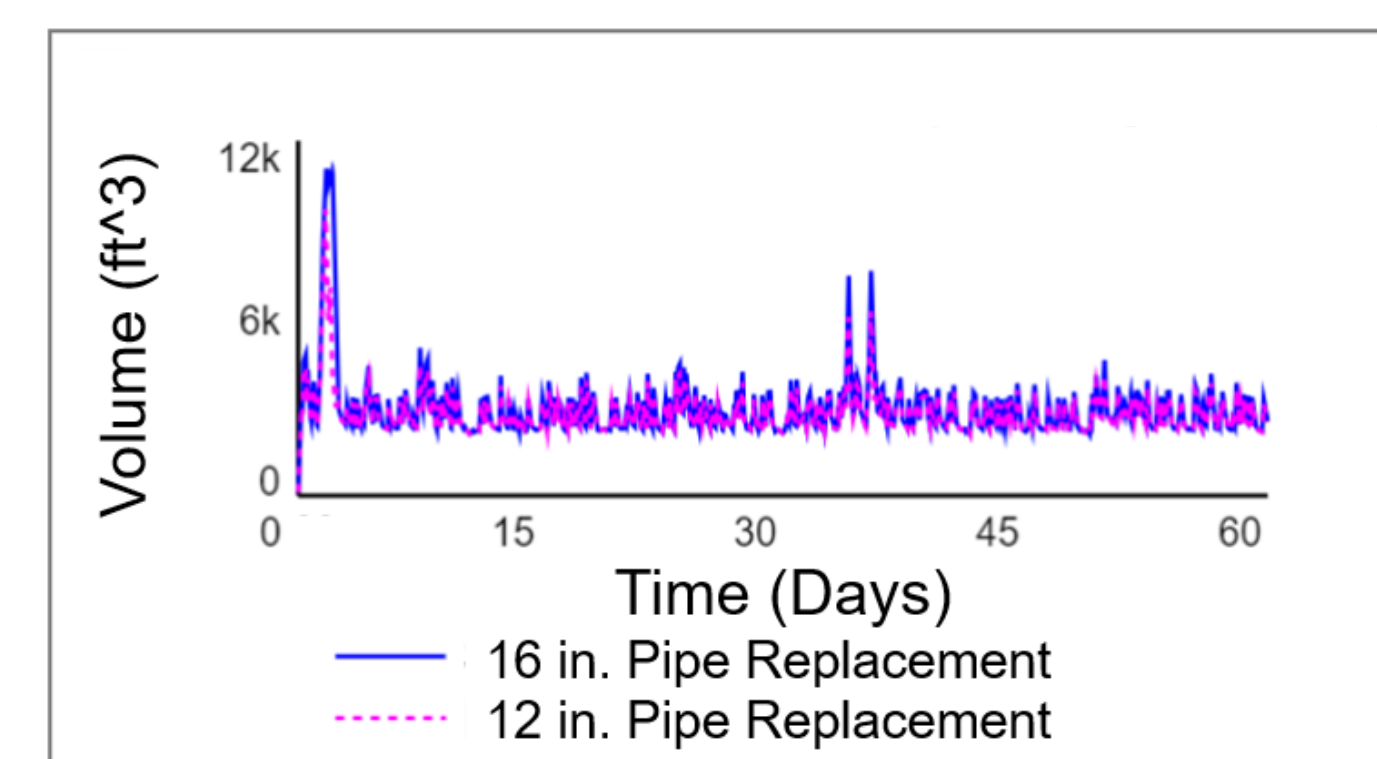


Figure 6: Pipe Sizing Sensitivity for Subsurface Volume in Blocks B and C

Economics

The estimated bill of materials is provided for the Specialized Improvements Plan with expected ranges of potential costs in Table 4. A 10% overhead was included.

Table 4. Estimate Bill of Material for the Specialized Improvements Plan

Item	Qty.	Unit	Cost (\$)	Low (\$)	High (\$)
12" Pipe	5	ft	230	200	1250
Excavation (dredge)	793	yd ³	81,584	34,124	129,044
Haul and Disposal	793	yd ³	32,666	30,564	34,768
Sandy Loam Soil	339	yd ³	10,170	10,170	10,170
Plantings	0.6	ac	5,500	5,500	5,500
Mulch	1,525	ft ³	2,546	2,546	2,546
Overhead (10%)			13,270	8,310	18,328
Total			145,966	91,414	201,606

Returns are found in the avoided costs over a 20-year span.

- The annual break-even avoided cost was determined to be \$9,811 at a 3% discount rate
- This stems from preventing additional maintenance, emergency response, nuisance flooding, landscape repair, and deferred rehabilitation.

Justification

- Avoided flood damage costs from peak runoff during major storm events
- Avoided cost of equivalent storage space (~80,000 gallons added)
- Underground detention/retention is typically three to four times more expensive according to U.S. EPA (2024) estimates

Conclusion

Specialized Improvements offers best treatment and accommodates higher volumes

- Unclogs Broken Pipe
- Ensures proper flow is going to all basins
- Gives plantings that help treat stormwater

Select References

1. U.S. Environmental Protection Agency. (2021, November). Stormwater best management practice: Bioretention (rain gardens). <https://www.epa.gov/system/files/documents/2021-11/bmp-bioretention-rain-gardens.pdf>
2. Michigan State University. (2024). MSU stormwater management program. <https://www.canr.msu.edu/msu-water/msu-stormwater-management-program>
3. Stantec Inc. (2025, February 20). Native Plant Nursery price list [PDF]. <https://www.stantec.com/content/dam/stantec/files/PDFAssets/native-plant-nursery/native-plant-nursery-pricing-20250221.pdf>