CITY OF ROYAL OAK



GREEN INFRASTRUCTURE EVALUATION REPORT

MARCH 6, 2018







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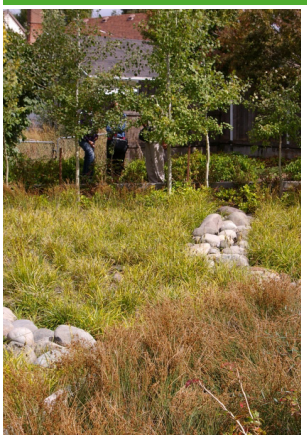




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Section 1



EXECUTIVE SUMMARY

The City of Royal Oak commissioned an evaluation of using Green Infrastructure (GI) to reduce runoff entering the City's stormwater system. GI utilizes predominantly natural processes such as infiltration and evapotranspiration, as well as rainwater harvesting and reuse, to manage stormwater runoff. GI diverts stormwater runoff from the traditional network of catch basins and conveyance pipe systems and reduces the need to convey and treat essentially clean water.

When applied across a watershed, the cumulative benefits of deploying GI as part of an integrated framework for stormwater management can include:

- Restored hydrologic functions for natural systems, wetlands and streams
- Mitigation of excessive runoff from high frequency return interval storm events
- Stormwater managed at the source of runoff rather than at the outfall
- Low volume, low-tech stormwater controls that are less costly to build and maintain
- Creative multi-functional landscapes that improve community aesthetics
- Improved site design for land development and redevelopment practices
- Improved water quality for runoff entering the collection system and the environment
- Improved habitat for wildlife

GI can be implemented in an array of practices that balance conservation of the natural features of the site with the goals of the site development proposal. Traditional stormwater practices that may be combined with GI to provide large volume capture include infiltration basins, pipe-bundles and vaults or cisterns. Smaller scale GI practices implemented at the site development scale include permeable pavements and bioretention cells. Selecting the appropriate menu of practices is dependent on the goals for the stormwater control desired and the needs of the site. This report will demonstrate the application of a variety of GI stormwater management solutions to be used as a guide for future stormwater management planning in the City of Royal Oak.

Royal Oak has historically used the 10-year, 1-hour event for evaluating the capacity of its storm sewer system. Designing GI to the 98th percentile design storm will capture all but 2% of all storm events and is consistent with guidance from the US Environmental Protection Agency (USEPA). With this in mind, the design team evaluated two storm events: the NOAA Atlas 14 10-year, 1-hour storm and the 98th percentile storm. The 98th percentile storm for Royal Oak is nearly identical to the 10-year, 1-hour design storm.

In addition, as part of this study, the consultant team reviewed the city-wide existing soils and groundwater elevations as well as conducted site-specific geotechnical evaluations at six locations identified as pilot project locations by the City. Groundwater observations were made during and upon completion of the excavation of the boring operations and no groundwater was observed. We would expect seasonal fluctuations in perched and long-term groundwater levels as well as variations following prolonged periods of precipitation. Variations such as these should be anticipated during detailed design of GI in the City.

In all cases, the results of this evaluation conclude that the City should require the GI designers to anticipate soil properties that are highly variable and for the designers to perform testing at each proposed GI site as part of the engineering design due diligence. Further, the GI designer that is relying on infiltration to meet the volume reductions should assume negligible rates for infiltration when the GI practice is placed in locations with fill soils or into native cohesive soils. However, there are significant regions in the city that could pro-

vide measurable infiltration volumes as the results of the borings performed in this study prove.

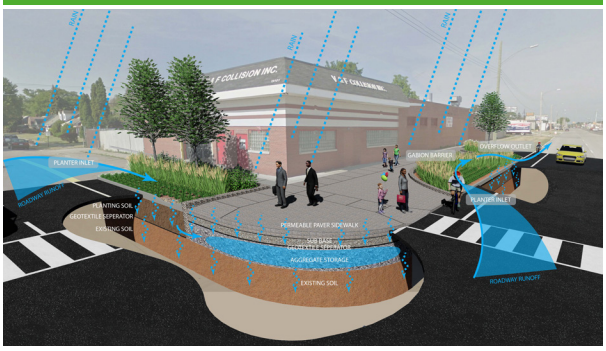
As the use of GI practices has proliferated, the study team members have seen new funding programs developed each year at all levels of government. In addition, philanthropic organizations that promote sustainability and environmental stewardship have partnered with local communities to implement GI projects across Michigan and the Metro Detroit region. Funding for GI projects is constantly changing as the range of programs available at the local, state and federal level fluctuate based on political agendas at each level of government. A sustainable source of funding is required for implementing a stormwater program. The city has designated this as an action item and will be establishing a stormwater utility for this purpose.

Many communities across the state have sought funding through grant programs. Programs such as the Clean Water Act Section 319 have provided funding for GI projects implemented across the country as well as Michigan. However, grant programs are not considered to be a reliable long-term source of funding for establishing a GI Program. Loan programs, such as the USEPA Clean Water State Revolving Fund, are another source that communities can use. Again, this is limited available funding and requires communities to compete for the pool of available funding each year.

The City of Royal Oak Stormwater Management Plan for Green Infrastructure has been advanced through the evaluation phase to provide the final recommendations for implementing GI at various pilot sites including:

- Parking Lots/Alleys: Downtown City Parking Lot/Woodward Alley
- Local Streets: Woodwardside Subdivision
- Major Roadway: Campbell Road
- City Parks: Starr Jaycee Park/VFW Park

The pilot projects implemented in this evaluation capture and treat 2.2 million gallons of runoff. We believe the efficacy of GI, as demonstrated in this report, coupled with the diversity of application sites available to the City, will make GI a valuable tool in the City's toolbox of stormwater management technologies to be deployed across the City.



EVALUATION

Background Conditions and General Project Approach

Project team members and the geotechnical consultants performed the initial field work at each Pilot Project site. In addition, data collected and assembled relevant to the study from the City and available data sets from Oakland County GIS. Initial site visits were conducted to identify potential improvements and observe existing conditions. Throughout the project, additional site visits were made, as needed, to obtain more information and clarify project questions from team reviews and evaluations.

Soil and groundwater conditions were investigated at all pilot project sites and opportunities to propose infiltration GI practices were evaluated with on-site geotechnical evaluations at each of the proposed pilot sites. Soil borings were obtained with a bucket hand auger extending to a minimum depth of 5 feet below grade. The relative consistency of the in-situ soils was evaluated using a dynamic cone penetrometer in general accordance with ASTM STP #399 (Sowers DCP) at the depths samples were obtained. Soil samples were sealed and transported to the laboratory for testing and classification. During the excavation operations, the geotechnical engineer maintained logs of the encountered subsurface conditions, including changes in stratigraphy and observed groundwater levels. The final soil logs along with details of the testing and evaluation performed, are presented in the geotechnical evaluation (Appendix A).

From these soil investigations, the design assumptions for the suitability for proposing GI infiltration practices was evaluated. Estimated infiltration rate ranges for the soils evaluated are detailed in Exhibit 1.

For future GI implementation projects, our project team recommends that the City require borings and soil infiltration evaluations for undisturbed, native soils, as well as fill soils, to inform the design of GI practices that will rely on infiltration for their effectiveness.

At each pilot project site, the drainage area and all sub-catchments were determined, including verification of off-site drainage entering the catchment and all storm or roof drain leads to

Exhibit 1 Summary of In-situ Soil Infiltration Evaluations

PILOT PROJECT SITE LOCATION	SOIL BORING NO.	SOIL TYPE	ELEVATION OF SOILS SUITABLE FOR INFILTRATION (FT. BELOW GRADE)	ESTIMATED INFILTRATION RATE (IPH)	GROUND-WATER ELEVATION (FT.)
Downtown Parking Lot	B-05	Sand	3.5	11 to 17	>5
Woodward Alley	B-04	Urban Fill Clayey Sand & Sandy Clay	N/A	0	>5
Neighborhood Study Area-Woodwardside Subdivision	B-01	Urban Fill-Sandy Clay	N/A	0	>5
Campbell Road Corridor	B-03	Urban Fill Clayey Sand & Sandy Clay	N/A	0	>5
Starr Jaycee Park	B-02	Sand	3.5	11 to 18	>5
VFW Park	B-06	Silty Sand	2	1 to 3	>5

Groundwater Infiltration Rates Based On Hazen (1930)

the catchments. Once the drainage inputs for the catchment were verified, the runoff estimates for the design storm were produced. This volume was used to develop the design of the GI stormwater practices to be used in the pilot site. The design team conducted an alternatives evaluation session with City staff using this review to select the preferred GI solution for each site.

Design Approach for GI Practices

For each pilot demonstration site, the design team identified a strategy to reduce the runoff volume reaching the stormwater system. The preferred design recommends the GI solution to cost-effectively capture the design volume and address the constraints at each site.

As was noted in the previous section, the soils report (G2 2017) provided infiltration rates for native soils at a depth of 5 feet below grade. If native soils were not observed at 5 feet, an estimated infiltration rate was not reported. A factor of safety of 3 was applied to the mean estimated infiltration rates to account for soil variability and saturated conditions. For example, if a mean estimated infiltration rate of 2 inches per hour was reported, a 0.7 inches per hour infiltration rate was used for design. If a soil infiltration rate was not reported, the saturated hydraulic conductivity from the NRCS web soil survey (NRCS 2017) was used instead. Exhibit 2 has the estimated design infiltration rates that were used for GI sizing and performance calculations. Before advancing any of the pilot project concepts to final design, the team recommends obtaining soil borings and performing infiltration tests at exact locations of GI design.

Exhibit 2 Estimated Design Infiltration Rates Used for GI Calculations

SITE	DESIGN INFILTRATION RATE (INCHES/HOUR)
Downtown Parking Lot	4.7
Woodward Alley	0.1
Local Streets	0.1
Major Road	0.1
Starr Jaycee Park	4.8
VFW Park	0.7

Design Storm Analysis

With regards to designing and evaluating GI for the City of Royal Oak, we proposed to use two storm events in our analysis - the NOAA Atlas 14 10-year, 1-hour storm and the 98th percentile storm (NOAA 2013). The 10-year, 1-hour storm is used by the City to evaluate capacity of its current storm sewer system. As storm events become more frequent and intense, GI can be used to address current and future capacity issues of the city's current system. The 98th percentile storm rainfall amount represents the total rainfall volume for which 98% of all storms are smaller. Designing for the 98th percentile storm is consistent with the *U.S. Environmental Protection Agency (EPA) Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act (USEPA 2009)*.

In many situations, GI is designed for the 2-year, 24-hour event which is approximately 2.4 inches of rainfall. The 2-year, 24-hour event is also referred to as a channel protection event since, in many situations, the 2-year, 24-hour event commonly dictates channel morphology. For an urban situation such as Royal Oak, designing for channel protection is less prudent and costlier, hence our recommendation is to use the 98th percentile event as the local target for GI storage.

The 98th percentile rainfall event calculations for Royal Oak were determined using the procedure outlined in *U.S. Environmental Protection Agency (EPA) Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act (USEPA 2009)*. The process is as follows:

- Daily precipitation totals were obtained from the nearest National Weather Station to the project site (GHCND: USC00202015 in Dearborn, MI). It was retrieved from the National Oceanic and Atmospheric Administration database.
- Data within the date range of 1980 through 2016 was analyzed. Data has been recorded at this weather station since 1952, but only the past 36 years were analyzed to focus on more recent rainfall trends and to meet the

minimum 30 years of records.

- Daily rainfall totals of 0.1 inches and over were included in the calculations (USEPA 2009).
- Snowfall was eliminated from the precipitation records by removing days with 'at time of observation' temperatures of 32 Degrees F or less.

Per this methodology, the 98th percentile rainfall event for Royal Oak is 1.64 inches. Atlas14 reports the 10-year, 1-hour storm for Royal Oak is 1.66 inches (NOAA 2013). As such, our GI design used the 10-year, 1-hour storm event (1.66 inches) as a substitute for the 98th percentile event since they are effectively identical.

Capture Area and Volume Determinations

Several numerical techniques are available to predict GI performance including the SCS Curve Number (CN) Approach (SCS 1986), Simple Runoff Volume Method (SEMCOG 2009), Modified Rational Method (MRM) (New Jersey 2014), TR-55 (USDA 2009), and Storm Water Management Model (SWMM, etc.) (US EPA 2015). The accuracy of these volumetric predictions depends significantly on rainfall amount, the level of impervious surface, size of the drainage area, and soil conditions. To demonstrate the variability of these techniques for estimating runoff volume, our team considered three different locations of various soil conditions and imperviousness – downtown parking lot (high level of imperviousness and high infiltration rates), Campbell Road (moderate level of imperviousness and poor infiltration rates), and Starr Jaycee Park (low level of imperviousness and high infiltration rates). For each location, the runoff volume was calculated using four methods (SCS Curve Number, Simple Runoff Volume, TR-55, and MRM) based on the 10-year, 1-hour storm event (1.66 inches).

Exhibits 3, 4 and 5 provide the runoff volume estimate for the Downtown Parking Lot, Campbell Road, and Starr Jaycee Park respectively. For sites that are primarily impermeable (Exhibit 3), the models yield similar runoff volume estimates. As the level of imperviousness and infiltration rate vary, the models yield more disparate results (Exhibits 4 and 5). Finally, for Starr Jaycee Park (Exhibit 5), the TR-55 model does not yield an estimated runoff volume because the parameters are outside model predictive capabilities for a 1.66-inch rainfall.

In conclusion, our team recommends using the SCS Curve Number (CN) approach for computing the runoff volumes for GI design sizing. The SCS CN approach is an industry standard and widely used for computing runoff volumes. The SCS CN approach is also consistent with the pending Oakland County Water Resources Commissioner (OCWRC) Stormwater Rules that are scheduled to be released in 2018[1].

Evaluation/Design Criteria, Assumptions and Considerations

Runoff volumes were calculated using the SCS CN Method (SCS 1986) for existing and proposed conditions. A 10-year, 1-hour storm (1.66 inches

Exhibit 3 Runoff Volume Estimate for Downtown Parking Lot

RUNOFF CALCULATION METHOD	RUNOFF VOLUME (CFT)
SCS Curve Number	6,971
Simple Method	6,916
TR55	7,656
MRM - Detroit	7,548

Exhibit 4 Campbell Road

RUNOFF CALCULATION METHOD	RUNOFF VOLUME (CFT)
SCS Curve Number	5,044
Simple Method	4,901
TR55	2,523
MRM - Detroit	5,298

Exhibit 5 Starr Jaycee Park

RUNOFF CALCULATION METHOD	RUNOFF VOLUME (CFT)
SCS Curve Number	17,149
Simple Method	15,246
TR55	NA
MRM - Detroit	23,072

[1]*Based on communication from Oakland County Water Resources Commissioner office*

of rainfall) was used for the calculations (NOAA 2013). Calculations were performed in an excel spreadsheet.

Calculation Process

Drainage Areas
Each site is broken into sub-drainage areas determined by common outlet points. The areas and locations of catch basins were determined through site visits and Google Earth elevations (Google Earth 2017). AutoCAD drawings were reproduced from aerial imagery in Exhibit 6. A site plan of existing conditions was created in AutoCAD and used to determine the areas for calculations.

Cover Type
Cover type was determined from site visits and Google Earth aerial images (Google Earth 2017).

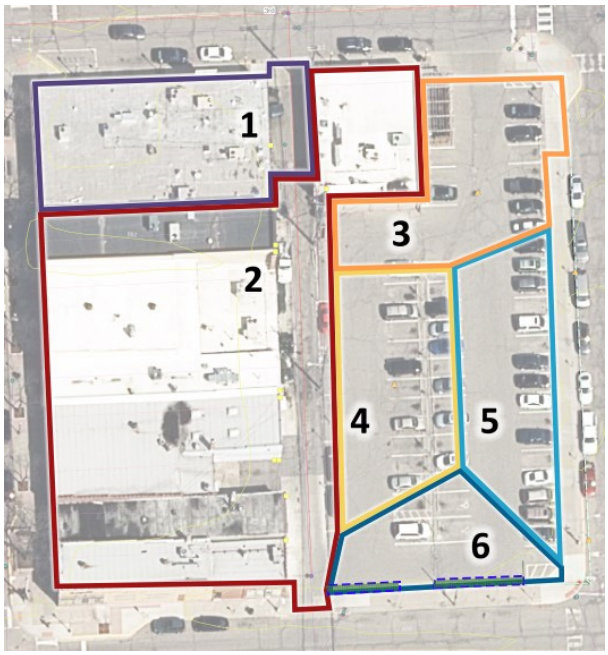
Soil Type
Soil type was determined from USDA Web Soil Survey for each sub-area (NRCS 2017).

CN Values
The CN values were selected after determining the cover type and soil type. All CN values, excluding GI, are taken from SCS Method (SCS 1986).

Volume of Runoff
Drainage areas and CN values for each sub-area were used to calculate the runoff with the SCS Method (SCS 1986). The equation details are in the spreadsheet. The SCS Method (SCS 1986) generates runoff values which were multiplied by the sub-area's total area to obtain runoff volumes.

Green Infrastructure Sizing and Performance
An infiltration based volume was included as part of our conceptual design for sites that had good infiltration (greater than 0.5 inches per hour). This accounts for the volume of stormwater that infiltrates while the practice is receiving stormwater runoff. The overall effect is that the GI practice is smaller because it does not have to simultaneously hold the entire 98% event volume. A 3-hour duration was used to calculate for infiltration based volume. The total treatment volume is a summary of the storage volume and the infiltrated volume (when applicable).

Exhibit 6 Example Sub-catchment Areas Delineation



Runoff Reductions
Runoff for each alternative scenario is calculated with the SCS method. The alternative scenario runoff, with total treated volumes subtracted out, is then compared with existing condition calculations to determine runoff reductions.

Cost Estimate Assumptions
Cost estimates for implementation of the pilot projects represent the cost of all items directly associated with the cost of the GI construction only and do not include off-site infrastructure construction, repair or restoration that is coincidental to the GI construction.



PREFERRED PILOT PROJECTS

Six neighborhood-scale GI projects were evaluated in this study as a means to test the feasibility of implementing GI as a stormwater management control program in the City of Royal Oak. The locations included parking lots and alleys in urban areas as well as established neighborhoods, major road corridors and city parks. All the areas noted are City owned and therefore do not posses any acquisition issues. In some cases, the potential for construction easements would be evaluated on a case-by-basis as the projects are advanced to detailed design.

Evaluations of GI performance considered the expected management capacity of the practices deployed at each site and accounted for in the volume of stormwater that can be managed by the GI practice through a combination of available storage volume (including on the surface, in engineered soil, and in open graded aggregate or chambers). Also, the volume of water that infiltrates in the underlying soils was estimated. In the planted GI, the volume of water removed via evapotranspiration was not estimated as this can be highly variable and subject to seasonal fluctuations. Exhibit 7 provides a summary of the expected runoff volume reductions.

Implementing pilot projects followed up by a meaningful monitoring plan are an effective means to prove the effectiveness estimates in this report are valid and therefore worthy of more widespread implementation. Performance data that is presented in this report is based on standard engineering analyses including hydraulic models, empirical formulas and past performance data from similar projects. This report presents a methodology for evaluating the performance of GI in a variety of contexts that are readily available within the limits of the City.

Summaries for each pilot project follow.

Exhibit 7 Estimated Runoff Volume Removed From Pilot Projects

PILOT PROJECT AREA/ALTERNATIVE	TOTAL RUNOFF VOLUME CAPTURED (CF)
Downtown Parking Lot/Alternative 2A Underground Reservoir and Permeable Pavers	5,874
Woodward Alley/Alternative 2 Center-strip Permeable Pavers and Chamber Storage	16,131
Local Streets - Woodwardside Subdivision/2A Trench Drain and Stone Reservoir	27,661
Major Road - Campbell Road 14 Mile to 11 Mile/Porous Pavement Gutter Pan	32,453
City Park - Star Jaycee Park/Bioretention Basins	141,186
City Park - VFW Park/Bioretention Basins	69,670
Total	292,975 CF 2,191,453 Gal.

DOWNTOWN PARKING LOT/ALTERNATIVE 2A UNDERGROUND RESERVOIR AND PERMEABLE PAVERS

The downtown parking lot and alley were analyzed concurrently. There were several options considered in the initial analysis phase including:

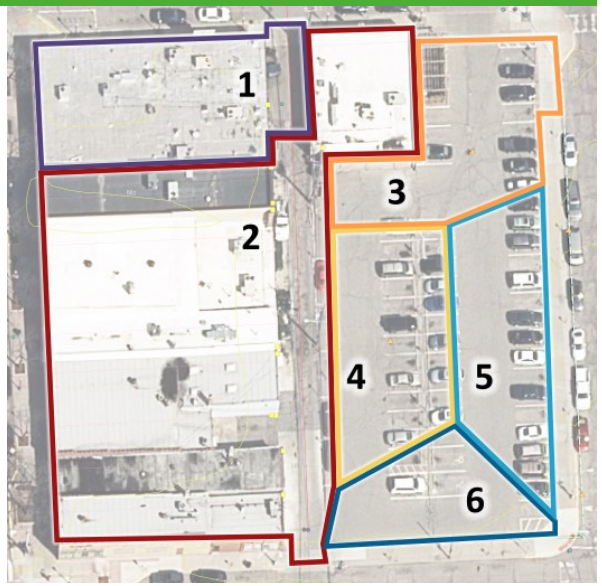
- Permeable pavers in the alley and parking lot around existing catch basins
- Stone and plastic chamber underground reservoirs for storage
- At and below grade bioretention planters along the south and east edges of the parking lot
- At grade stone trenches along the south and east edges of the parking lot
- Above grade bioretention planters in the alley

In addition, the configuration of parking stalls and traffic flow patterns were analyzed to determine if the space could be utilized more efficiently such that impervious surface could be removed but number of parking spaces retained. Finally, the soil borings indicated sandy underlying soils with good infiltration rates. This allows for effective infiltration based volume removal and smaller green stormwater infrastructure practices.

There are three design alternatives presented herein:

- Alternative 1 - Permeable Pavers and Underground Reservoirs for drainage areas (DA) 3 through 6 (the parking lot)
- Alternative 2 - Underground Reservoir and Permeable Pavers in DA4 with stormwater runoff from DA 1 through 3 captured using grey infrastructure and piped to underground reservoir. This alternative has two design options for underground storage of stormwater:
  - Alternative 2A - Stone Reservoir
  - Alternative 2B - Proprietary Plastic Chamber Reservoir
- Alternative 3 - Bioretention for DA6 (south side of the parking lot)

During the analysis phase, it was determined it was infeasible to include green stormwater infrastructure in the alley. There are too many underground utility conflicts and at-grade usage conflicts, primarily trash and grease receptacles. However, stormwater runoff from the alley and the buildings fronting Main Street could be captured using traditional grey infrastructure and piped to an underground storage reservoir beneath the parking lot (Alternative 2). If this design alternative is implemented, it is recommended that the city include oil and grease separators at the alley catch basins to serve as pre-treatment before runoff is piped to the underground storage reservoir.



With regards to the parking lot, it was determined because of human traffic flow patterns that at-grade stone trenches along the east and south side are not advisable. It was also determined that bioretention along the east side of the parking lot is not advisable. The only viable location for bioretention is along the south side of the parking lot (Alternative 3). For the remainder of the parking lot, it is feasible to include permeable pavers around existing catch basins or along parking lot edges to capture and infiltrate the design volume (Alternative 1). It is also feasible to have a central location to infiltrate the design volume by utilizing either a stone reservoir or a plastic chamber system (higher void ratio so smaller design surface area).

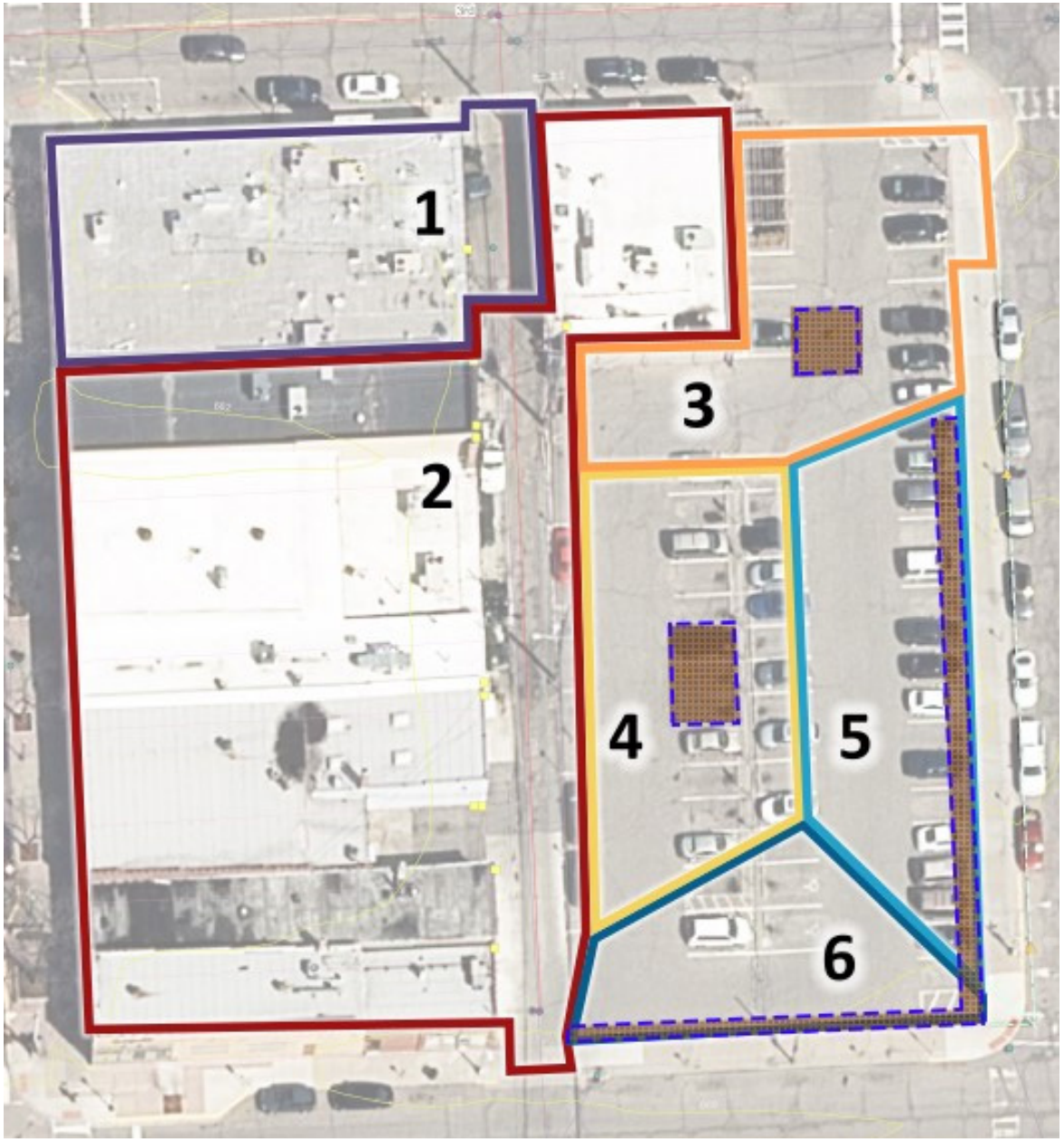
DOWNTOWN CITY PARKING LOT ALTERNATIVE 1 PERMEABLE PAVERS

DA1 & 2: Not Treated

DA3: 20 ft x20 ft Permeable Pavers

DA4: 3 Parking Spots Permeable

DA5 & 6: 3 ft strip of permeable pavement along edge of parking



DOWNTOWN CITY PARKING LOT ALTERNATIVE 1 AREA 3 PERMEABLE PAVERS



Existing condition



Proposed condition

DOWNTOWN CITY PARKING LOT ALTERNATIVE 1 AREA 4 PERMEABLE PAVERS

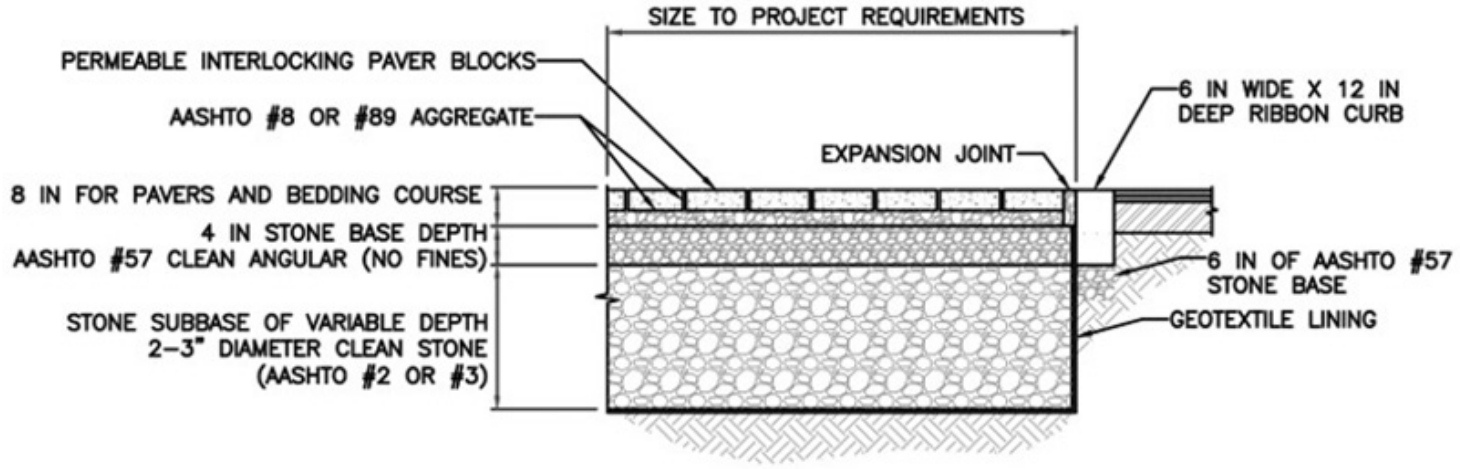


Existing condition



Proposed condition

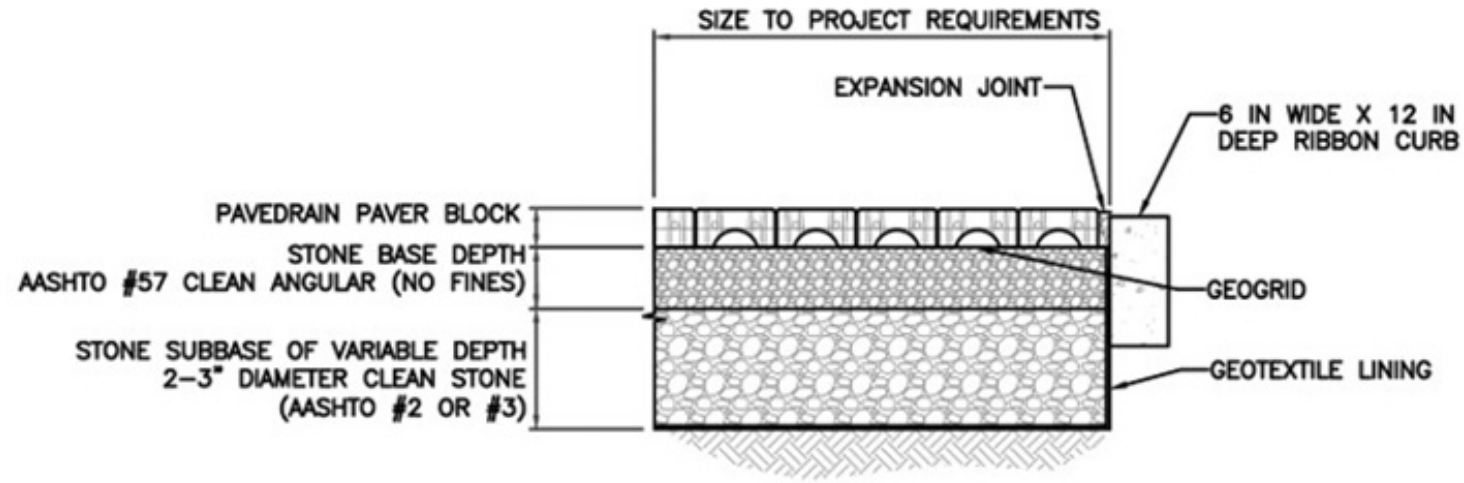
DOWNTOWN CITY PARKING LOT ALTERNATIVE 1 PERMEABLE INTERLOCKING PAVER BLOCK DETAIL







DOWNTOWN CITY PARKING LOT ALTERNATIVE 1 PAVEDRAIN DETAIL



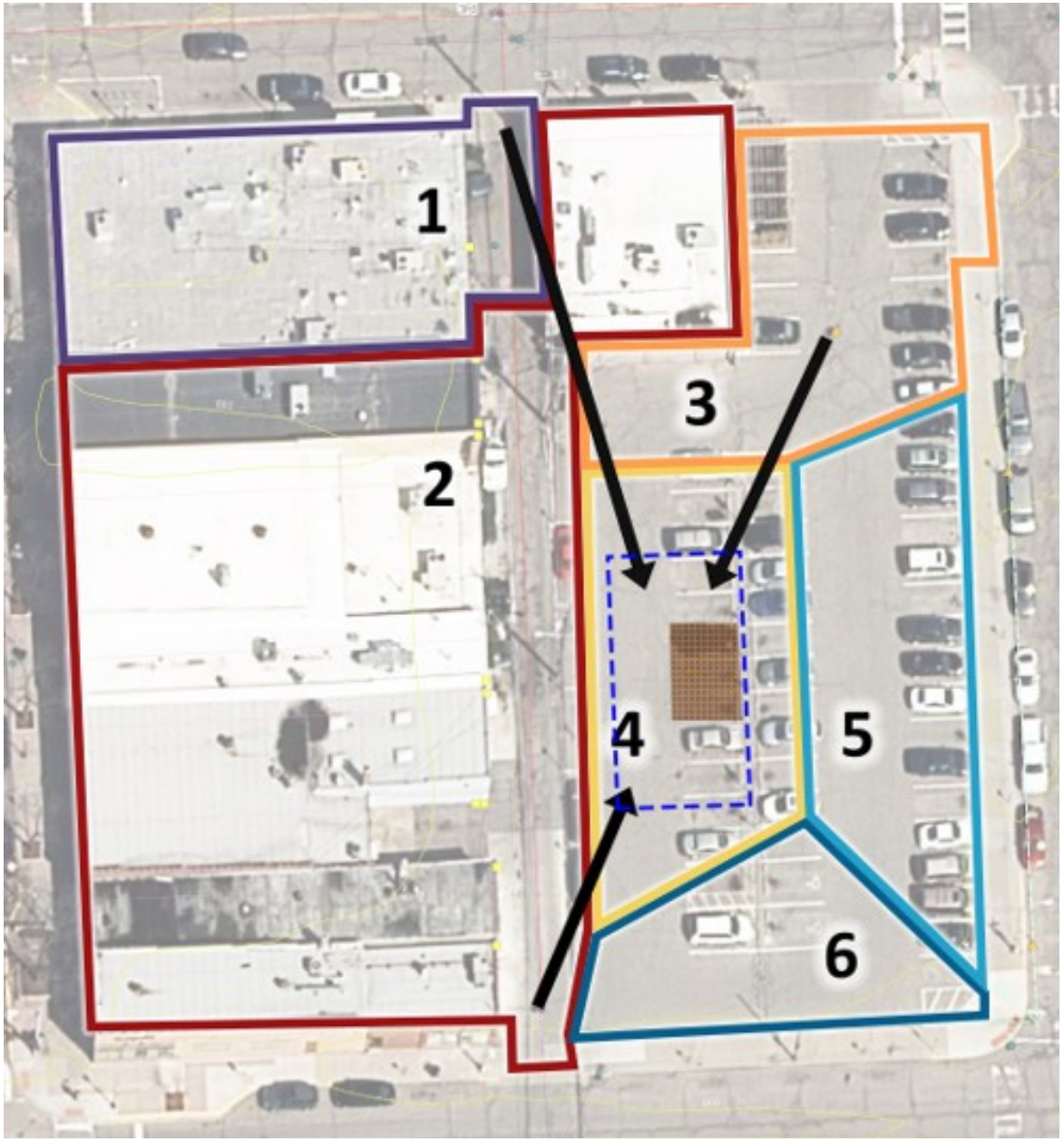


DOWNTOWN CITY PARKING LOT ALTERNATIVE 2A CATCH BASINS TO STONE RESERVOIR

DA1-3: Catch Basins Diverted to DA4

DA4: 44 ft by 60 ft Stone Reservoir with 3 Parking Spaces Permeable

DA5 & 6: Untreated



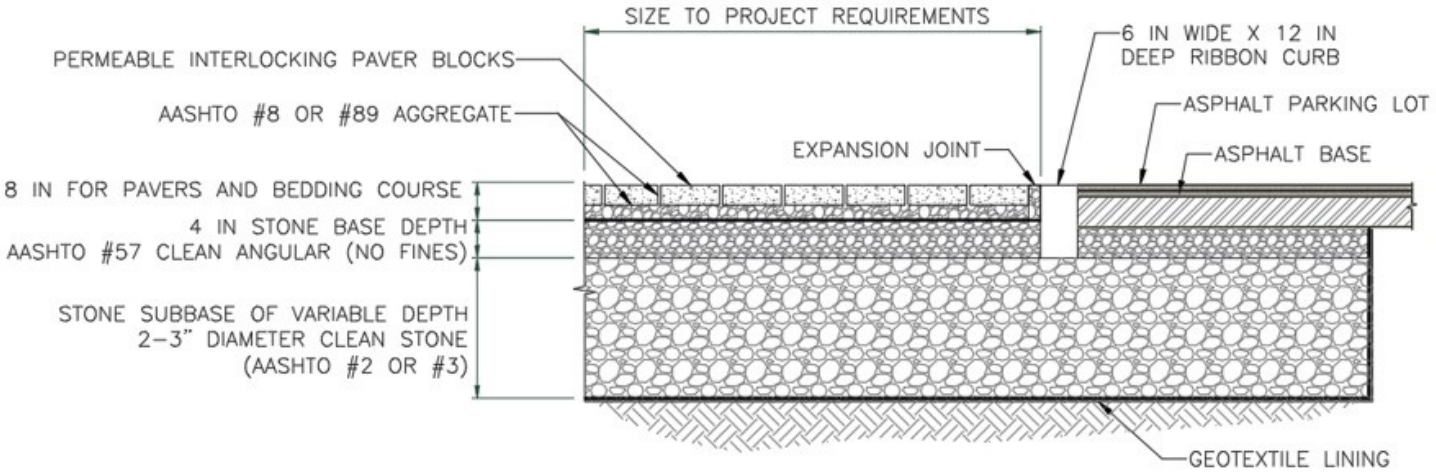
DOWNTOWN CITY PARKING LOT ALTERNATIVE 2 AREA 4 PERMEABLE PAVERS



Existing condition



Proposed condition

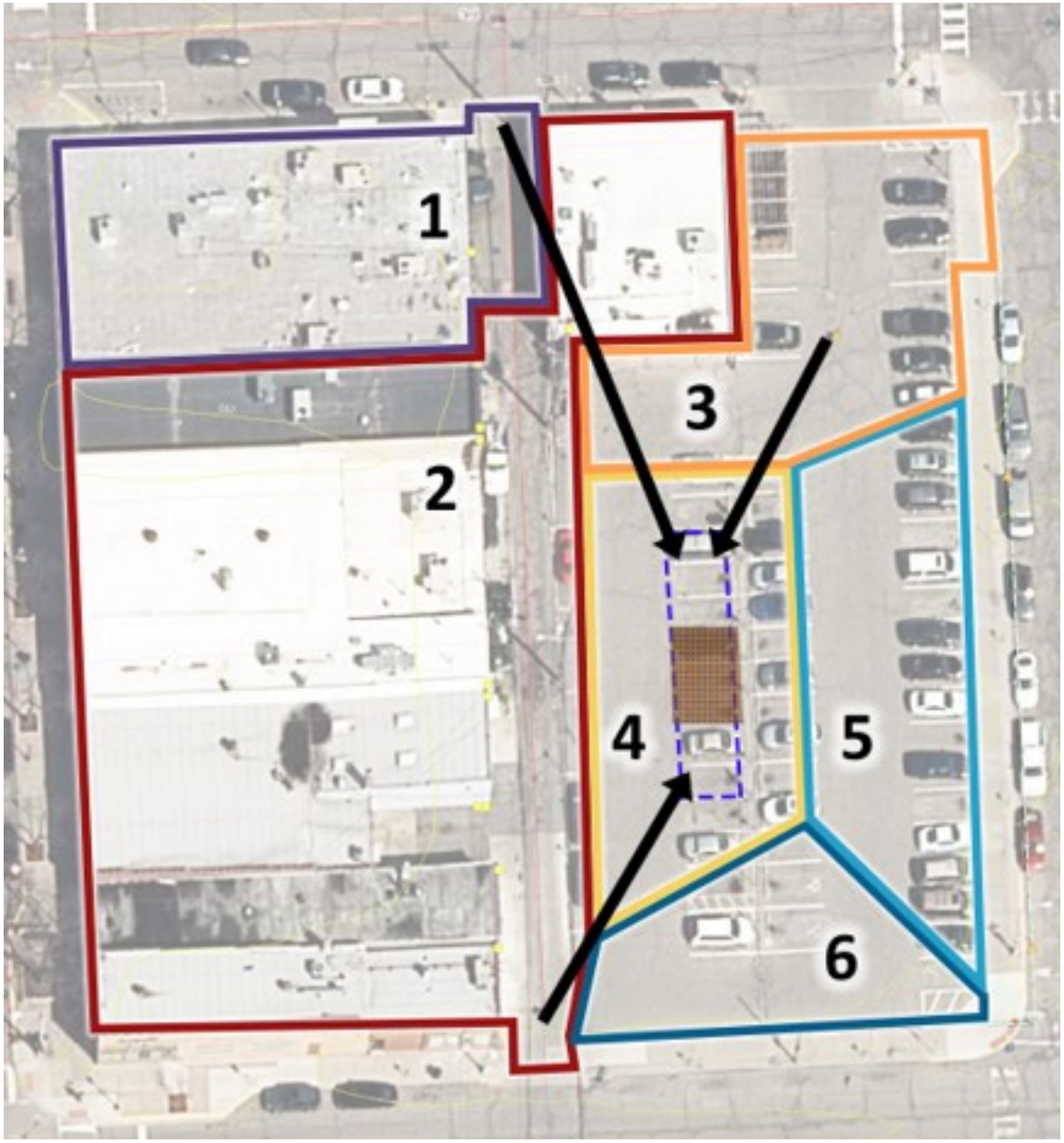


DOWNTOWN CITY PARKING LOT ALTERNATIVE 2B CATCH BASINS TO CHAMBER STORAGE

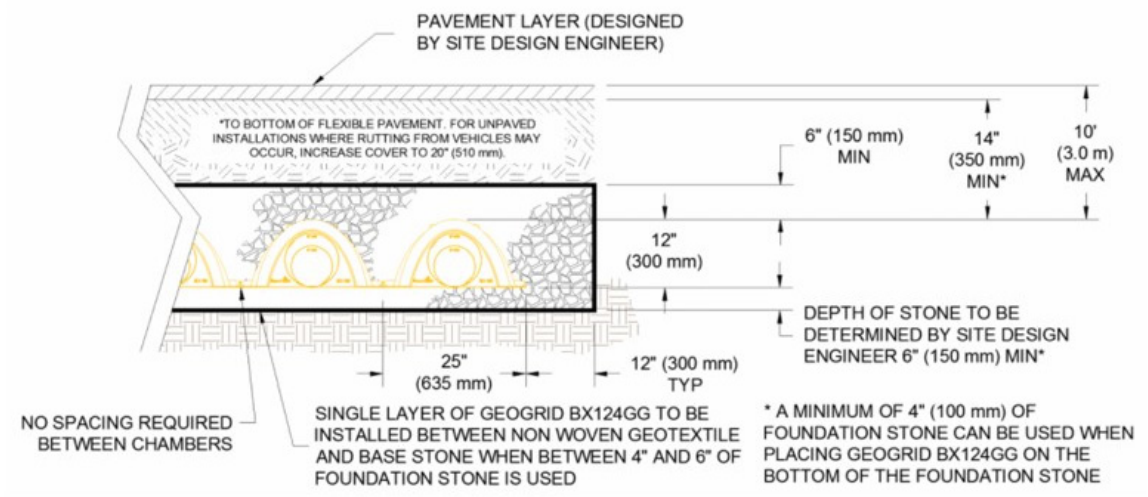
DA1-3: Catch Basins Diverted to DA4

DA4: 20 ft x 82 ft Chamber Storage with 3 Parking Spaces Permeable

DA5 & 6: Untreated



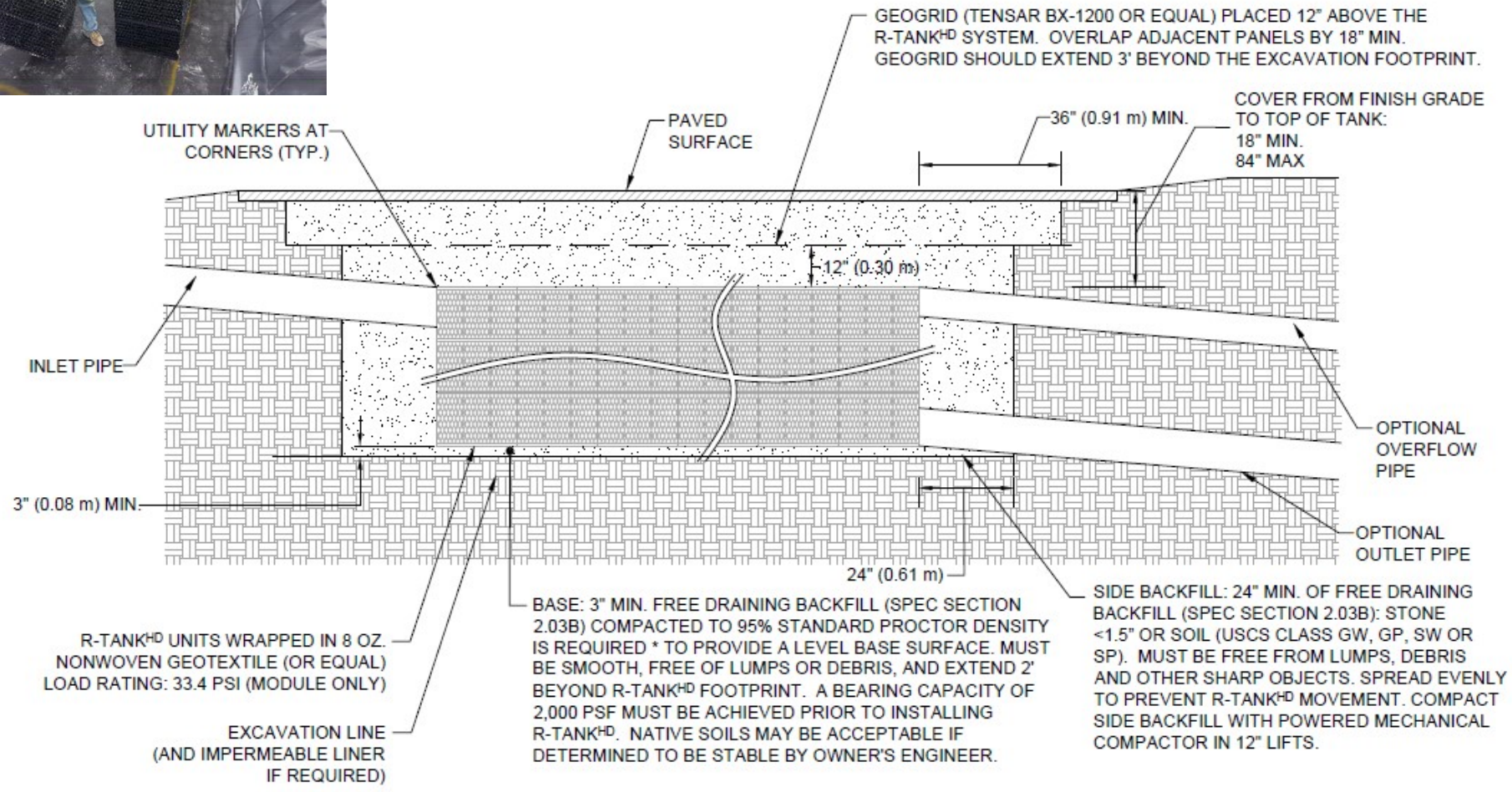
DOWNTOWN CITY PARKING LOT ALTERNATIVE 2B STORMTECH ARCH CHAMBERS





DOWNTOWN CITY PARKING LOT ALTERNATIVE 2B R-TANK CHAMBERS DETAIL

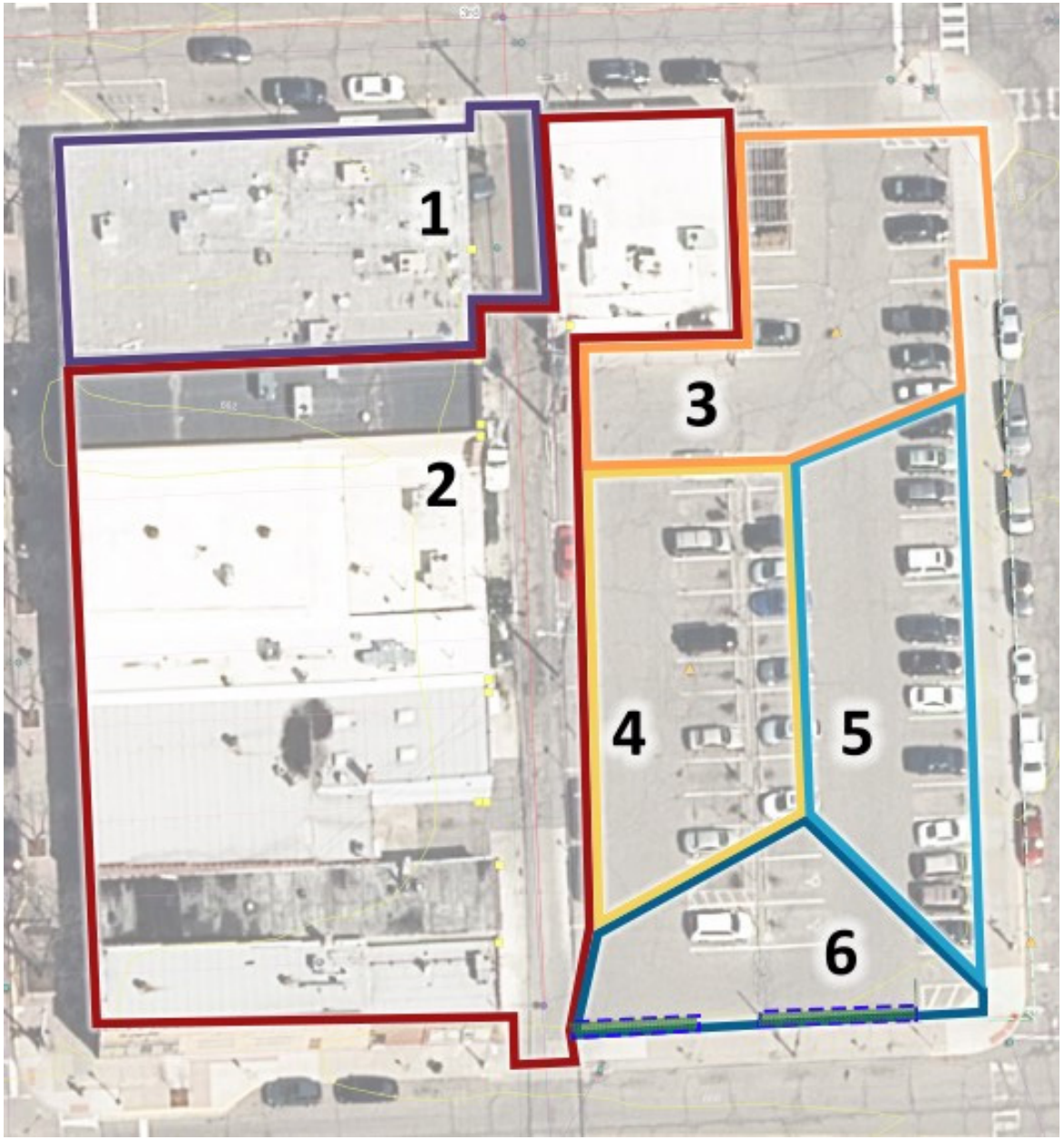




DOWNTOWN CITY PARKING LOT ALTERNATIVE 3 BIORETENTION

DA 1-5: Not Treated

DA 6: 3 ft wide Bioretention extending into sidewalk



DOWNTOWN CITY PARKING LOT ALTERNATIVE 3 BIORETENTION RENDERING



Existing condition



Proposed condition

DOWNTOWN CITY PARKING LOT ALTERNATIVE 3 CURBED BIORETENTION DETAIL

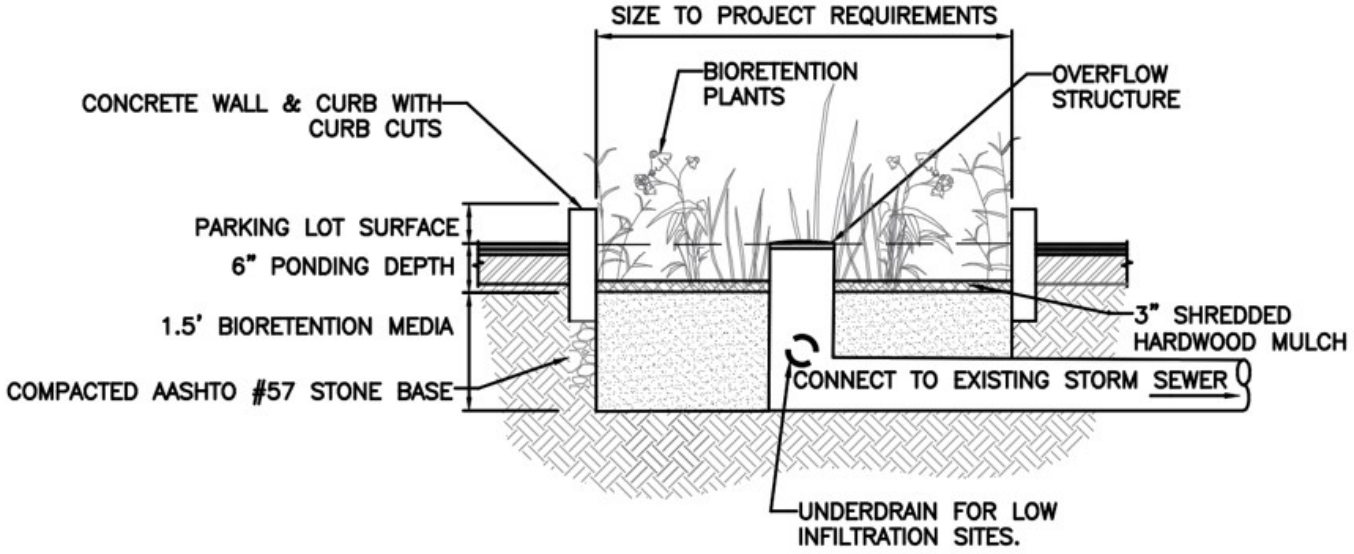


Exhibit 10 Downtown City Parking Lot Design Summary

ALTERNATIVE	TREATMENT	TREATMENT AREAS	TREATMENT SA (SF)	DEPTH (FT)	VOLUME TREATED (CF)	VOLUME REQUIRED (CF)	TOTAL COST	COST/CF TREATED
1	Permeable Pavers and Reservoirs in DA3-6	DA3-6	1,672	1.5 to 2.8	2,918	2,793	$59,700	$20.45
2A	Permeable Pavers and Stone Reservoir in DA4, DA1-3 Diverted to DA4	DA1-4	2,640	3.5	5,874	5,816	$102,900	$17.52
2B	Permeable Pavers and Chamber Reservoir in DA4, DA1-3 Diverted to DA4	DA1-4	1,638	2.5	5,822	5,816	$117,300	$20.15
3	Bioretention in DA6	DA6	255	2	542	498	$35,400	$65.27

WOODWARD ALLEY/ALTERNATIVE 2 CENTER-STRIP PERMEABLE PAVERS AND CHAMBER STORAGE

There were several options considered in the initial analysis phase including:

- Permeable pavers along the length of the alley
- Stone or plastic chamber underground reservoirs for storage
- At and below grade bioretention planters at select locations

Based on analysis, there are three design alternatives presented herein:

- Alternative 1 – 3 foot wide Permeable Paver Center with 9 foot wide Stone Reservoir
- Alternative 2 – 3 foot wide Permeable Paver Center with Chamber Storage
- Alternative 3 – Planter Box/Bioretention

The soil boring in the alley indicated significant fill and likely poor infiltration capacity of the native soils so underdrains are recommended for all designs. Overall, the drainage areas along the reservoir are irregular with the alley intermittently capturing runoff from adjacent buildings and parking lots. However, instead of implementing different practices in different drainage areas, it is recommended that the green stormwater infrastructure be installed continuously along the length of the alley.

Based on information provided on underground utilities, it is feasible to install a stone reservoir (Alternative 1) or chambered storage reservoir (Alternative 2) in the center of the alley; however the reservoir would be located over a sanitary sewer and gas service leads should be accounted for in final design. With regards to planter boxes or bioretention cells, there are a couple of possible applications along the length of the alley so one was included as Alternative 3 as an example.

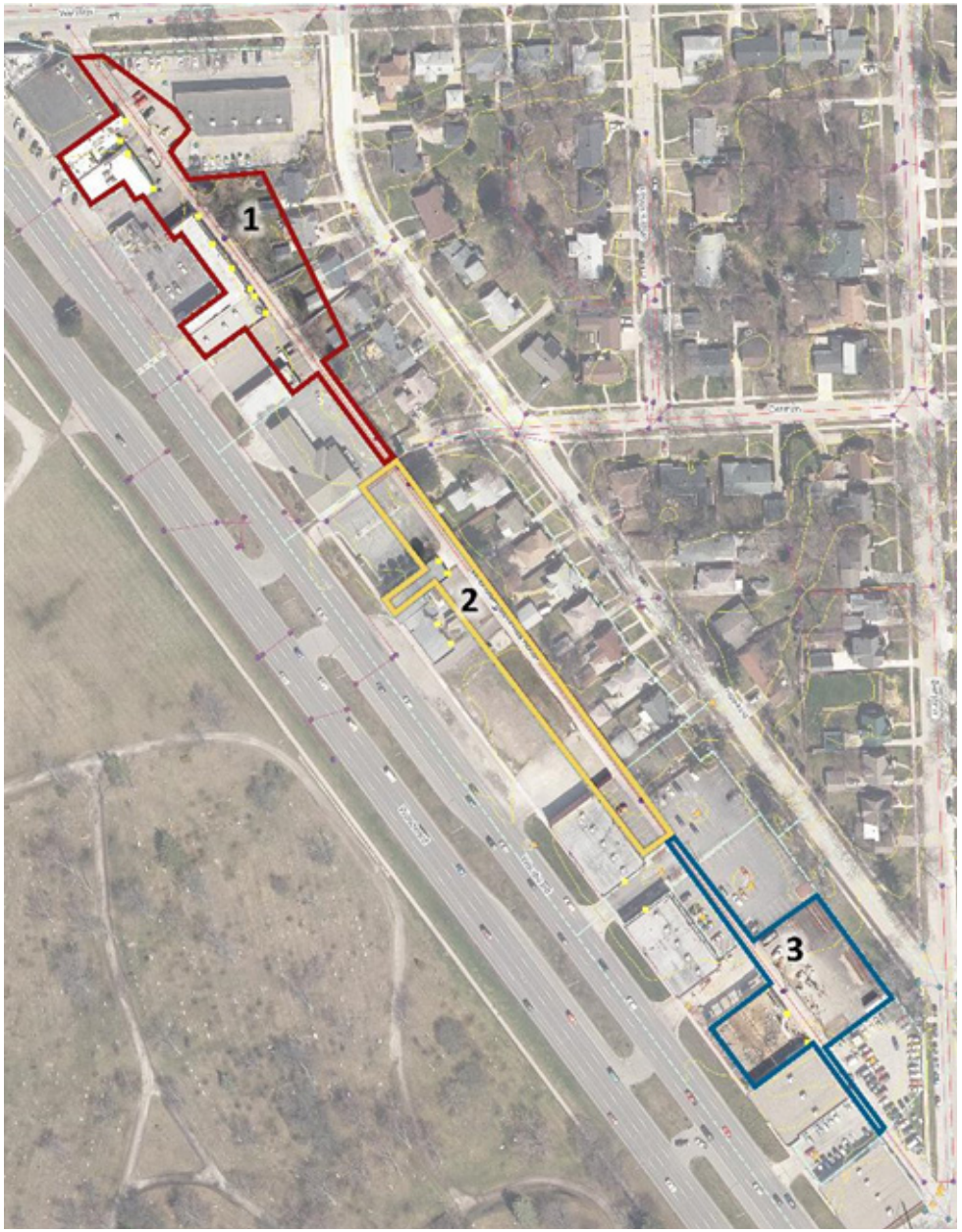


WOODWARD ALLEY ALTERNATIVES

Alternative 1
3’ Permeable Pavers Center Strip with 9’ Stone Reservoir

Alternative 2
3’ Permeable Pavers Center Strip with Chamber Storage

Alternative 3
Planter Box/Bioretention

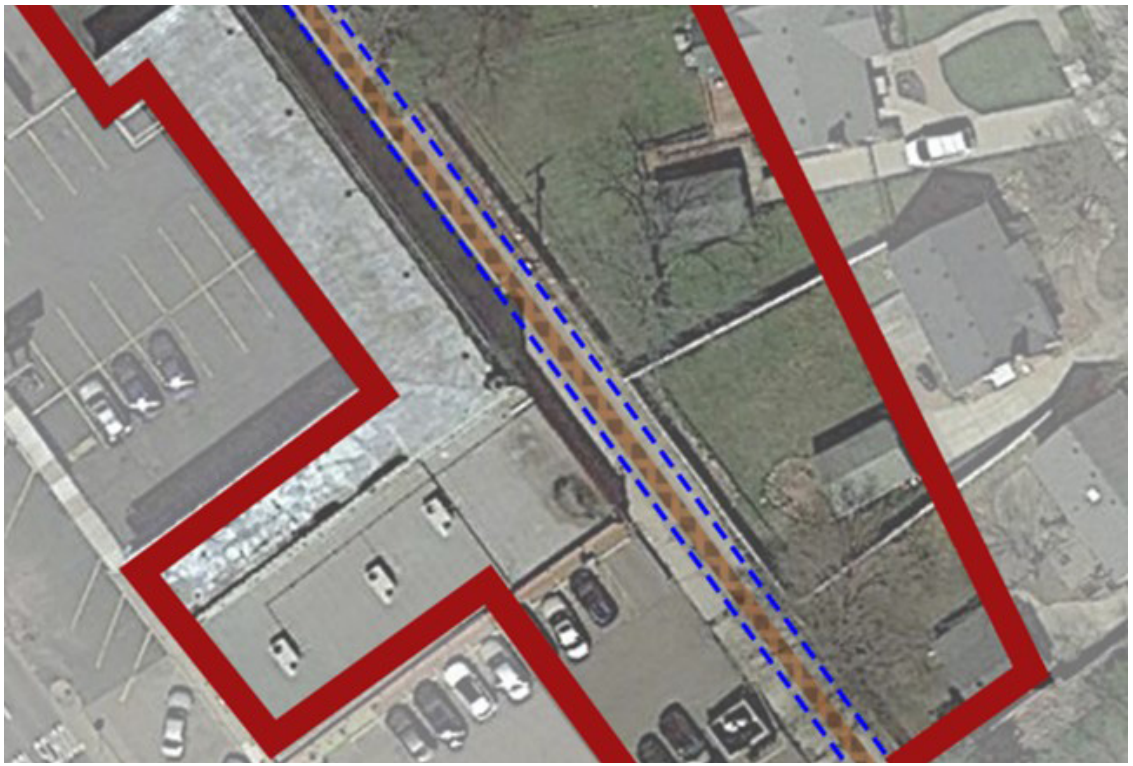


WOODWARD ALLEY ALTERNATIVE 1 PERMEABLE PAVERS



3 ft Wide Center Strip of Permeable Pavers, Full Length of Alley

9 ft Wide Stone Reservoir



WOODWARD ALLEY ALTERNATIVE 1 PERMEABLE PAVERS WITH STONE RESERVOIR

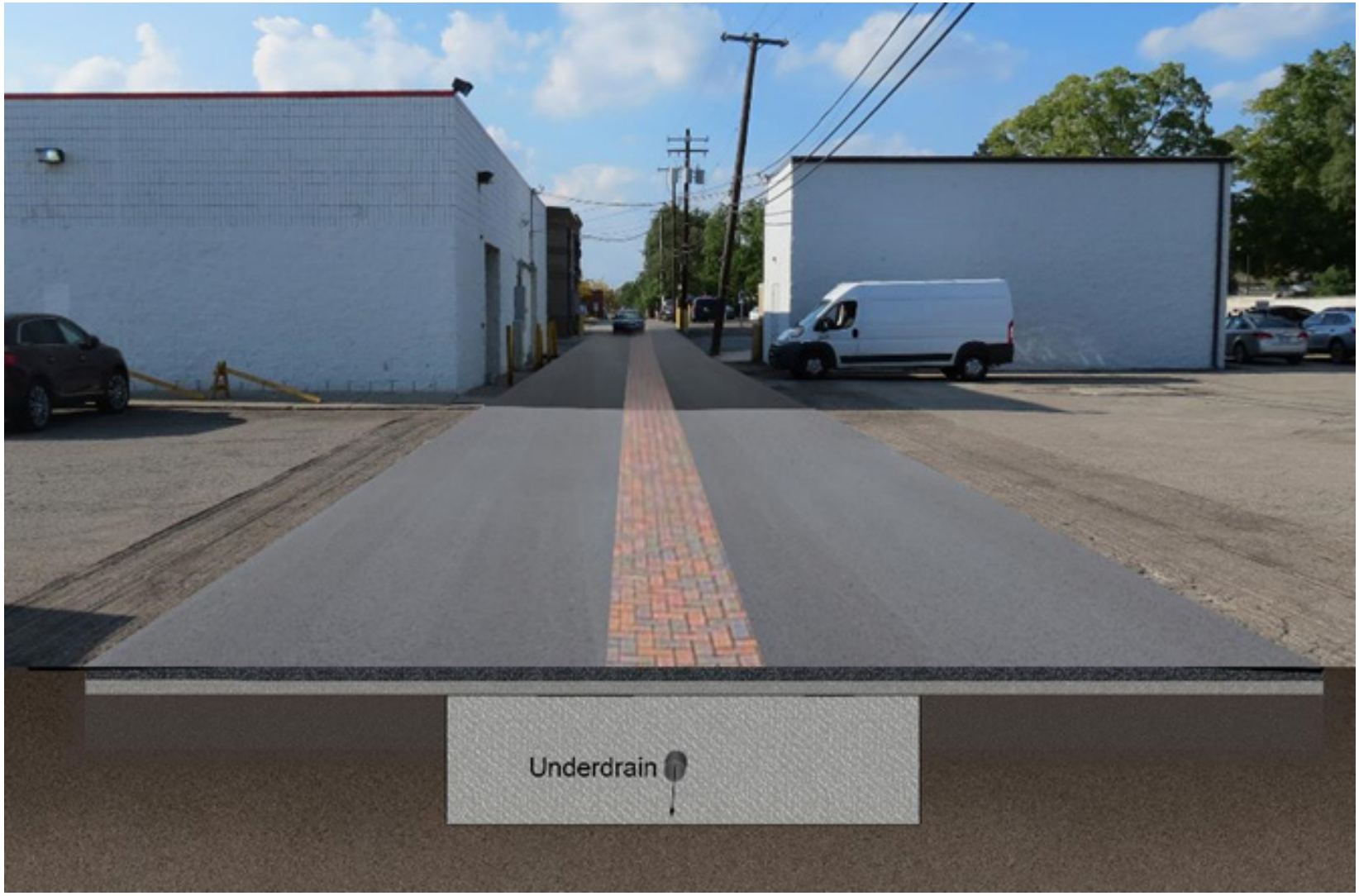


Existing condition



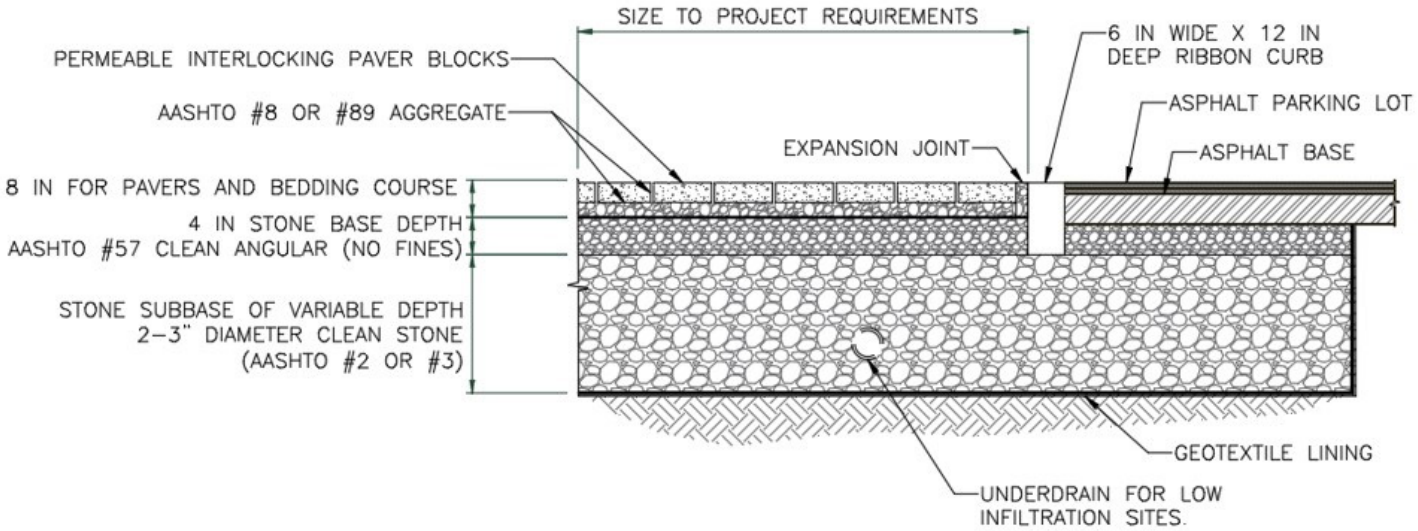
Proposed condition

WOODWARD ALLEY ALTERNATIVE 1 PERMEABLE PAVERS WITH STONE RESERVOIR AND ALLEY REPAIR



Note: Full alley repaving not included in cost estimate

WOODWARD ALLEY ALTERNATIVE 1 STONE RESERVOIR UNDER PAVERS AND ASPHALT DETAIL



WOODWARD ALLEY UTILITY CONFLICTS

Sanitary line in center of alley approximately 8 ft below grade

Gas line approximately 3 ft off east side of alley right of way at unknown depth

Individual property gas connections potentially through proposed reservoir area



WOODWARD ALLEY ALTERNATIVE 2 CHAMBER STORAGE

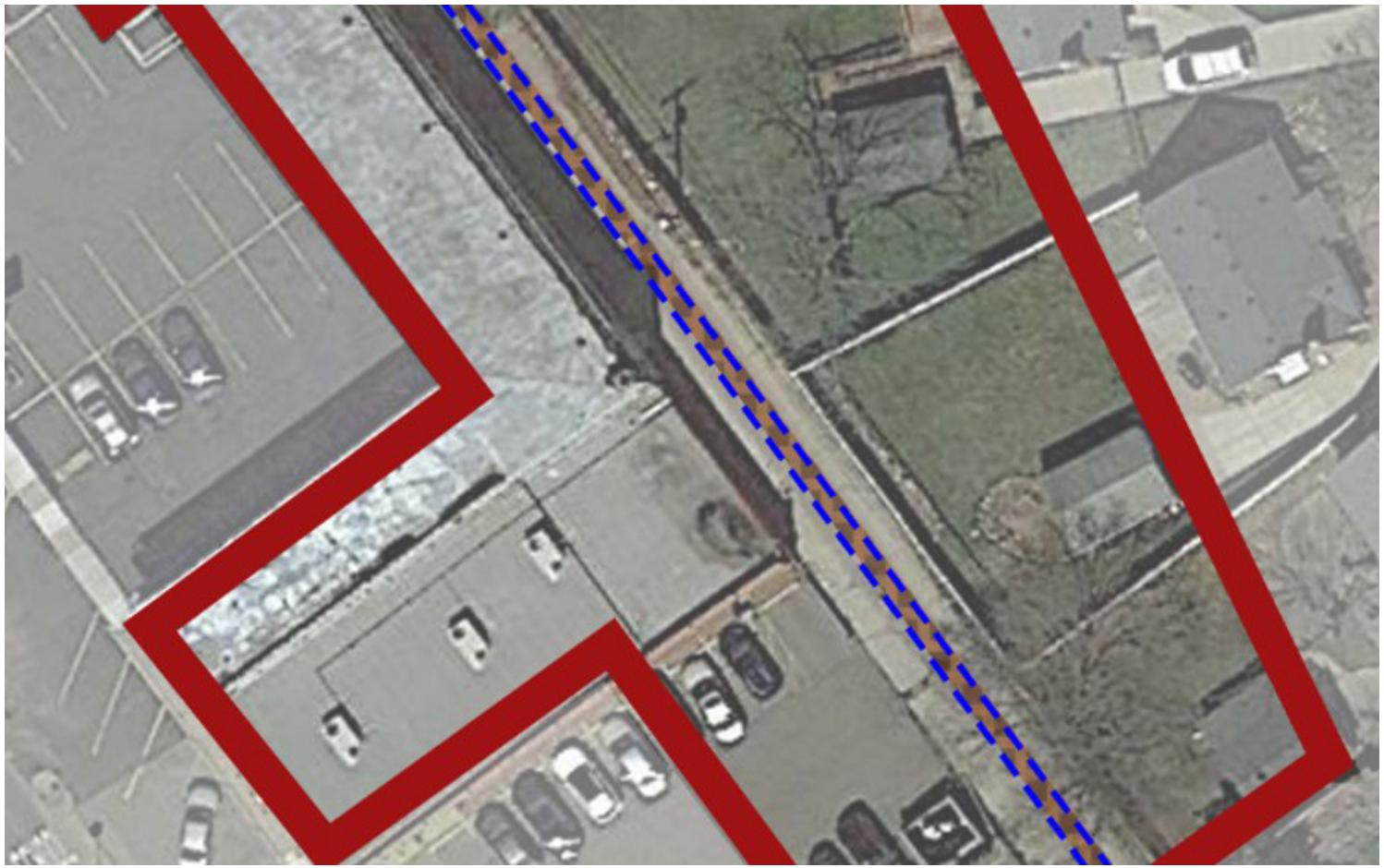




Permeable pavement or catch basins (not shown) directing flow into underground storage chambers

Approx. 4 ft x Full Length of Alley of Underground Storage Chambers

WOODWARD ALLEY ALTERNATIVE 2 CHAMBER STORAGE

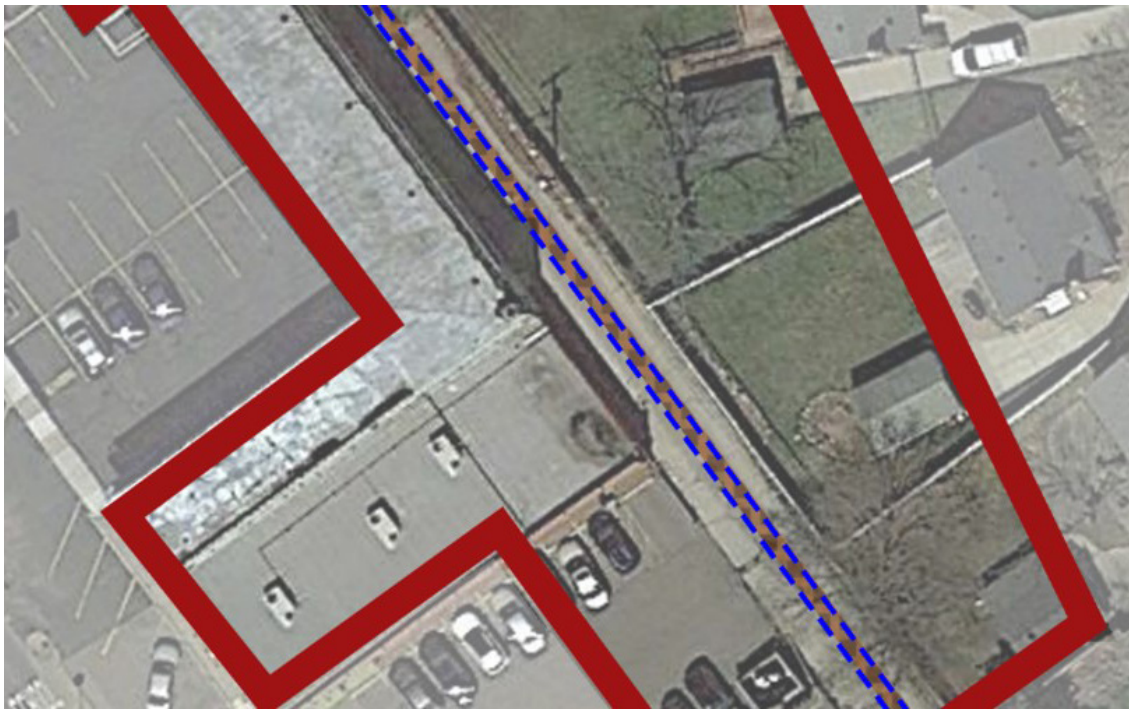


WOODWARD ALLEY ALTERNATIVE 2 CHAMBER STORAGE



3 ft Wide Center Strip of Permeable Pavers, Full Length of Alley or Catch Basins (not shown)

Chamber Storage under pavers



WOODWARD ALLEY ALTERNATIVE 2 PERMEABLE PAVERS WITH CHAMBER RESERVOIR

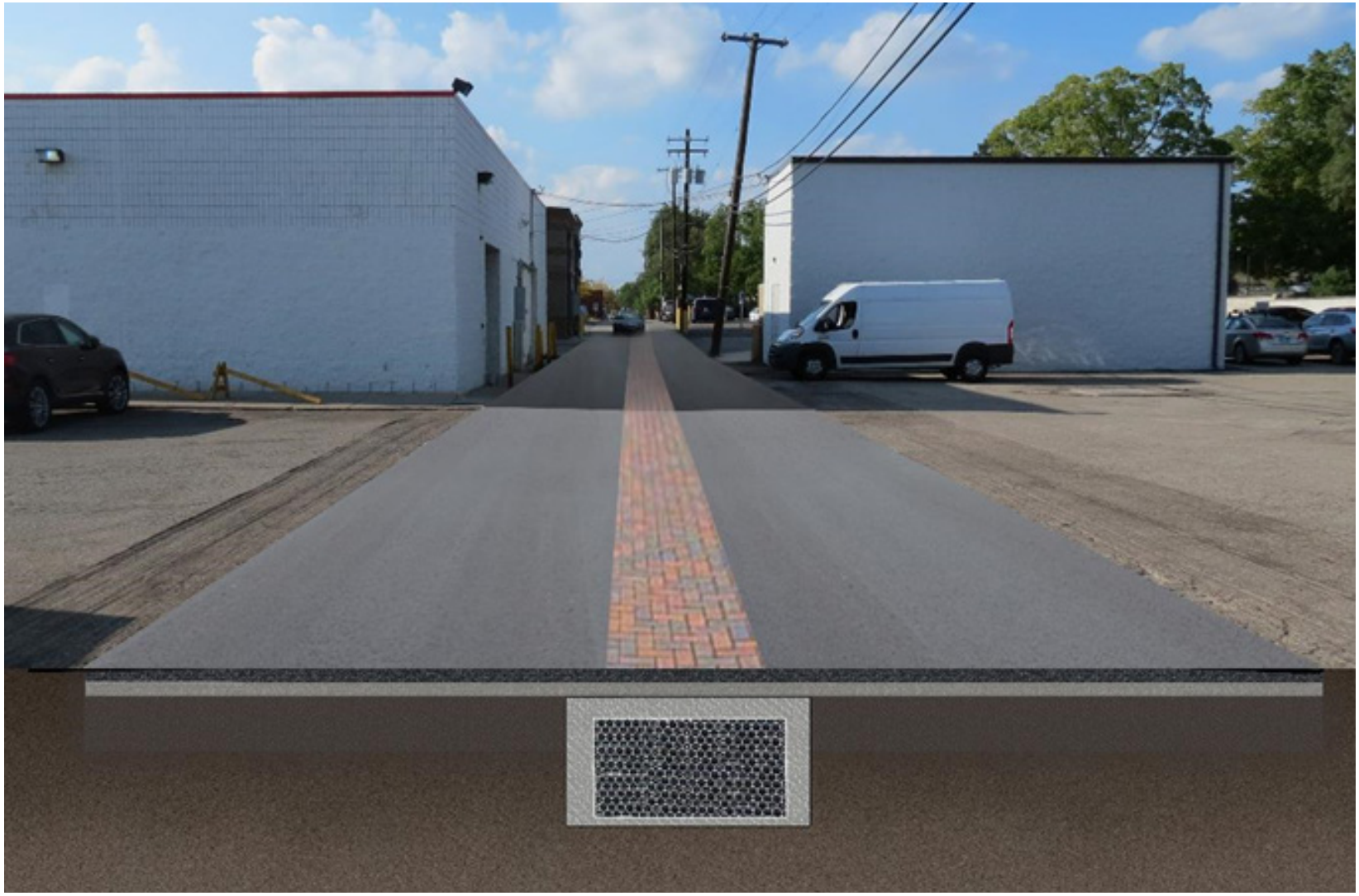


Existing condition



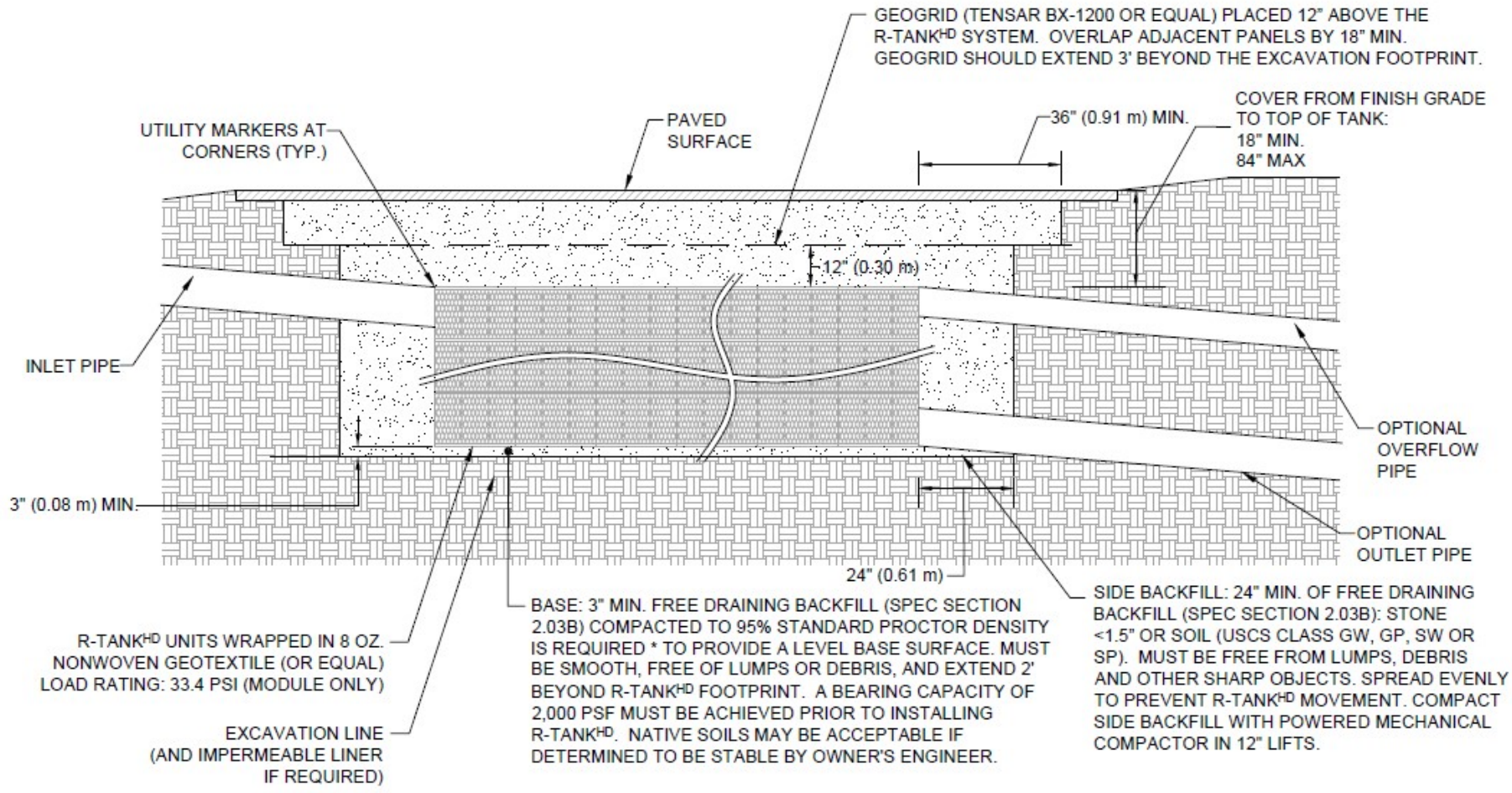
Proposed condition

WOODWARD ALLEY ALTERNATIVE 2 PERMEABLE PAVERS WITH CHAMBER RESERVOIR AND ALLEY REPAIR

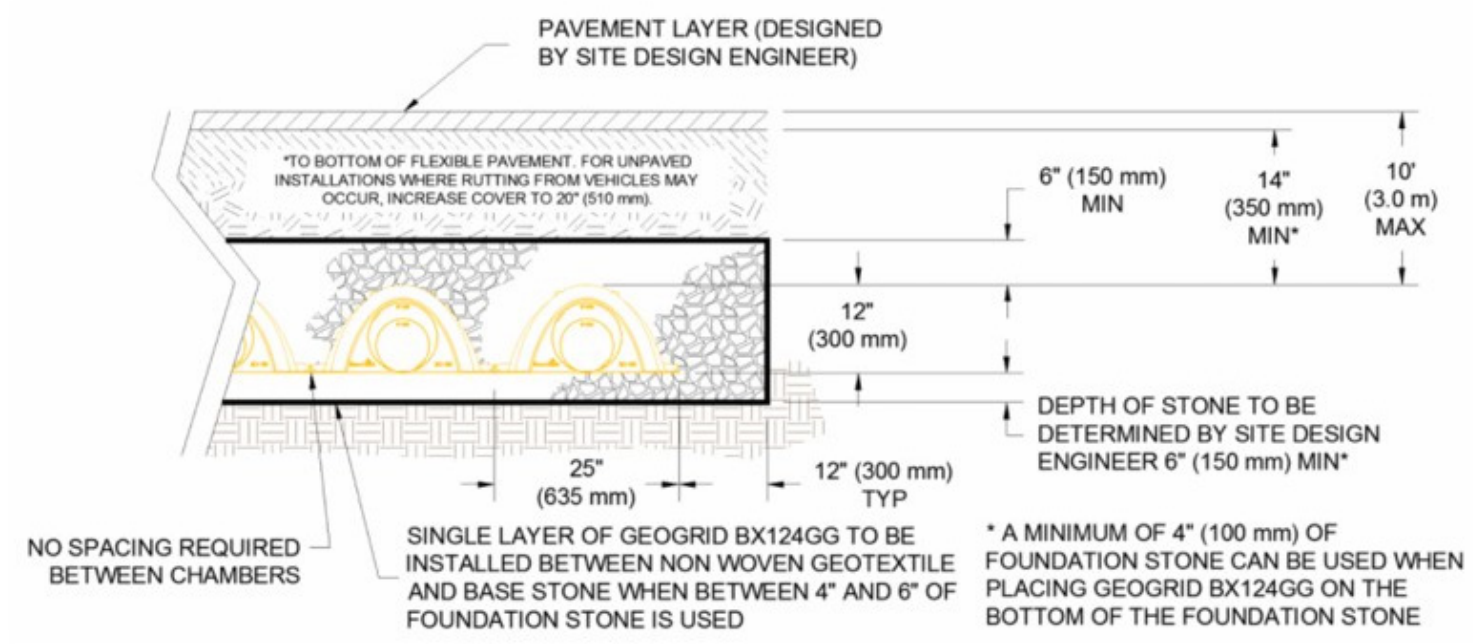


Note: Full alley repaving not included in cost estimate

WOODWARD ALLEY ALTERNATIVE 2A R-TANK CHAMBERS DETAIL



WOODWARD ALLEY ALTERNATIVE 2B STORMTECH ARCH CHAMBERS





WOODWARD ALLEY ALTERNATIVE 3 BIORETENTION

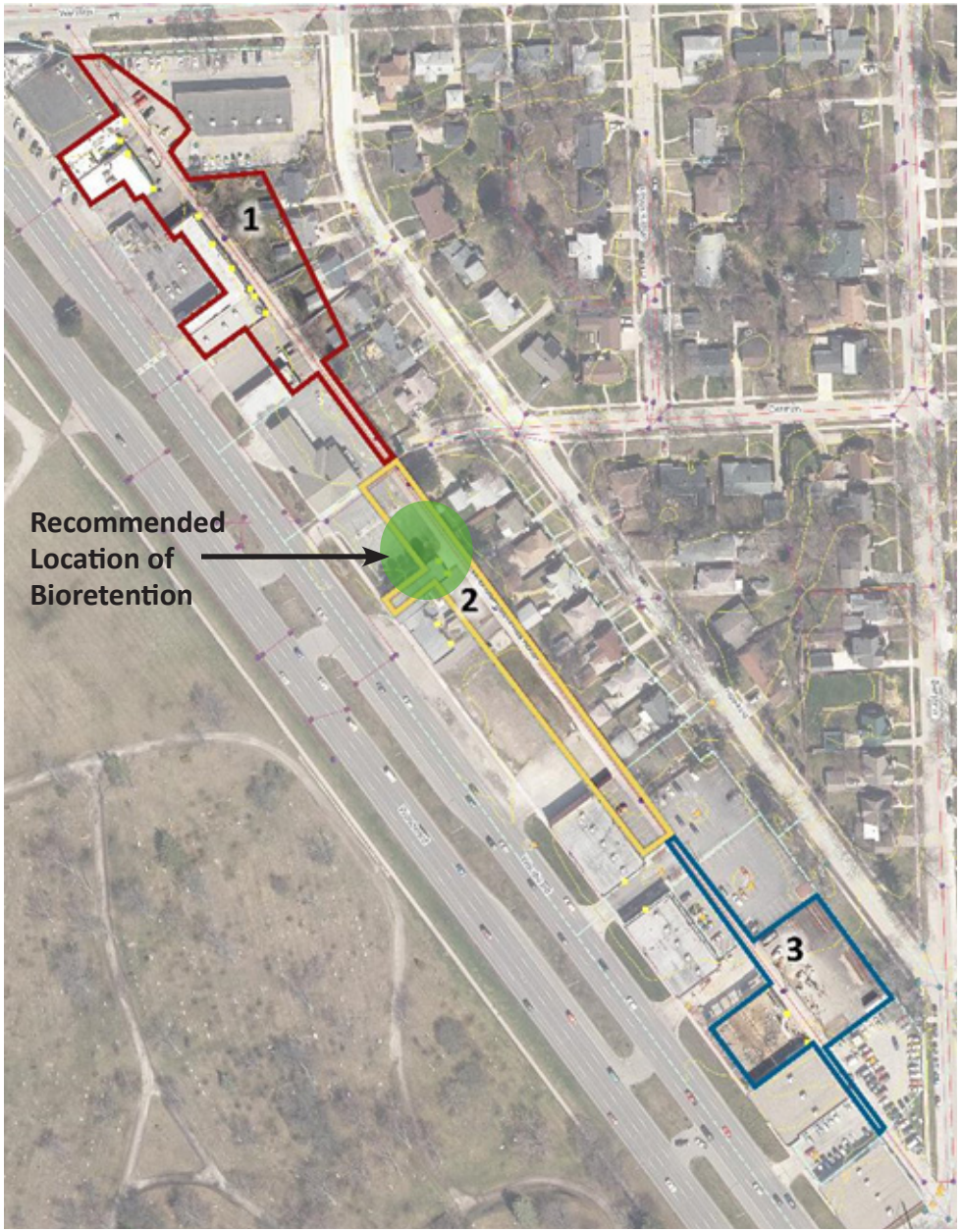
Open-Bottom Planter Boxes Capturing Roof Runoff

Curbed Edges or Raised Planter Boxes

Raised for Less Excavation and More Storage



WOODWARD ALLEY ALTERNATIVE 3
BIORETENTION LOCATION



WOODWARD ALLEY ALTERNATIVE 3 BIORETENTION /PLANTER BOXES



Existing condition



Proposed condition

WOODWARD ALLEY ALTERNATIVE 3 CURBED BIORETENTION DETAIL

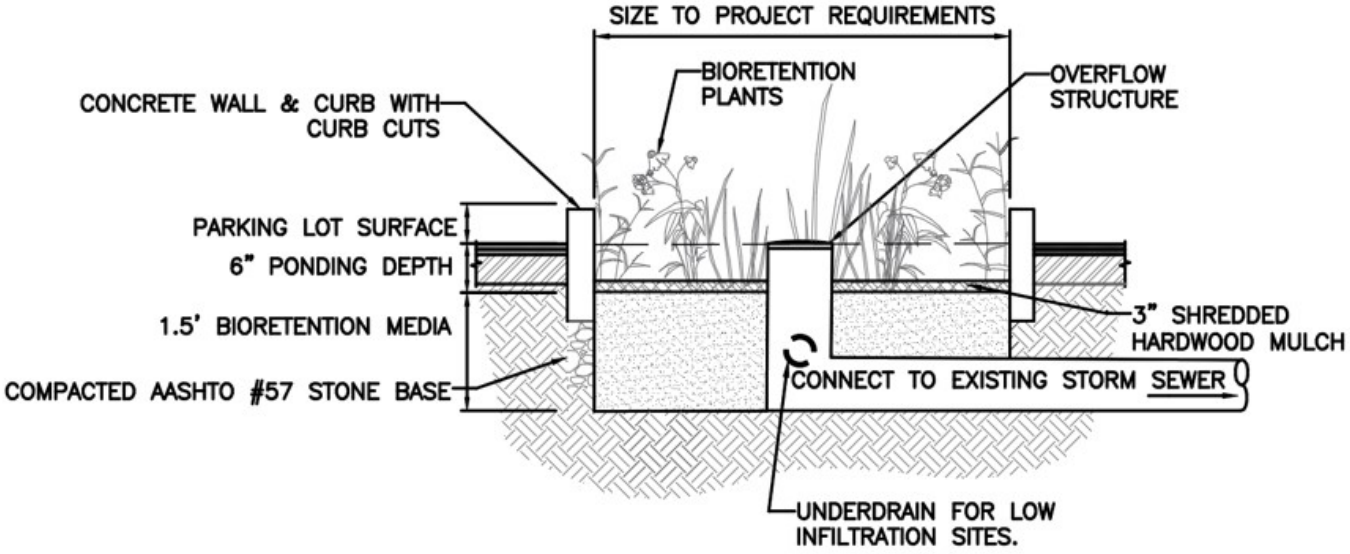


Exhibit 11 Woodward Alley Design Summary

ALTERNATIVE	TREATMENT	TREATMENT SA (SF)	DEPTH (FT)	VOLUME TREATED (CF)	VOLUME REQUIRED (CF)	TOTAL COST	COST/CF TREATED
1	Permeable Pavers with Stone Reservoir	15,282	3.2	14,671	13,890	$520,600	$35.48
2	Permeable Pavers with Chamber Storage	5,848	3	16,131	13,890	$418,400	$25.94
3	Bioretention in DA2	200	2.5	220	3,932	$3,900	$17.82

LOCAL STREETS - WOODWARDSIDE SUBDIVISION/2A TRENCH DRAIN AND STONE RESERVOIR

There were several options considered in the initial analysis phase including:

- Bioretention or grass swales in the right of way in tree-less locations
- Stone or plastic chamber underground reservoirs under the local streets
- Permeable pavers along street edges (with or without curbs)
- Catch basins and edge drains for capturing stormwater runoff and directing flow into underground reservoirs

A site investigation of the subdivision indicated there are very few locations in the right of way (between the sidewalk and curb) that do not include mature trees. These locations could be retrofit with rain gardens but the total volume captured would be relatively small when compared to the runoff volume of the entire neighborhood. In addition, the soils analysis indicated likely poor infiltration capacity of the native soils so underdrains are recommended for all designs.

Based on analysis, there are two design alternatives presented herein:

- Alternative 1 – 4 foot wide Section of Permeable Pavers along curb (in parking areas). This alternative have two design options for underground storage of stormwater:
  - Stone Reservoir
  - Proprietary Plastic Chamber Reservoir
- Alternative 2 – Trench drain in gutter to serve as inlet to underground storage. This alternative have two design options for underground storage of stormwater:
  - Stone Reservoir
  - Proprietary Plastic Chamber Reservoir

Based on existing underground utilities, poorly infiltrating soils, and potential of high water table, the underground storage must be designed to be no more than three feet below ground. The options for underground storage of



stormwater is identical for Alternative 1 and 2. For Alternative 1, the existing infrastructure would have to retrofit such that catch basins serve as either the inlet for the reservoir or the overflow outlet. It is feasible to retrofit/replace a catch basin to serve both inlet and outlet functions, but the hydraulics of such a structure would have to be analyzed during design. For Alternative 2, the trench drain along the gutter serves as the inlet and existing catch basins would serve as the outlet structure. Finally, if the stone reservoir option is implemented, only 91% of the 98th percentile design storm can be captured.

WOODWARDSIDE SUBDIVISION ALTERNATIVES

Local Streets (Areas 1 – 4)

Alternative 1: Permeable Pavers

- **Alternative 1A:** With Stone Reservoir
- **Alternative 1B:** With Chamber Reservoir

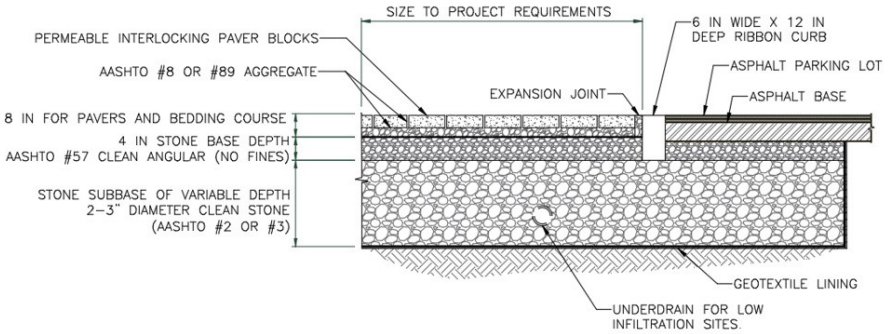
Alternative 2: Trench Drain

- **Alternative 2A:** With Stone Reservoir
- **Alternative 2B:** With Chamber Reservoir

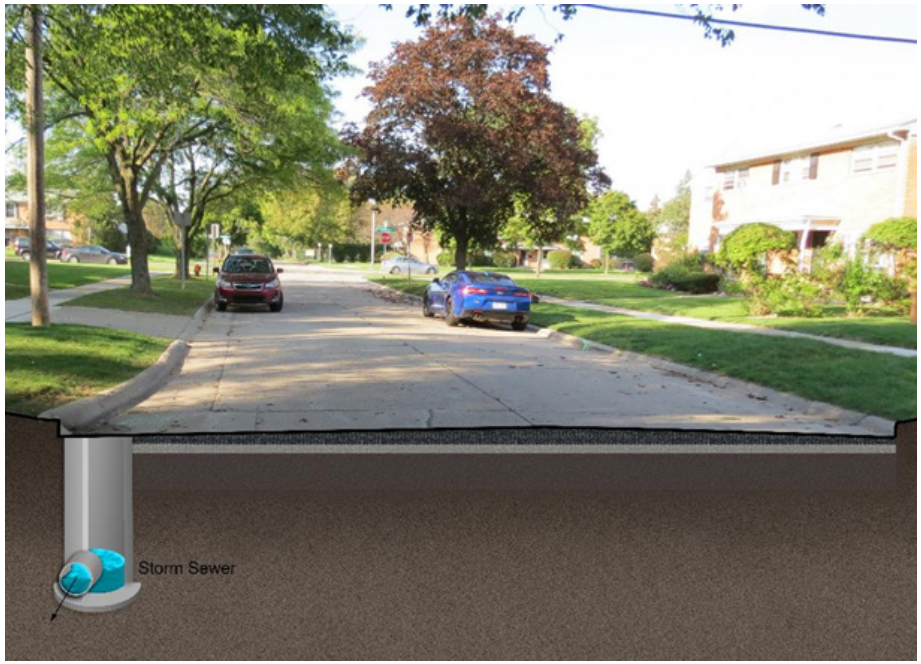


WOODWARDSIDE SUBDIVISION ALTERNATIVE 1A PERMEABLE PAVERS WITH STONE RESERVOIR





4’ Permeable Pavement on Each Side of Street
Stone Reservoir Across Full Roadway



Existing condition

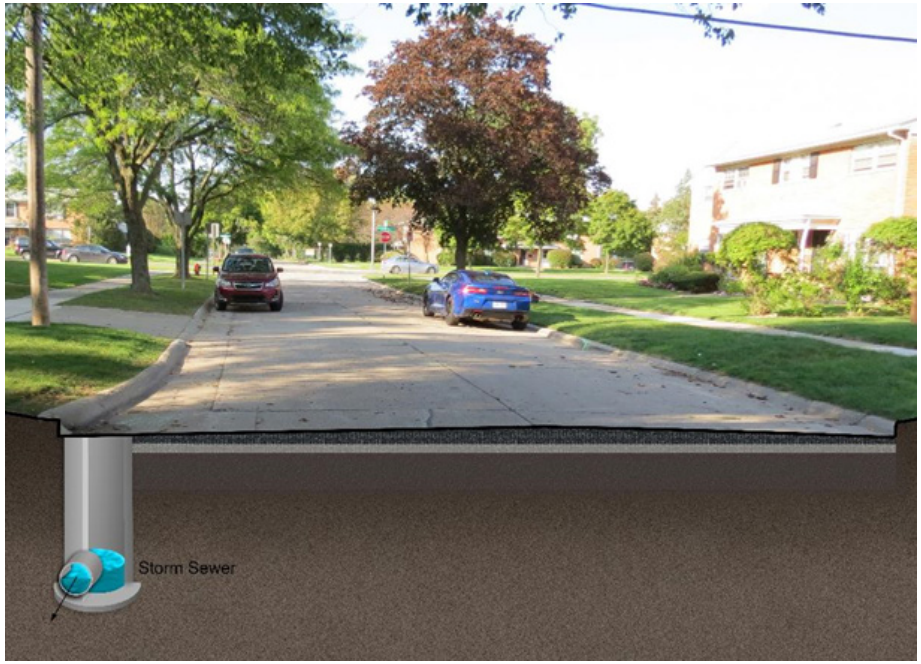


Proposed condition

WOODWARDSIDE SUBDIVISION ALTERNATIVE 1B PERMEABLE PAVERS WITH CHAMBER RESERVOIR



4’ Permeable Pavement on Each Side of Street
16 feet wide of Chamber Reservoirs

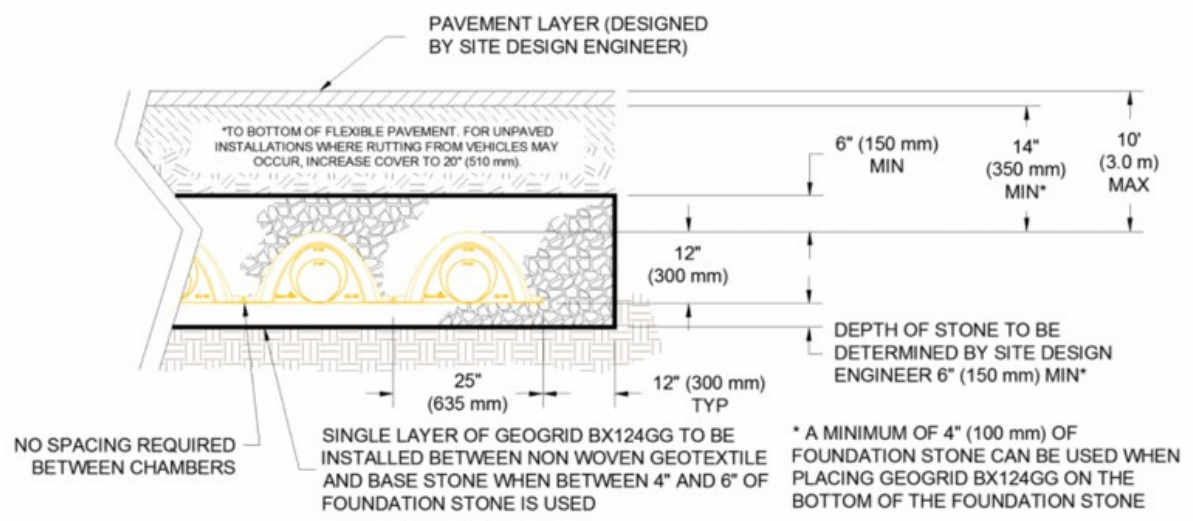


Existing condition



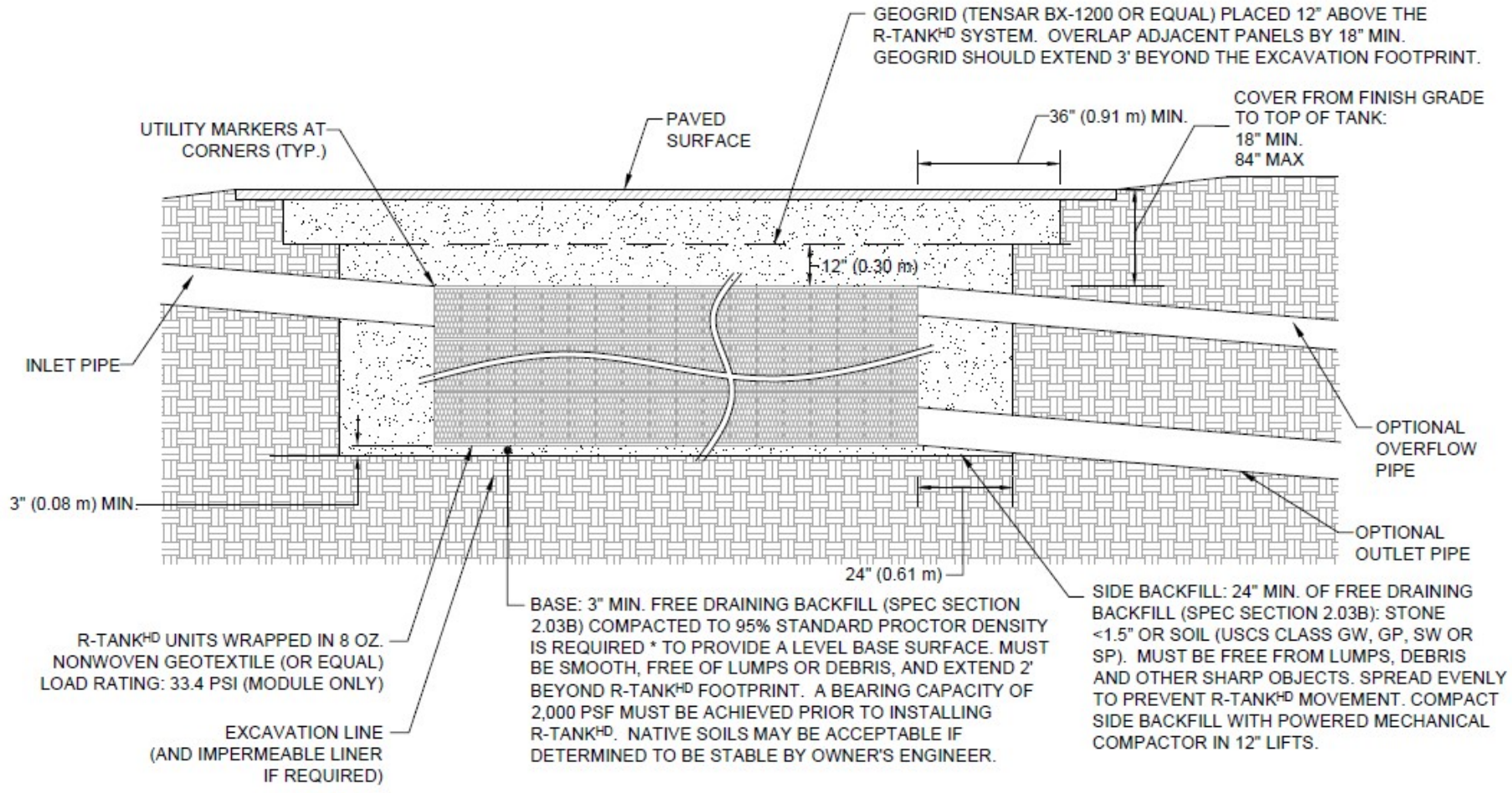
Proposed condition

WOODWARDSIDE SUBDIVISION ALTERNATIVE 1B STORMTECH ARCH CHAMBERS





WOODWARDSIDE SUBDIVISION ALTERNATIVE 1B R-TANK CHAMBERS DETAIL



WOODWARDSIDE SUBDIVISION ALTERNATIVE 2A TRENCH DRAIN WITH STONE RESERVOIR





Trench drain to stone reservoir across full street



Existing condition



Proposed condition

WOODWARDSIDE SUBDIVISION ALTERNATIVE 2B TRENCH DRAIN WITH CHAMBER RESERVOIR



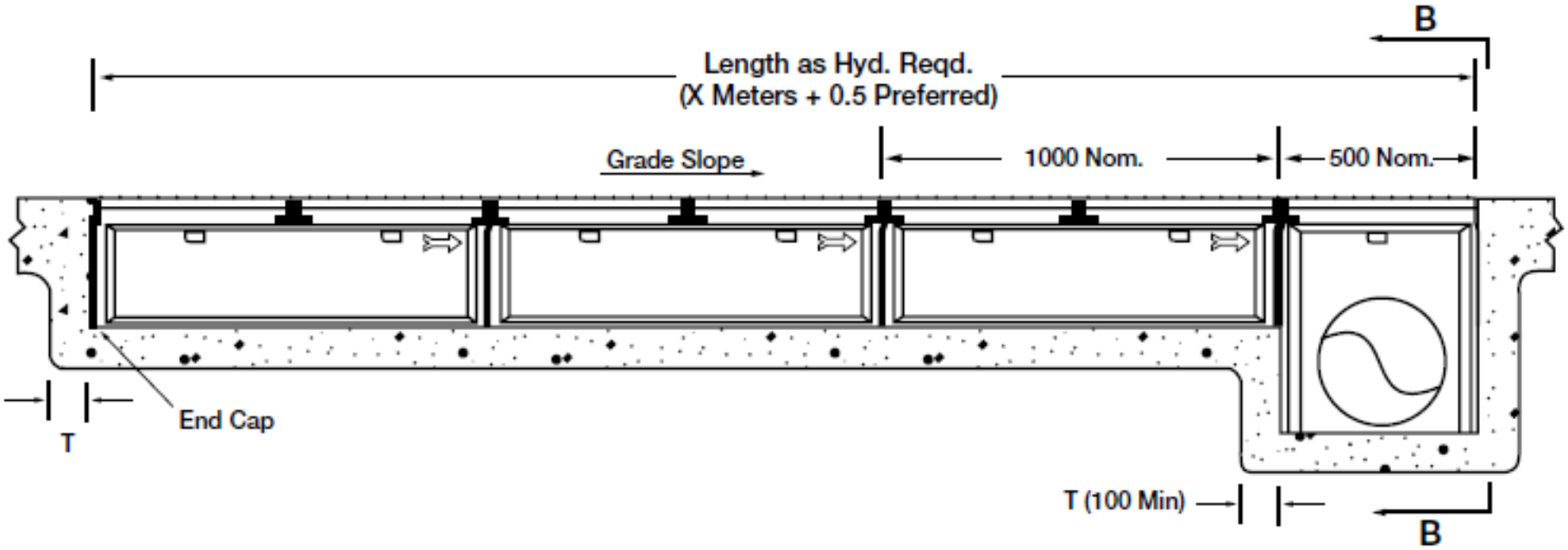
Existing condition

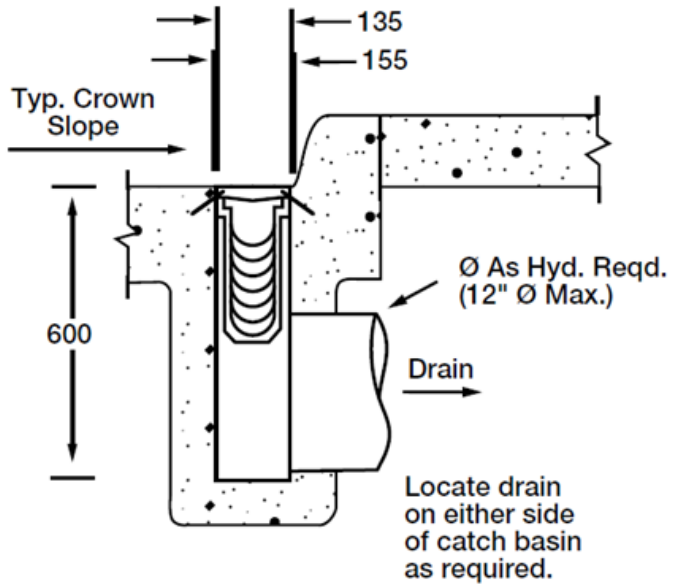


Proposed condition

Trench Drain to 16’ of Chamber Reservoir Along Entire Roadway

WOODWARDSIDE SUBDIVISION ALTERNATIVE 2 TRENCH DRAIN DETAIL





WOODWARDSIDE SUBDIVISION ALTERNATIVES REDUCTION CHART (AREAS 1 - 4)

Exhibit 8 Woodwardside Subdivision Design Summary

ALTERNATIVE	TREATMENT	TREATMENT SA (SF)	DEPTH (FT)	VOLUME TREATED (CF)	VOLUME REQUIRED (CF)	TOTAL COST	COST/CF TREATED
1A	Permeable Pavers w/Stone	33,528	2.75	27,661	30,410	$1,013,330	$36.63
1B	Permeable Pavers w/Chambers	21,340	1.42	31,852	30,410	$971,400	$30.50
2A	Trench Drain w/Stone	33,528	2.75	27,661	30,100	$779,670	$28.19
2B	Trench Drain w/Chambers	21,340	1.42	31,852	30,100	$737,750	$23.16

Alternatives 1B and 2B have a reservoir depth of 1.42', but require at least 18" of cover, so actual depth will be close to 36" maximum depth specified by Royal Oak for the residential areas.

Exhibit 9 Woodwardside Subdivision Extrapolated Reductions

	SIZE (ACRES)	IMPERVIOUS %	SA OF RESERVOIR (FT^2)	TOTAL TREATED VOLUME (FT^3)
Alternative 1A				
Areas 1-4	9.64	46%	33,528	27,661
Full Pilot Area	62.25	46%	216,506	178,617
Alternative 1B				
Areas 1-4	9.64	46%	21,340	31,852
Full Pilot Area	62.25	46%	137,804	205,681
Alternative 2A				
Areas 1-4	9.64	46%	33,528	27,661
Full Pilot Area	62.25	46%	216,506	178,617
Alternative 2B				
Areas 1-4	9.64	46%	21,123	31,852
Full Pilot Area	62.25	46%	136,398	205,681

15.5% Ratio of Areas 1-4 to Pilot Area

MAJOR ROAD - CAMPBELL ROAD 14 MILE TO 11 MILE/POROUS PAVEMENT GUTTER PAN

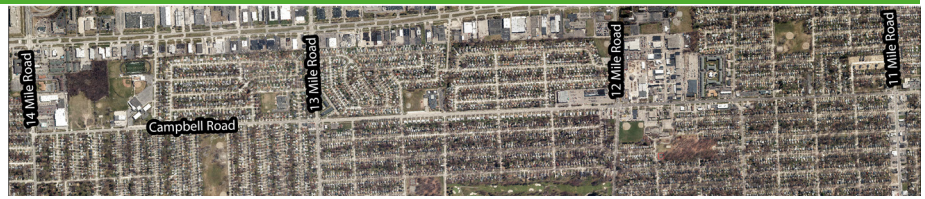
Early in the evaluation phase of this pilot project site, the design team identified several alternative GI projects including lane width reductions (Road Diet), pervious pavement sections and roadside bioretention. However, it was determined during initial reviews that lane reductions and roadside bioretention were not feasible for this 3-mile corridor. Lane reductions were not viable due to the heavy traffic volume this corridor carries. Roadside bioretention (the lawn area between the curb and sidewalk) was not feasible due to the number of mature trees planted in the roadside lawns, particularly along the west side of the corridor, which also happens to be all within the City's right-of-way. Each looked promising until the realities for construction were more closely evaluated by the team and City. However, one option presented a potentially feasible alternative:

- Permeable pavers at the street edge

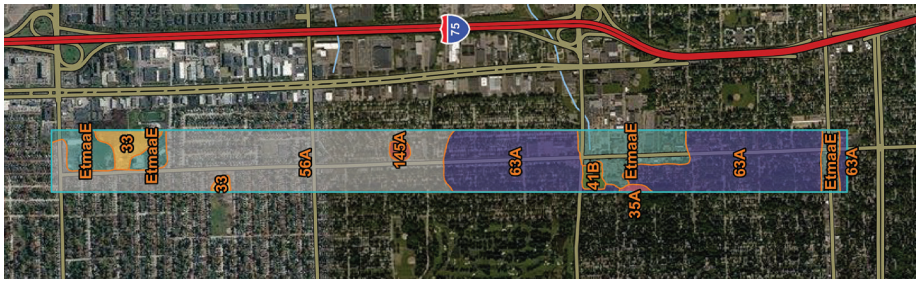
The permeable pavers alternative will have limitations due to the poor infiltration capacity of soils discovered during the soils evaluation, so underdrains are recommended for this design.

The recommended pilot project evaluated was refined to propose a curbside storage trench beneath the gutter pan area that would capture runoff and then overflow once the aggregate storage layer is filled to the existing catch basins. This alternative could be constructed without the need to implement a full pavement section reconstruction by simply retrofitting the curb and gutter with this design.

The construction cost per volume of runoff removed is high for this alternative and would require additional design and engineering to optimize the design to reach the maximum return on investment for this pilot project should it be advanced to implementation. Opportunities to implement GI on major roads do exist and should be evaluated on a case-by-case basis.



STUDY CORRIDOR 11 MILE TO 14 MILE ROADS



- NRCS Mapped with a mixture of Urban Land Soils with moderate to low permeability.
- Soil Boring 03 and 06, clayey and silty sand soil with an estimated infiltration rate of zero to 1-3 inches.

CAMPBELL ROAD EXISTING CONDITIONS



Mature trees at roadside



Small open areas at roadside

CAMPBELL ROAD PROPOSED CROSS SECTION



CAMPBELL ROAD POROUS PAVEMENT GUTTER PAN

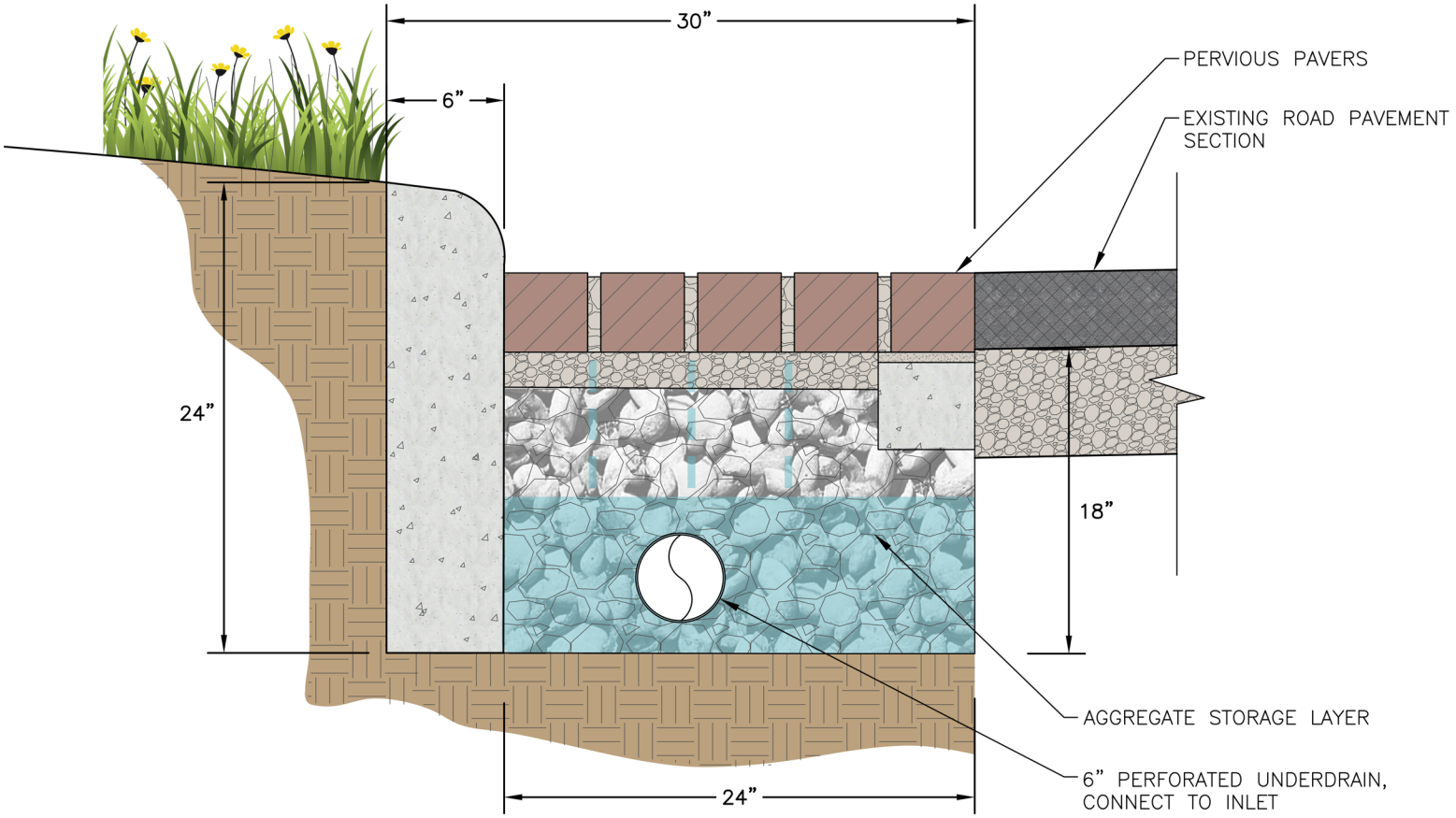


Exhibit 12 Campbell Road Design Summary

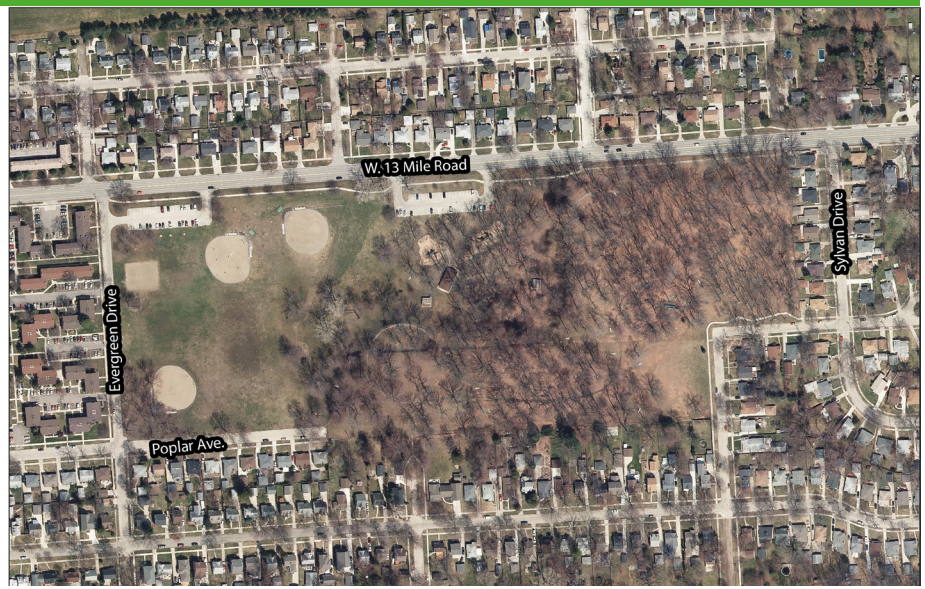
CATCHMENT NUMBER	GI METHOD	GI AREA (SF)	DEPTH (FT)	VOLUME TREATED (CF)	VOLUME REQUIRED (CF)	TOTAL COST	COST/CF TREATED
1 Mile Section Area East	Porous Pavement Gutter Pan	10,650	1.5	8,165	16,064	$1,224,960	$150.03
3 Mile Section Area West	Porous Pavement Gutter Pan	31,680	1.5	24,288	68,112	$3,674,880	$151.30

CITY PARK - STAR JAYCEE PARK/BIORETENTION BASINS

In most cases, parkland provides a very robust opportunity for stormwater runoff volume storage as was the case for the two parks evaluated for the pilot projects. At each of these sites, integrating green infrastructure into the park site design was observed to be feasible, without obvious impacts to existing recreation resources/programs. In fact, well-designed green infrastructure practices blend seamlessly into the existing landscape and can be designed to be a visual reference point or a focal point for interpretation of education. There is a growing need for City parkland to accommodate a variety of activities, purposes and user groups. Parks are increasingly being designed or redesigned to allow for flexible, multi-purpose program space. If green stormwater infrastructure is added to the design programming for the civic spaces, they can be designed or retrofitted to serve stormwater management purposes, often without impeding recreational use.

An on-site assessment of the parks was performed, however, we believe formal community and stakeholder engagement is needed. We recommend the City engage the stakeholder users, neighboring community, and maintenance and operation staff with the pre-design activities if these projects are advanced to implementation. This will enable the ideas presented in this evaluation to be fine-tuned to truly represent the needs of all stakeholders as well as the stormwater management needs for each area of the City.

The design team evaluated retrofitting the park sites with green infrastructure by replacing impervious surfaces with pervious pavements. However, the versatility of bioretention stormwater management practices was preferred. Their flexible design features, relatively small footprint, and ability to be adjusted to accommodate utilities and other conflicts allowed them to rise to the top as the preferred solution for the project sites. Bioretention areas are depressed, flat-bottom cells of various shapes and configurations that include plants and an engineered soil mix. Due to the high infiltration of the insitu soils, no underdrain was required at these sites and improved the performance and cost effectiveness of the design alternative.

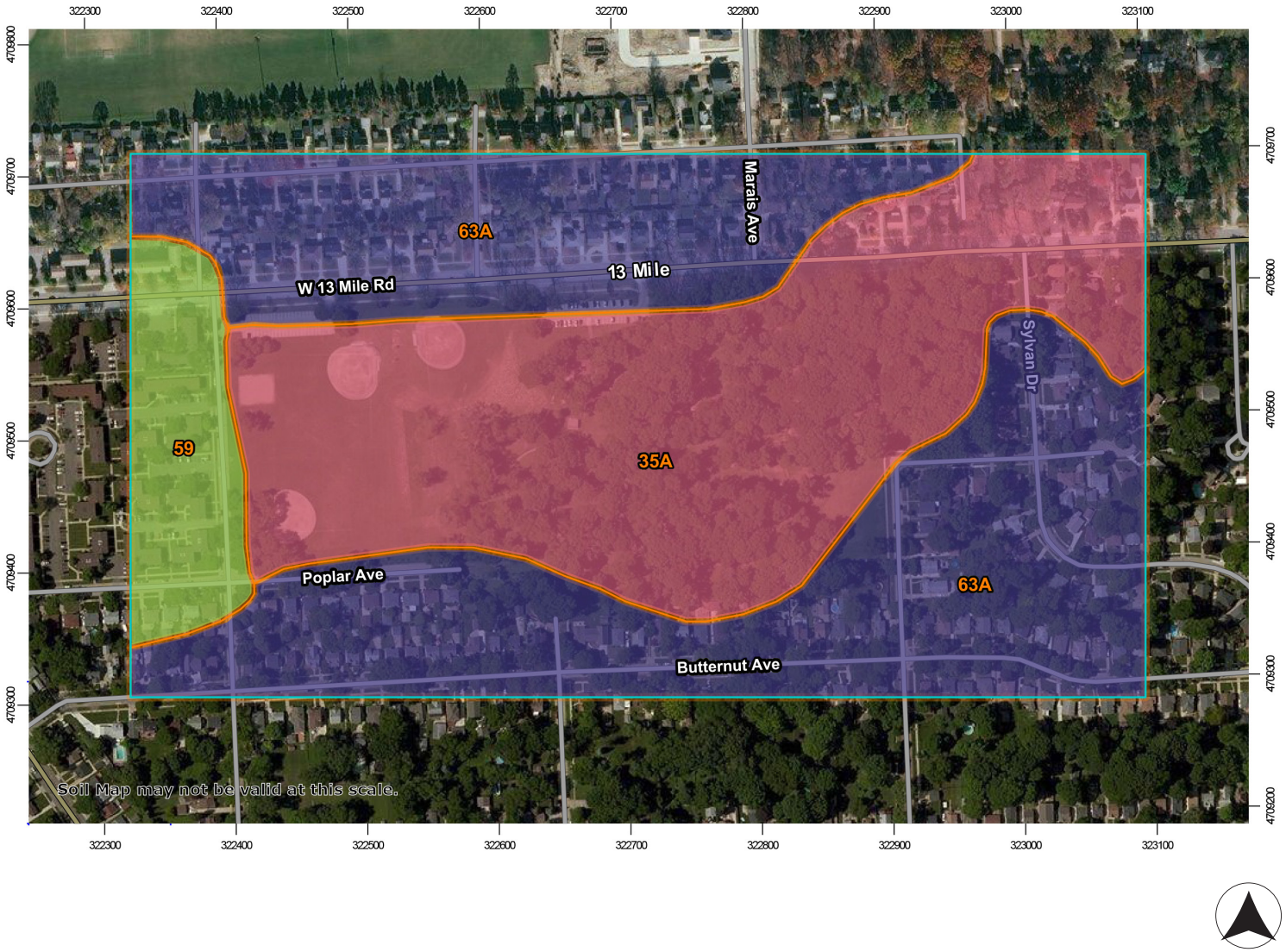


The evaluation demonstrates that the available capacity to manage runoff volume is quite high and in all cases, exceeds the design storm event volume targets. In some cases, the volume managed is 5 to 10 times the design target volumes. When this occurs, the cost per volume managed is very cost effective and could be enhanced with additional offsite drainage connections to these proposed systems. We provided this higher level of service to demonstrate the capacity to optimize the design opportunities at each of the sites. The high performance of these pilot projects should be exploited during the detailed design phase with retrofits to the off-site stormwater collection system to direct additional off-site drainage sub-catchments to these areas so that the available volumes for storage can be maximized and the optimal cost-benefit ratio is achieved.

STARR JAYCEE PARK SOILS

NRCS Mapped predominantly as Thetford Loamy Fine Sand with moderate permeability.

Soil Boring 02, sandy soil with an estimated infiltration rate of 11 to 18 inches.



STARR JAYCEE PARK EXISTING CONDITIONS





STARR JAYCEE PARK DRAINAGE AREAS

Sub-catchments

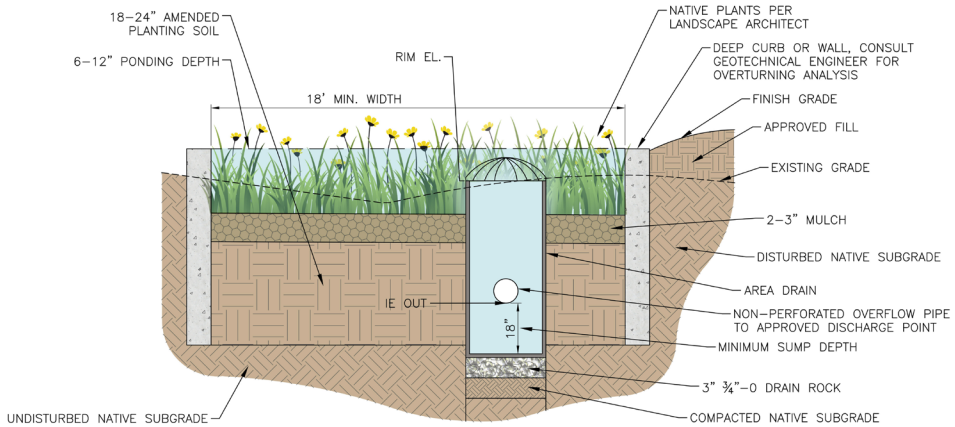
DA 1 = 3.48 acres
DA 2 = 0.48 acres
DA 3 = 8.95 acres
DA 4 = 1.49 acres
DA 5 = 9.88 acres
DA 6 = 9.22 acres



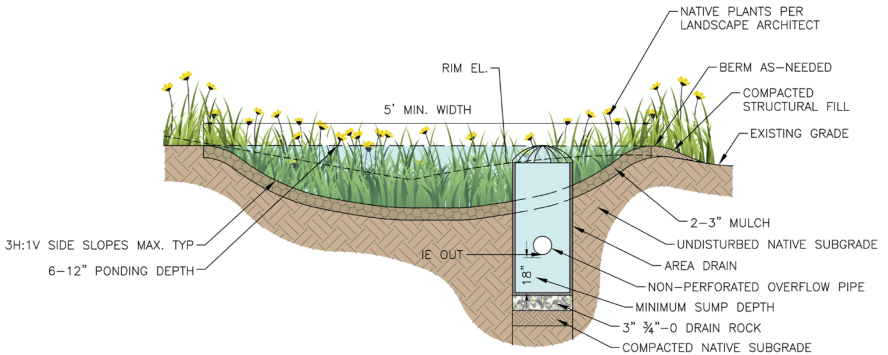
STARR JAYCEE PARK PROPOSED GI CONCEPT



STARR JAYCEE PARK BIORETENTION BASIN OR RAIN GARDEN



INFILTRATION PLANTER WITH PLANTING SOIL
NO SCALE



INFILTRATION RAIN GARDEN
NO SCALE

Exhibit 14 Starr Jaycee Park Design Summary

CATCHMENT NO.	GI METHOD	GI AREA (SF)	DEPTH (FT)	VOLUME TREATED (CF)	VOLUME REQUIRED (CF)	TOTAL COST	COST/CF TREATED
1	Bioretention	10,143	2	21,807	12,031	$266,964	$12.24
2	Bioretention	4,078	2	8,768	1,785	$107,333	$12.24
3	Bioretention	15,394	2	33,097	9,730	$405,170	$12.24
4	Bioretention	6,506	2	13,988	1,484	$171,238	$12.24
5	Bioretention	8,539	2	18,359	2,954	$224,746	$12.24
6	Bioretention	21,008	2	45,167	13,167	$552,931	$12.24

Note: Walks/bridges not included in construction costs

CITY PARK - VFW PARK/BIORETENTION BASINS



In most cases, parkland provides a very robust opportunity for stormwater runoff volume storage as was the case for the two parks evaluated for the pilot projects. At each of these sites, integrating green infrastructure into the park site design was observed to be feasible, without obvious impacts to existing recreation resources/programs. In fact, well-designed green infrastructure practices blend seamlessly into the existing landscape and can be designed to be a visual reference point or a focal point for interpretation of education. There is a growing need for City parkland to accommodate a variety of activities, purposes and user groups. Parks are increasingly being designed or redesigned to allow for flexible, multi-purpose program space. If green stormwater infrastructure is added to the design programming for the civic spaces, they can be designed or retrofitted to serve stormwater management purposes, often without impeding recreational use.

An on-site assessment of the parks was performed, however, we believe formal community and stakeholder engagement is needed. We recommend the City engage the stakeholder users, neighboring community, and maintenance and operation staff with the pre-design activities if these projects are advanced to implementation. This will enable the ideas presented in this evaluation to be fine-tuned to truly represent the needs of all stakeholders as well as the stormwater management needs for each area of the City.

The design team evaluated retrofitting the park sites with green infrastructure by replacing impervious surfaces with pervious pavements. However, the versatility of bioretention stormwater management practices was preferred. Their flexible design features, relatively small footprint, and ability to be adjusted to accommodate utilities and other conflicts allowed them to rise to the top as the preferred solution for the project sites. Bioretention areas are depressed, flat-bottom cells of various shapes and configurations that include plants and an engineered soil mix. Due to the high infiltration of the insitu soils, no underdrain was required at these sites and improved the performance and cost effectiveness of the design alternative.

The evaluation demonstrates that the available capacity to manage runoff volume is quite high and in all cases, exceeds the design storm event volume targets. In some cases, the volume managed is 5 to 10 times the design target volumes. When this occurs, the cost per volume managed is very cost effective and could be enhanced with additional offsite drainage connections to these proposed systems. We provided this higher level of service to demonstrate the capacity to optimize the design opportunities at each of the sites. The high performance of these pilot projects should be exploited during the detailed design phase with retrofits to the off-site stormwater collection system to direct additional off-site drainage sub-catchments to these areas so that the available volumes for storage can be maximized and the optimal cost-benefit ratio is achieved.

VFW PARK SOILS

NRCS Mapped predominantly as Urban Land-Thetford Complex and Thetford Loamy Fine Sand with moderate permeability.

Soil Boring 06, silty sand soil with an estimated infiltration rate of 1-3 inches.



VFW PARK EXISTING CONDITIONS



Campbell Road frontage



Interior park landscape character

VFW PARK DRAINAGE AREAS

Sub-catchments

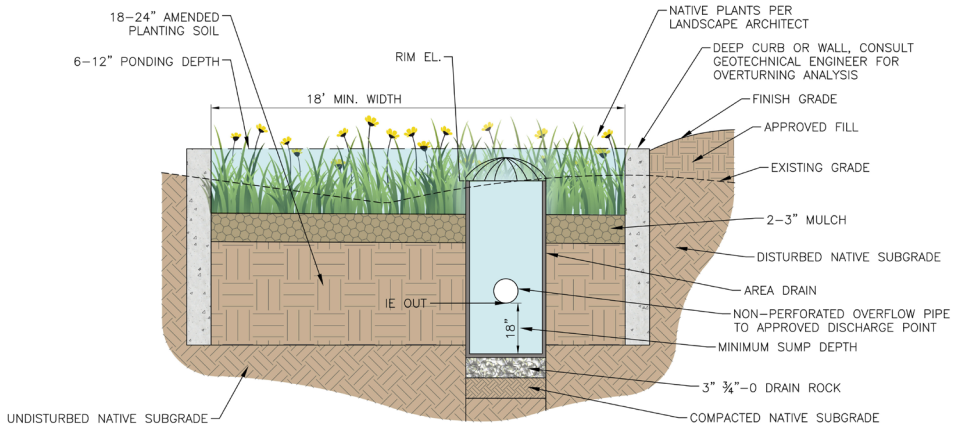
DA 1 = 0.51 acres
DA 2 = 1.71 acres
DA 3 = 0.38 acres
DA 4 = 0.49 acres
DA 5 = 2.19 acres



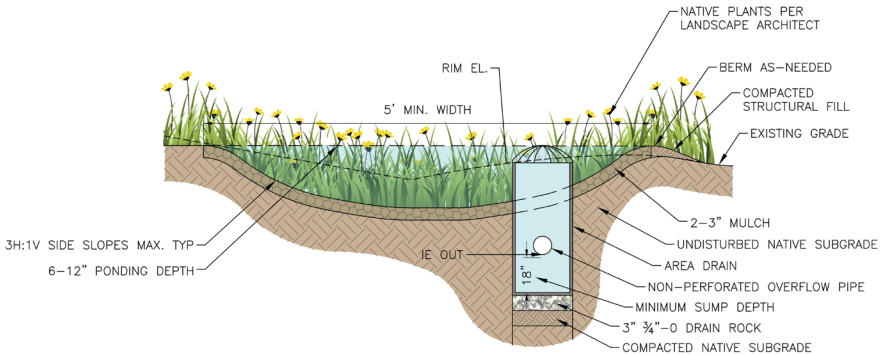
VFW PARK PROPOSED GI CONCEPT



VFW PARK BIORETENTION BASIN OR RAIN GARDEN



INFILTRATION PLANTER WITH PLANTING SOIL
NO SCALE



INFILTRATION RAIN GARDEN
NO SCALE

Exhibit 13 VFW Park Design Summary

CATCHMENT NO.	GI METHOD	GI AREA (SF)	DEPTH (FT)	VOLUME TREATED (CF)	VOLUME REQUIRED (CF)	TOTAL COST	COST/CF TREATED
1	Bioretention	4,219	2	4,746	728	$105,475	$22.22
2	Bioretention	20,383	2	22,931	5,167	$509,575	$22.22
3	Bioretention	4,375	2	16,078	1,580	$109,375	$6.80
4	Bioretention	1,145	2	1,975	1,797	$28,625	$14.49
5	Bioretention	4,626	2	23,940	6,758	$115,650	$4.83

Note: Walks/bridges not included in construction costs

Section 4



IMPLEMENTATION

Green Infrastructure (GI) represents an emerging and rapidly evolving engineering and design approach to stormwater management that encompasses may unique features when compared to traditional gray stormwater infrastructure. While this approach can provide a multitude of benefits, implementation, particularly during the planning and design stage, is not without challenges. The following provides a framework to serve as a road map for implementation and address issues such as GI operation and maintenance considerations, funding mechanisms to collaborate with other agencies that are advancing stormwater management that utilizes these new green technologies, and GI plant material recommendations.

General Implementation Challenges

Unlike traditional stormwater controls, which are hidden underground or within facilities not accessible to the general public, GI source controls are by design, distributed throughout the community and often highly visible. For this reason, maintenance is a necessary consideration to gain public acceptance and support as well as provide long-term benefits. While the requirements for maintenance is not unique to GI, the types of activities involved in the maintenance and operation of these facilities requires public and private sector implementers to perform activities associated with landscaping, erosion repair, soil replacement, and collection of debris and sediment from these facilities. While these activities are not more expensive, by the distributed pattern, there are more of them over a wider area. In addition, opportunities to designate easements for inspection and maintenance, or agreements with property owners to share responsibility of system maintenance, are a consideration. We have found a successful approach to implementation requires the implementer to identify opportunities to consolidate GI maintenance with other operations within the City so that effective maintenance is integral to the planning and design efforts.

Maintenance Considerations

GI requires operation and maintenance (O&M) to continue ongoing performance. This section includes recommended maintenance information for porous pavement, bioretention, and underground storage. The products noted in this section are used as general product descriptions and not as an endorsement of any specific product.

Porous Pavement Maintenance

Porous pavement is a broad category that includes porous asphalt, porous concrete, Permeable Interlocking Concrete Pavers (PICP), and proprietary flexible porous pavement systems. Porous asphalt and concrete are based on mix-design. Two professional trade organizations, the National Asphalt Pavement Association (NAPA)[2] and the National Ready Mix Concrete Association (NRMCA)[3], represent these industries and have published design guidelines and O&M manuals. The Interlocking Concrete Pavement Institute (ICPI)[4] also published a manual (Smith 2011) that covers design, specifications, construction, and maintenance of PICP products and maintains a website[4] with resources.

For any porous paver surface, ongoing O&M considerations include:

- Pressure wash and/or vacuum surface periodically to maintain permeability
- Inspect for excess ponding on porous pavement surface as an indicator the system is not performing as designed
- Replace any broken or damaged concrete pavers (if relevant)
- Prevent soil, sand, and mulch from being stockpiled near or washed onto porous pavement

[2] *www.asphaltpavement.org*
[3] *www.perviouspavement.org*
[4] *www.icpi.org*

- Inspect and clean any overflow structures
- Remove vegetation as needed

Unilock®

Unilock® has published a detailed maintenance manual (Unilock® 2012) that includes information on preventive and restorative maintenance. Unilock® recommends employing either a rotary brush, broom sweeping, or regenerative air sweeping unit at least once per non-winter season and either vacuum sweeping or power washing if pavement is clogged such that it no longer satisfactorily infiltrates water (Unilock® 2012). Unilock® paver system includes aggregate materials in the joints that need to be replaced as needed based on loss from maintenance activities.

For winter maintenance, Unilock® recommends light sodium chloride or calcium chloride (Unilock® 2016) and no sand (Unilock® 2012, 2014). Unilock® also recommends plowing with a rubber tipped blade since the metal blade can cause aesthetic damage to the pavers.

PaveDrain®

As part of the construction specifications (CSI 2016; PaveDrain® 2016a), PaveDrain® will provide recommendations for a 3-year monthly maintenance program based on specific site conditions as part of the cost of installation. The maintenance program normally includes regular visual inspections and surface cleaning using either a proprietary PaveDrain® VAC Head (attached to a side mounted hydro-excavation water pressure unit on a combination sewer vacuum truck) or one of their recommended street cleaning vacuum trucks (either Elgin Whirlwind or Megawind) (PaveDrain® 2016). The PaveDrain® VAC Heads are available for purchase from local distribution centers[5]. Even if routine maintenance is neglected, research has shown that the PaveDrain® System can be rehabilitated and desired infiltration returned using the techniques described (PaveDrain® 2016).

For winter maintenance, PaveDrain® (2016) recommends light sodium chloride and no sand. However, if sand is used for winter traction, it can be removed through vacuuming as described above. PaveDrain® also recommends plowing with a rubber tipped blade (PaveDrain 2016), but it can be plowed using a regular steel blade similar to any other concrete surface. The damage risk to the PaveDrain® concrete blocks is similar to any concrete paving or curb surface.

Bioretention Maintenance

Bioretention cells and bioswales require routine maintenance to ensure hydrologic performance and aesthetic appeal. There are numerous rain garden and/or bioretention cell design manuals and fact sheets available. Generally, maintenance consists of the following categories (SEMCOG 2008):

- Irrigation: Water landscaping plants routinely throughout the first growing season (one inch of water per week). It is recommended to use native or adapted species to minimize any required irrigation. If drought-tolerant native plants are chosen, only water in times of significant drought after the plants are established. Otherwise, water as necessary.
- Weeding/Pruning: Prune landscaping plants and remove weeds approximately once per month depending on plants chosen and desired aesthetics. Perennial plants should be trimmed to ground at the end of the growing season to promote root growth. Remove excess trimmed organic material.
- Mulch: Mulch should be replenished every other year or as necessary. It is important to not have a landscaping contract in place that specifies adding mulch annually since it is unnecessary and even undesirable to have excess mulch. If surface erosion is evident after heavy rains, mulch should be re-spread with consideration of adding velocity control measures, such as stone, in areas that experience repeat erosion.
- Sedimentation: Excess sediment can cause surface clogging and excessive ponding. Inspect semi-annually for sediment accumulation and remove any sediment build-up from parking lot runoff. Add mulch or level existing mulch if sediment removal caused significant removal of mulch.

[5] *http://www.PaveDrain.com/pdf/PaveDrain-Sales-Distribution-Partners.pdf*

- Aesthetics: Inspect twice a year for trash or dead plants (or more frequently as needed). Trash and dead plant material should be removed and mulch re-spread, if necessary.

The *Field Guide for Maintaining Rain Gardens, Swales and Stormwater Planters* (OSU 2013)[6] is a good maintenance reference and includes maintenance check lists, suggestions, and instructional photos. Another reference is *Professional Rain Garden Maintenance* (URI 2016), which is a two-page document that includes monthly and annual inspection recommendations. It is recommended that the site adapt civil contact the local jurisdiction to determine if a site-specific O&M plan is required and the specific schedule of activities that might be required as part of the site permit process.

Funding

Appendix B presents a summary of the available funding sources that can be engaged to assist in the implementation of the GI projects planned for the City. Funding is a rapidly changing landscape and the matrix presented this year should be updated on an annual basis as programs change and requirements are adjusted to meet the objectives of the funders.

Plant Material Recommendations

Appendix C presents a detailed matrix of plant material recommendations for use in GI practices where plantings are required or desired. While not exhaustive, the matrix of trees, shrubs, grasses and perennials is a selection of plants our team has researched as the most suitable for our region and with the desired adaptations for use in GI practices for the lower Great Lakes. Data on tolerances and bloom times is adapted from experience and published documentation and may vary based on the specific conditions of each site being considered. Therefore, a competent landscape professional should be engaged to prepare the planting plans for any GI project.

[6] *http://extension.oregonstate.edu/stormwater/sites/default/files/fieldguide.pdf*

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APPENDIX A
GEOTECHNICAL EVALUATION

CONSULTING GROUP

October 6, 2017

Mr. David Anthony, ASLA
WadeTrim
25251 Northline Road
Taylor, Michigan 48180

RE: Letter of Geotechnical Evaluation
Green Infrastructure Improvements
City of Royal Oak, Oakland County, Michigan
G2 Project No. 173394

Dear Mr. Anthony,

In accordance with your request, we have completed the geotechnical evaluation related to the green infrastructure improvements to be constructed within the City of Royal Oak, Oakland County, Michigan. We understand the proposed project includes the use of green infrastructure in order to reduce the volume of water introduced into the city storm water management system. At the time of this report, information related to the exact location and types of green infrastructure is unknown; however, we understand the types and locations of the proposed structures will be contingent on the depth of the groundwater as well as the suitability of the subgrade soils for infiltration.

FIELD OPERATIONS

WadeTrim, in conjunction with G2 Consulting Group, LLC (G2), selected the number depth and location of the soil borings. The soil boring locations were determined in the field by use of GPS assisted mobile technology by a G2 representative prior to the execution of the field work. The approximate soil boring locations are shown on the Soil Boring Location Plan, Plate No. 1, in the Appendix.

In the area of soil borings B-04 and B-05, the existing pavements were cored using a 4-inch outside diameter diamond tipped core barrel. Throughout the entirety of the investigation, the soil borings were excavated with a 3-inch outside diameter bucket hand-auger extending to the explored depths. Within each soil boring, soil samples were taken at regular 2 foot intervals or at depths where transitions in the observed soils were noted. The relative consistency of the in-situ soils was evaluated using a dynamic cone penetrometer in general accordance with ASTM STP #399 (Sowers DCP) at depths samples were obtained. The Sowers DCP testing involves driving a 1-1/2 inch diameter cone with a 45 degree convex angle into the ground using a 15-pound weight falling 20-inches after the cone is seated into the bottom of the hand augered borehole. The DCP is driven in successive 1-3/4 inch increments. The blow counts for each 1-3/4 inch increment are equated to an equivalent SPT N-value and are presented on the individual soil boring logs. Upon completion of the soil boring operations, the soil borings were backfilled with on-site soils.

Soil samples were placed in sealed containers in the field and brought to the laboratory for testing and classification. During the excavation operations, a G2 project engineer maintained logs of the encountered subsurface conditions, including changes in stratigraphy and observed groundwater levels to be used in conjunction with our analysis of the subsurface conditions. The final soil boring logs, Figure Nos. 1 through 6 in the Appendix, are based on the field logs supplemented by laboratory soil classification and testing.

LABORATORY TESTING

Representative soil samples were subjected to laboratory testing to determine soil parameters pertinent to the evaluation of the soils for infiltration. Soil samples obtained in the field were stored in sealed bags and transported to our Troy office for laboratory testing and classification. An experienced geotechnical engineer classified the samples in accordance with the G2 General Notes Terminology and applications of the Visual-Manual Unified Soil Classification System (ASTM D2488). Laboratory testing included determinations in accordance with the following standards:

- ASTM D2216 – Moisture Content of Soil
- ASTM D422 – Sieve & Hydrometer Analysis
- ASTM D2488 – Visual-Manual Unified Soil Classification System (USCS)

Unconfined compressive strengths were determined using a spring-loaded hand penetrometer. The hand penetrometer estimates unconfined compressive strength to a maximum of 4-1/2 tons per square foot (tsf) by measuring soil sample resistance to the penetration of a calibrated spring-loaded cylinder.

The results of the field and laboratory testing are indicated on the soil boring logs at the depths samples were taken. The soil boring logs are presented on Figure Nos. 1 through 6. The results of the sieve analysis in accordance with ASTM D422 are presented graphically on Figure No. 7. We will hold the soil samples for a period of 60 days following the issuance of this report. If you would like the samples retained beyond this period, or if you would the samples returned to you, please let us know.

SITE CONDITIONS

Soil boring B-01 was excavated within the greenbelt area located to the northeast of the intersection of Bembridge Road and Essex Street. A recreational area is present south of the soil boring location and several mature trees are present to the north. Site grades in the area of the soil boring B-01 are generally flat at an elevation of approximately 688 feet.

Soil boring B-02 was excavated to the north of Poplar Avenue and to the east of Evergreen Drive in an area to the south of an existing baseball field at Starr Jaycee Park. Site grades in the area of soil boring B-02 are generally flat at an approximate elevation of 663 feet.

Soil boring B-03 was drilled within the greenbelt area located to the west of Campbell Road and to the north of E. Bloomfield Avenue. Based on our observation of utility markings in the field, several underground utilities are present adjacent to soil boring B-03. Site grades in the area of soil boring B-03 slope downward from a high elevation of 644 feet near the adjacent residences to the west to a low elevation of 640 feet near soil boring B-03.

Soil boring B-04 is located within the existing pavements near the western terminus of Carman Avenue to the east of Woodward Avenue and to the west of Hawkins Avenue. Site grades within the existing pavement adjacent to soil boring B-04 are relatively flat at an elevation of approximately 674 feet.

Soil boring B-05 is located within an existing parking lot to the east of a retail plaza along S. Main Street to the north of 4th Street. Site grades within the area of soil boring B-05 are generally flat with an elevation of approximately 660±1 foot.

Soil boring B-06 is located to the southwest of the intersection of Campbell Road and 6th Street within the VFW Park. Soil boring B-06 is situated to the east of a gravel recreational area. Site grades within the area of soil boring B-06 are generally flat at an elevation of approximately 637 feet. It should be noted that the aforementioned elevation data is based on information accessible within Google Earth Pro.

SOIL AND GROUNDWATER CONDITIONS

Approximately 6 to 15 inches of sandy clay or silty sand topsoil are present at the ground surface of soil borings B-01, B-02, and B-03; however, it should be noted 24 inches of silty sand topsoil are present at the ground surface of soil boring B-06. Approximately 7 inches of Portland cement concrete and 5-1/2 inches of bituminous concrete are present at the ground surface of soil borings B-04 and B-05, respectively. In general, varying layers of granular and cohesive fill soils are present beneath the topsoil or existing pavements extending to depths ranging from 3-1/2 feet to the explored depths in soil borings B-01 through B-05. It should be noted that the fill within soil boring B-04 included deleterious debris at depths ranging from 1-1/2 to the explored depth. Native sand or silty sand is present beneath the topsoil or fill in soil borings B-02, B-05, and B-06 extending to the explored depths in soil borings B-02 and B-05; however, extending to a depth of approximately 4 feet within soil boring B-06. Native silty clay is present beneath the upper granular soil in soil boring B-06 extending to the explored depth.

The granular fill soils are generally medium compact with equivalent Standard Penetration Test (SPT) N-values ranging from 15 to 18 blows per foot. The cohesive fill soils are generally very stiff in consistency within soil boring B-01 having natural moisture cotnents ranging from 10 to 13 percent and unconfined compressive strengths ranging from 4,000 to 5,000 pounds per square foot; however, the cohesive fill in the area of soil boring B-04 is generally stiff in consistency with natural moisture contents ranging from 24 to 25 percent and unconfined compressive strengths of approximately 2,000 pounds per square foot. The native granular soils have a diameter of which 10 percent of the material is finer ranging from 0.035 to 0.092 millimeters.

Groundwater observations were made during and upon completion of the excavation operations. No groundwater was observed during or upon completion of the excavation operations; however, it should be noted that fluctuations in perched and long-term groundwater levels should be anticipated due to seasonal variations and following prolonged periods of precipitation.

INFILTRATION CONSIDERATIONS

The following table provides the results of our observations during hand auger operations:

Soil Boring ID	Ground Surface Elevation (ft)[1]	Soil Type[3] (USCS[4])	Soil Type(s)[5]	Approx. El. of Soil Suitable for Infiltration (ft)	D_{10} Value (mm)	Estimated Infiltration Rate Range (iph)
B-01	688	---	Fill: Sandy Clay	---	---	---
B-02	663	SP	Sand	659-1/2	0.092	11 to 18
B-03	641	---	Fill: Clayey Sand & Fill: Sandy Clay	---	---	---
B-04	674	---	Fill: Silty Sand & Fill: Silty Clay	---	---	---
B-05	661	SP	Sand	657-1/2	0.088	11 to 17
B-06	637	SM	Silty Sand	635	0.035	1 to 3

Notes:
1. Estimated based on elevation data available within Google Earth Pro.
2. No observable groundwater during or upon completion of the excavation operations.
3. Soil identified as suitable for infiltration. Note: fill material not considered suitable for infiltration.
4. Description in general accordance with Visual-Manual Unified Soil Classification System (ASTM D2488).
5. Primary soil type observed in soil boring at typical infiltration structure depths.

The aforementioned infiltration rates are based on Hazen's (1930) permeability approximation which relates the D_{10}, the effective diameter through which 10 percent of the sample is finer, to the permeability. Please note significant variations in localized infiltration rates can occur due to the relative compactness of the soil layer and variations in the overall grainsize distribution for an individual layer.

Infiltration structures should not discharge into existing fill soils as fill soils are typically placed in an uncontrolled manner having a wide range of grainsize distribution and relative compactness. Furthermore, infiltration structures designed to discharge into native cohesive soils should be designed assuming a negligible rate of infiltration.

Based on the results of our observations and testing, we recommend the proposed infiltration structures in the area of soil borings B-02, B-05, and B-06, extend through the upper granular or cohesive fill soils and bear within the native sand or silty sand. In order to connect the infiltration structures to the underlying sand or silty sand, we recommend the existing fill soils be undercut to expose the underlying native granular soils and backfilled to the proposed infiltration structure bottom with a material such as MDOT 6A. The use of the MDOT 6A open-graded aggregate will permit the transmission of the collected stormwater to the underlying sand and gravel layer. In the area of soil boring B-01, B-03, and B-04, we anticipate that the removal and replacement of the existing fill soils with materials suitable for infiltration will be impractical.

In the event porous pavements are used for this project, we recommend porous pavements be tested to verify their conformity with project specifications prior to the acceptance on-site. The Michigan Concrete Association recommends creating an on-site test panel and performing a battery of tests prior to their acceptance. The following are a list of suggested test methods to use prior to the acceptance of the pervious concrete mix and placement methods:

- ASTM C1688 – Density and Void Content of Freshly Mixed Pervious Concrete
- ASTM C1701 – Infiltration Rate of In-Place Pervious Concrete
- ASTM D1754 – Density and Void Content of Hardened Pervious Concrete
- ASTM C1747 – Determining Potential Resistance to Degredation of Pervious Concrete by Impact and Abrasion

We recommend that a qualified geotechnical engineer or technician be present on-site during the excavation of the infiltration structures to verify that soils at the base of the proposed structures are consistent with soil conditions identified within this report. Furthermore, we recommend an experienced quality control technician be present on site in order to perform the aforementioned battery of tests in the event pervious pavements are used.

GENERAL COMMENTS

If changes occur in the design, location, or concept of the project, conclusions and recommendations contained in this report are not valid unless G2 Consulting Group, LLC reviews the changes. G2 Consulting Group, LLC will then confirm any assumptions regarding the project scope presented herein or make changes in writing. The scope of the present investigation was limited to evaluation of subsurface conditions at the proposed hand auger locations. No chemical or environmental testing or analyses were included in the scope of this investigation.

We base the analyses and recommendations submitted in this report upon the data from the soil borings performed at the approximate locations shown on the Soil Boring Location Plan, Plate No. 1. This report does not reflect variations that may occur between the actual soil boring locations and the actual infiltration structure locations. The nature and extent of any such variations may not become clear until the time of construction. We recommend G2 Consulting Group, LLC observe all geotechnical related work, including subgrade preparation and engineered fill placement.

We appreciate the opportunity to be of service to you on this project and look forward to discussing the results presented. In the meantime, if you have any questions regarding this report or any other matter pertaining to the project, please call us.

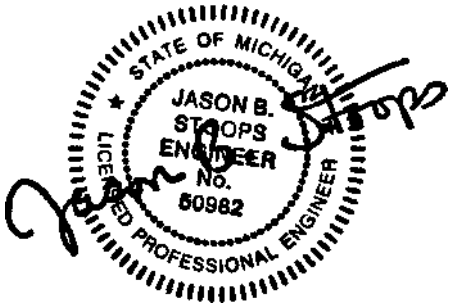
Sincerely,

G2 Consulting Group, LLC

Michael G. Dagher, P.E.
Project Engineer

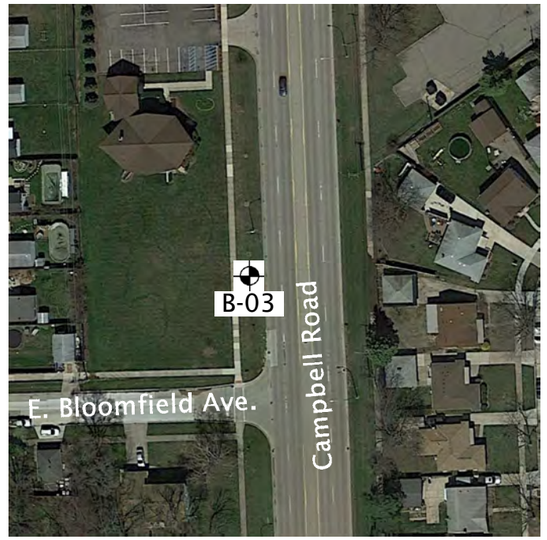
Jason B. Stoops, P.E.
Office Manager / Project Manager

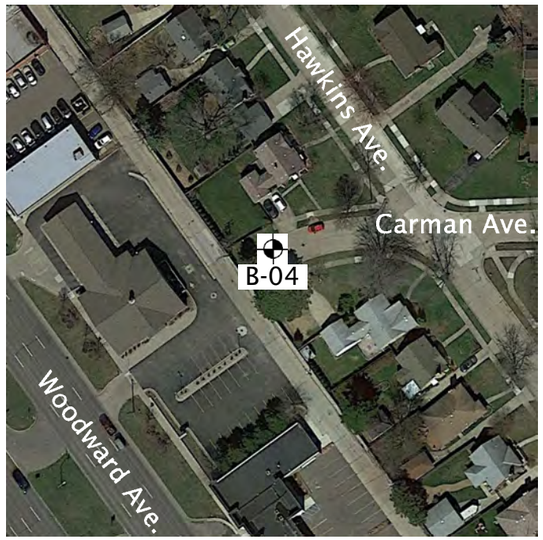
Encl: Plate No. 1 – Soil Boring Location Plan
Figure No. 1 through 6 – Soil Boring Logs
Figure No. 7 – Grainsize Distribution Results
Figure No. 8 – General Notes Terminology















Legend

Soil Borings Drilled by G2 Consulting Group, LLC on September 22, 2017.

Soil Boring Location Plan

Green Infrastructure Improvements
City of Royal Oak, Oakland County, Michigan

G2 CONSULTING GROUP	Project No. 173394	
	Drawn by: MGD	
	Date: 9/20/17	Plate No. 1
	Scale: NTS	

Project Name: Green Infrastructure Improvements

Project Location: City of Royal Oak, Oakland County, Michigan

G2 Project No. 173394

Latitude: N/A Longitude: N/A

Soil Boring No. B-01

G2 CONSULTING GROUP

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 688.0 ft ±	DEPTH (ft)	SAMPLE TYPE/NO.	DCP BLOWS/ 1.75-INCHES	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCOF. COMP. ST. (PSF)
		Topsoil: Dark Brown Sandy Clay (15 inches)						
		1.3						
		Fill: Brown Sand (3 inches)						
		1.5		S-1	12	10.4		4000*
		Fill: Very Stiff Brown Sandy Clay with trace silt and gravel						
683.0		5.0	5	S-2	13	12.4		4000*
		End of Boring @ 5 ft						

Total Depth: 5 ft
Drilling Date: September 22, 2017
Inspector:
Contractor:
Driller: J. Hayball, P.E.

Drilling Method:
4-inch diameter diamond tipped core barrel;
3-inch diameter hand auger

Water Level Observation:
Dry during and upon completion

Notes:
* Calibrated Hand Penetrometer

Excavation Backfilling Procedure:
Borehole backfilled with auger cuttings

Figure No. 1

PAVEMENT CORE DCP 173394.GPJ 20140820 G2 CONSULTING DATA TEMPLATE.GDT 10/6/17

Project Name: Green Infrastructure Improvements

Project Location: City of Royal Oak, Oakland County, Michigan

G2 Project No. 173394

Latitude: N/A Longitude: N/A

Soil Boring No. B-02

CONSULTING GROUP

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 663.0 ft ±	DEPTH (ft)	SAMPLE TYPE/NO.	DCP BLOWS/ 1.75-INCHES	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCOF. COMP. ST. (PSF)
		Topsoil: Dark Brown Silty Sand (12 inches)						
			1.0					
		Fill: Medium Compact Brown Silty Sand with trace gravel		S-1	16			
			3.5					
		Medium Compact Gray Sand with trace silt and gravel						
658.0			5.0	S-2	14			
		End of Boring @ 5 ft	5					

Total Depth: 5 ft
Drilling Date: September 22, 2017
Inspector:
Contractor:
Driller: J. Hayball, P.E.

Water Level Observation:
Dry during and upon completion

Excavation Backfilling Procedure:
Borehole backfilled with auger cuttings

Drilling Method:
4-inch diameter diamond tipped core barrel;
3-inch diameter hand auger

Figure No. 2

PAVEMENT CORE DCP 173394.GPJ 20140820 G2 CONSULTING DATA TEMPLATE.GDT 10/6/17

Project Name: Green Infrastructure Improvements

Project Location: City of Royal Oak, Oakland County, Michigan

G2 Project No. 173394

Latitude: N/A Longitude: N/A

Soil Boring No. B-03

G2 CONSULTING GROUP

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 641.0 ft ±	DEPTH (ft)	SAMPLE TYPE/NO.	DCP BLOWS/ 1.75-INCHES	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCOF. COMP. ST. (PSF)
		Topsoil: Dark Brown Clayey Sand (6 inches)						
		0.5						
		Fill: Medium Compact Brown Clayey Sand with trace silt and gravel		S-1	15			
		3.0						
		Fill: Very Stiff Brown Sandy Clay with trace silt and gravel						
636.0		5.0	5	S-2	17	13.1		5000*
		End of Boring @ 5 ft						

Total Depth: 5 ft
Drilling Date: September 22, 2017
Inspector:
Contractor:
Driller: J. Hayball, P.E.

Drilling Method:
4-inch diameter diamond tipped core barrel;
3-inch diameter hand auger

Water Level Observation:
Dry during and upon completion

Notes:
* Calibrated Hand Penetrometer

Excavation Backfilling Procedure:
Borehole backfilled with auger cuttings

Figure No. 3

PAVEMENT CORE DCP 173394.GPJ 20140820 G2 CONSULTING DATA TEMPLATE.GDT 10/6/17

Project Name: Green Infrastructure Improvements

Project Location: City of Royal Oak, Oakland County, Michigan

G2 Project No. 173394

Latitude: N/A Longitude: N/A

Soil Boring No. B-04

CONSULTING GROUP

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 674.0 ft ±	DEPTH (ft)	SAMPLE TYPE/NO.	DCP BLOWS/ 1.75-INCHES	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCOF. COMP. ST. (PSF)
		Portland Cement Concrete (7 inches) 0.6						
		Fill: Dark Brown Silty Sand with trace clay and organic matter 1.5		S-1	6	23.8		2000*
		Fill: Stiff Dark Brown Silty Clay with trace sand, gravel, and debris and occasional sand seams						
669.0		5.0	5	S-2	5	25.4		2000*
		End of Boring @ 5 ft						

Total Depth: 5 ft
Drilling Date: September 22, 2017
Inspector:
Contractor:
Driller: J. Hayball, P.E.

Drilling Method:
4-inch diameter diamond tipped core barrel;
3-inch diameter hand auger

Water Level Observation:
Dry during and upon completion

Notes:
* Calibrated Hand Penetrometer

Excavation Backfilling Procedure:
Borehole backfilled with auger cuttings and capped with cold patch

Figure No. 4

PAVEMENT CORE DCP 173394.GPJ 20140820 G2 CONSULTING DATA TEMPLATE.GDT 10/6/17

Project Name: Green Infrastructure Improvements

Project Location: City of Royal Oak, Oakland County, Michigan

G2 Project No. 173394

Latitude: N/A Longitude: N/A

Soil Boring No. B-05

CONSULTING GROUP

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 661.0 ft ±	DEPTH (ft)	SAMPLE TYPE/NO.	DCP BLOWS/ 1.75-INCHES	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCOF. COMP. ST. (PSF)
		Bituminous Concrete (5-1/2 inches)						
		0.5						
		Natural Aggregate Base: Brown Sand and Gravel with trace silt (7-1/2 inches)						
		1.0						
		Fill: Dark Brown Silty Sand wiht trace clay and organic matter						
		1.5						
		Fill: Medium Compact Brown Gravelly Sand with trace silt		S-1	18			
		3.5						
		Medium Compact Brown Sand with trace silt and gravel						
656.0		5.0	5	S-2	12			
		End of Boring @ 5 ft						

Total Depth: 5 ft
Drilling Date: September 22, 2017
Inspector:
Contractor:
Driller: J. Hayball, P.E.

Water Level Observation:
Dry during and upon completion

Excavation Backfilling Procedure:
Borehole backfilled with auger cuttings and capped with cold patch

Drilling Method:
4-inch diameter diamond tipped core barrel;
3-inch diameter hand auger

Figure No. 5

PAVEMENT CORE DCP 173394.GPJ 20140820 G2 CONSULTING DATA TEMPLATE.GDT 10/6/17

Project Name: Green Infrastructure Improvements

Project Location: City of Royal Oak, Oakland County, Michigan

G2 Project No. 173394

Latitude: N/A Longitude: N/A

Soil Boring No. B-06

G2 CONSULTING GROUP

SUBSURFACE PROFILE				SOIL SAMPLE DATA				
ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 637.0 ft ±	DEPTH (ft)	SAMPLE TYPE/NO.	DCP BLOWS/ 1.75-INCHES	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCOF. COMP. ST. (PSF)
		Topsoil: Dark Brown Silty Sand (24 inches)						
			2.0	S-1	8			
		Loose Brown Silty Sand with trace clay						
			4.0					
632.0		Stiff Brown and Gray Silty Clay with trace sand and gravel	5	S-2	10	32.5		3000*
			5.0					
		End of Boring @ 5 ft						

Total Depth: 5 ft
Drilling Date: September 22, 2017
Inspector:
Contractor:
Driller: J. Hayball, P.E.

Drilling Method:
4-inch diameter diamond tipped core barrel;
3-inch diameter hand auger

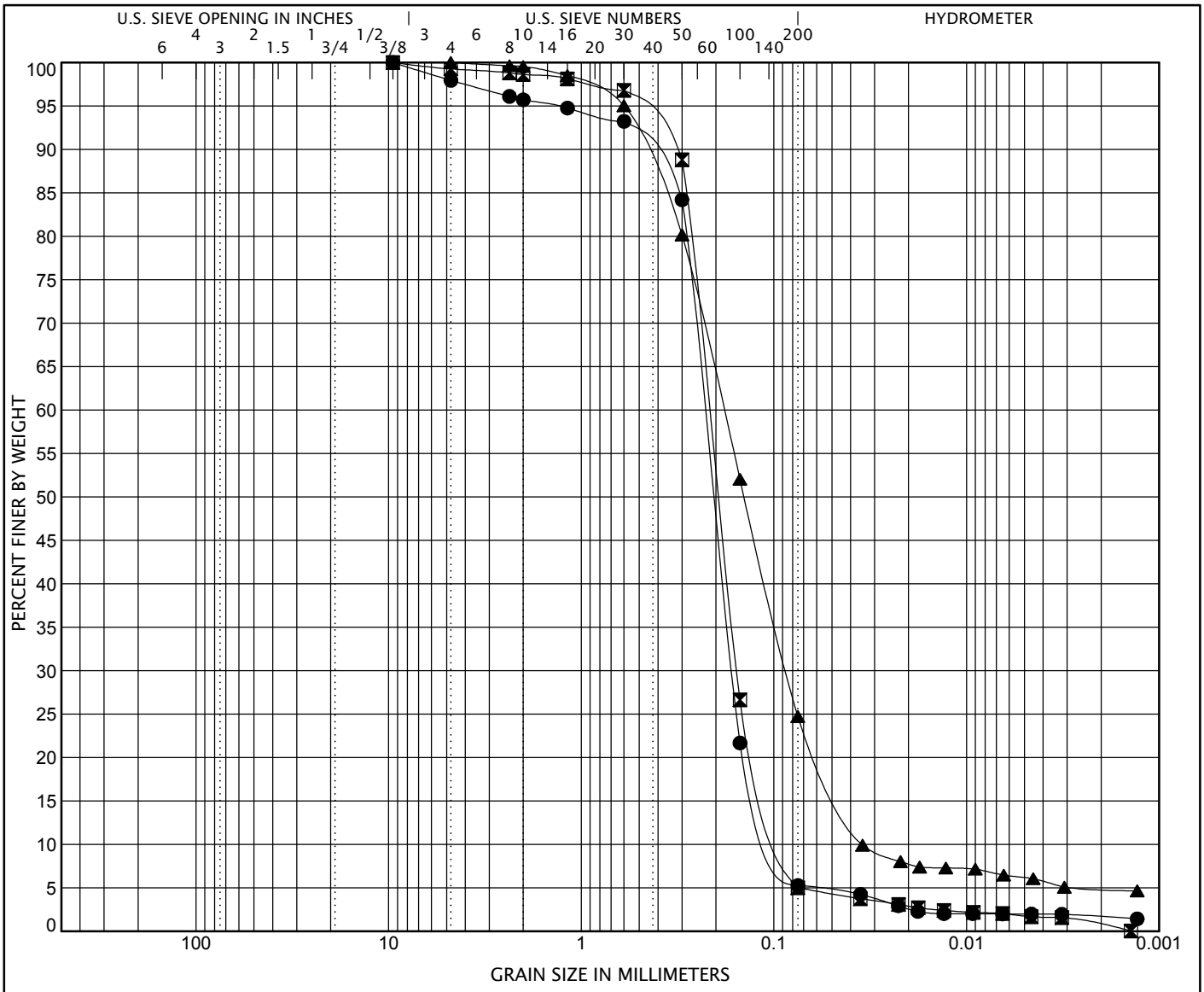
Water Level Observation:
Dry during and upon completion

Notes:
* Calibrated Hand Penetrometer

Excavation Backfilling Procedure:
Borehole backfilled with auger cuttings

Figure No. 6

PAVEMENT CORE DCP 173394.GPJ 20140820 G2 CONSULTING DATA TEMPLATE.GDT 10/6/17



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID		Description	LL	PL	PI	Cc	Cu
●	B-02	S-2	Gray Sand with trace silt and gravel				1.29	2.50
⊠	B-05	S-2	Brown Sand with trace silt and gravel				1.27	2.47
▲	B-06	S-1	Brown Silty Sand with trace clay				1.16	5.25

	Specimen ID		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-02	S-2	9.5	0.229	0.164	0.092	2.0	92.7	3.3	2.0
⊠	B-05	S-2	9.5	0.218	0.156	0.088	0.7	94.3	3.3	1.8
▲	B-06	S-1	4.75	0.183	0.086	0.035	0.0	75.3	18.6	6.2

CONSULTING GROUP

GRAIN SIZE DISTRIBUTION

Project Name: Green Infrastructure Improvements

Project Location: City of Royal Oak, Oakland County, Michigan

G2 Project No.: 173394

Figure No. 7

US_GRAIN_SIZE 173394.GPJ 20140820 G2 CONSULTING DATA TEMPLATE.GDT 10/6/17

GENERAL NOTES TERMINOLOGY

Unless otherwise noted, all terms herein refer to the Standard Definitions presented in ASTM 653.

PARTICLE SIZE

Boulders		- greater than 12 inches
Cobbles		- 3 inches to 12 inches
Gravel	- Coarse	- 3/4 inches to 3 inches
	- Fine	- No. 4 to 3/4 inches
Sand	- Coarse	- No. 10 to No. 4
	- Medium	- No. 40 to No. 10
	- Fine	- No. 200 to No. 40
Silt		- 0.005mm to 0.074mm
Clay		- Less than 0.005mm

CLASSIFICATION

The major soil constituent is the principal noun, i.e. clay, silt, sand, gravel. The second major soil constituent and other minor constituents are reported as follows:

Second Major Constituent (percent by weight)	Minor Constituent (percent by weight)
Trace - 1 to 12%	Trace - 1 to 12%
Adjective - 12 to 35%	Little - 12 to 23%
And - over 35%	Some - 23 to 33%

COHESIVE SOILS

If clay content is sufficient so that clay dominates soil properties, clay becomes the principal noun with the other major soil constituent as modifier, i.e. sandy clay. Other minor soil constituents may be included in accordance with the classification breakdown for cohesionless soils, i.e. silty clay, trace sand, little gravel.

Consistency	Unconfined Compressive Strength (psf)	Approximate Range of (N)
Very Soft	Below 500	0 - 2
Soft	500 - 1,000	3 - 4
Medium	1,000 - 2,000	5 - 8
Stiff	2,000 - 4,000	9 - 15
Very Stiff	4,000 - 8,000	16 - 30
Hard	8,000 - 16,000	31 - 50
Very Hard	Over 16,000	Over 50

Consistency of cohesive soils is based upon an evaluation of the observed resistance to deformation under load and not upon the Standard Penetration Resistance (N).

COHESIONLESS SOILS

Density Classification	Relative Density %	Approximate Range of (N)
Very Loose	0 - 15	0 - 4
Loose	16 - 35	5 - 10
Medium Compact	36 - 65	11 - 30
Compact	66 - 85	31 - 50
Very Compact	86 - 100	Over 50

Relative Density of cohesionless soils is based upon the evaluation of the Standard Penetration Resistance (N), modified as required for depth effects, sampling effects, etc.

SAMPLE DESIGNATIONS

AS - Auger Sample – Cuttings directly from auger flight
BS - Bottle or Bag Samples
S - Split Spoon Sample - ASTM D 1586
LS - Liner Sample with liner insert 3 inches in length
ST - Shelby Tube sample - 3 inch diameter unless otherwise noted
PS - Piston Sample - 3 inch diameter unless otherwise noted
RC - Rock Core - NX core unless otherwise noted

STANDARD PENETRATION TEST (ASTM D 1586) - A 2.0 inch outside-diameter, 1-3/8 inch inside-diameter split barrel sampler is driven into undisturbed soil by means of a 140-pound weight falling freely through a vertical distance of 30 inches. The sampler is normally driven three successive 6-inch increments. The total number of blows required for the final 12 inches of penetration is the Standard Penetration Resistance (N).

APPENDIX B
FUNDING SOURCES

FUNDING SOURCE	PROGRAM OBJECTIVE	ELIGIBILITY	CRITERIA	GREEN INFRASTRUCTURE (GI) APPLICATION	FUNDING	REQUIRED MATCH	ANNUAL DEADLINE	CONTACT AS OF 9/1/17
MICHIGAN DEPARTMENT OF NATURAL RESOURCES (MDNR) GRANTS								
See: http://www.michigan.gov/dnr/0,4570,7-153-58225---,00.html								
Recreation Acquisition and Development Grants								
Land and Water Conservation Fund (LWCF)	The objective of this program is to develop land for public outdoor recreation.	Any state or local unit of government, regional recreation authority, or federally-recognized Native American tribes that has a Department of Natural Resources (DNR) approved 5-year Recreation Plan is eligible.	Some of the criteria for selection includes how closely the proposed project aligns with the 5-year Recreation Plan, as well as how well it aligns with the overall State Comprehensive Outdoor Recreation Plan (SCORP).	Green infrastructure can be included as part of a larger park plan.	$30,000-$150,000	50% match	1-Apr	Christie Bayus 517-284-5923 bayusc@michigan.gov
Michigan Natural Resources Trust Fund (MNRTF)	The objective of this program is to acquire or develop land for outdoor recreation or for the conservation of Michigan's significant natural resources.	Any state or local unit of government or regional recreation authority that has a DNR approved 5-year Recreation Plan is eligible.	Some of the criteria for selection includes the natural resource based recreation opportunities in the area as well as collaboration with other entities. MNRTF Board priorities for 2017 included trails, great lakes access, wildlife/ecological corridors and projects located within urban lands.	Green infrastructure can be included as part of recreational land development or if the land will be for recreation this grant can help fund the land acquisition.	$15,000-$300,000	25% match	1-Apr	Jon Mayes 517-284-5954 mayesj@michigan.gov
Recreation Passport Grant Program (RP)	The objective of this program is to develop public recreation facilities that have outlived their useful life expectancy or development of new facilities.	Any local unit of government that has a DNR approved 5-year Recreation Plan or a current annual Capital Improvement Plan (CIP) is eligible.	Generally this fund is for the redevelopment of parks that are dilapidated and in need of revitalization, new parks are also eligible but not the focus.	Green infrastructure can be included as part of a park revitalization or new park design.	$7,500-$75,000	25% match	1-Apr	Christie Bayus 517-284-5923 bayusc@michigan.gov
Forestry Grants								
Community Forestry Grants	The objective of this program is to provide competitive funding for the promotion, protection and management of urban trees.	Non-profits, local units of government, schools and tribal government are eligible.	Projects are 1 year in duration and develop or enhance urban forestry resources in Michigan including: management, planning, and education.	Green infrastructure plans that include trees (street trees, swales with trees, naturalized areas, etc.) could be funded from this grant.	Up to $20,000 depending on project category.		Continuous	Kevin Sayers 517-284-5898 sayersk@michigan.gov
Michigan Invasive Species Grants								
Forestry Stewardship: Plan Writing Grants	The objective of this program is to help with the prevention, eradication and detection of invasive species.	Local municipalities and nonprofits are eligible.	Directed at preventing new invasions, monitoring for new invasive species, and eradicating current extents of invasive.	If areas planned for green infrastructure have issues with invasive species, this grant can help erradicate the invasive species.	$25,000-$5,000,000	10% match minimum	Mid-June	Kammy Frayre 517-284-5970 frayrek1@michigan.gov
Trail Management								
Recreational Trails Program Grants	The objective of this program is to fund the maintenance and development of recreational trails and trail related facilities.	State and local units of government are eligible, but the DNR (Regional Trail Specialists) must always be the applicant.	Projects are evaluated based on their relationships to enhancing state partnerships, the Michigan Comprehensive Trails Plan priority recommendations, meeting program legislative requirements, and leveraging other funding sources.	Recreational trails that incorporate GI techniques could be funded through this program.	No limit per project, but total of $2,900,000 available per year within the program.		1-May	Kristen Bennett bennettk@michigan.gov
Recreation Improvement Fund Grants	The objective of this program is to operate, maintain, and develop recreational trails and restore impacted lands and inland lakes.	State and local units of government are eligible, but the DNR (Regional Trail Specialists) must always be the applicant.	Projects are evaluated based on their relationships to enhancing state partnerships, the Michigan Comprehensive Trails Plan priority recommendations, meeting program legislative requirements, and leveraging other funding sources.	Recreational trails that incorporate GI techniques could be funded through this program. It could also cover GI that helps with the restoration of impacted lands or waters.	No limit per project, but total of $900,000 available per year within the program.		1-May	Kristen Bennett bennettk@michigan.gov
MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY (MDEQ) GRANTS AND LOANS								
See: www.michigan.gov/deq/0,1607,7-135-3307_3515---,00.html								
Community Pollution Prevention (P2) Grants	The objective of this program is to fund Pollution Prevention (P2) initiatives that foster partnerships and sustainability.	County governments, local health departments, school districts, and other public entities are eligible.	The project must be focused on achieving measurable reductions in waste, have a local or regional focus, and result in long-term improvements or protection of the environment.	GI that improves water quality with measurable waste reduction can be covered by P2 grants.	$250,000 total program funds	25% match minimum of cash or in-kind goods/services	To be determined	Debra Swartz 517-284-6903 swartzd@michigan.gov
Nonpoint Source (NPS) Control Grants – Federal Clean Water Act Section 319	The objective of this program is to implement NPS activities identified in MDEQ-approved watershed management plan (WMP), especially to restore waters impaired by NPS pollution and protect high quality waters.	County governments, state agencies and non-profits are eligible to apply for funding so long as they have a MDEQ WMP.	Projects that most effectively address anticipated water quality benefits in relation to costs, expected long-term improvement, and consistency with watershed management plans will all be used to help evaluate projects.	Green infrastructure that contributes to restoration of impared waters within the Watershed Management Plan could be funded through a NPS 319 grant.	$25,000-$3,000,000	50% match for conservation easements 25% minimum for all	Deadlines specified in funding proposal requests	Robert Sweet 517-284-5520 sweetr@michigan.gov
NPS Pollution Control Grants – Clean Michigan Initiative	The objective of this program is to implement physical improvements identified in MDEQ approved watershed management plans, to restore impaired waters and protect high quality waters.	County governments, state agencies and non-profits are eligible to apply for funding so long as they have a MDEQ WMP.	Projects that most effectively address anticipated water quality benefits in relation to costs, expected long term improvement, and consistency with watershed management plans will all be used to help evaluate projects.	Green infrastructure that contributes to restoration of impared waters within the Watershed Management Plan could be funded through this program.	$25,000-$2,000,000	50% match for conservation easements 25% minimum for all	Deadlines specified in funding proposal requests	Robert Sweet 517-284-5520 sweetr@michigan.gov
State Revolving Fund (SRF)	The objective of this program is to fund wastewater treatment improvements and storm water treatment projects, and NPS pollution control projects.	City, village, township, county or related authority as defined in Section 5301 (h) of Part 53, Act 451 of the Public Acts of 1994 are eligible.	Primarily applicants must present environmentally sound water pollution control projects drawn from Project Priority Lists administered by MDEQ.	Green infrastructure to improve water quality from stormwater runoff can be included. It must be included in the MDEQ water resources Project Priority List.	Dependent on federal grant amount.	Dependent on federal grant amount.	1-Jul	Sonya Butler 517-284-5433 butlers2@michigan.gov
Water Pollution Control Revolving Fund (Clean Water State Revolving Fund - CWSRF)	The objective of this program is to assist municipalities in addressing water quality problems identified in watershed management plan such as wastewater treatment system improvements, storm water treatment projects, and nonpoint source pollution control projects.	Applicants for NPS funding must have an approved 319 or Clean Michigan Initiative (CMI) watershed management plan and must develop a SRF project plan.	Municipalities investing in land conservation, reforestation, tree boxes, cisterns and rain barrels, downspout disconnections, wetland restoration, parks and greenways, rain gardens and bioinfiltration practices, permeable pavements, and/or green roofs. Applicant must address water quality benefits and have the capacity to repay the loan. Program only funds capital costs (planning, design, and construction) and not operational and maintenance expenses.	This program includes investment in GI, for example: land conservation, reforestation, tree boxes, cisterns and rain barrels, downspout disconnections, wetland restoration, parks and greenways, rain gardens and bioinfiltration practices, permeable pavements, green roofs.	$280,000,000 awarded annually	Loan with no required match	1-Jul	Sonya Butler 517-284-5433 butlers2@michigan.gov
MICHIGAN ECONOMIC DEVELOPMENT CORPORATION (MEDC) COMMUNITY DEVELOPMENT GRANTS AND LOANS								
To empower communities to chart their own growth, beginning October 1, 2017, Redevelopment Ready Communities® engagement will be a criterion used to assess and prioritize investments for MEDC Community Development.								
See: http://www.miplace.org								
Michigan Community Revitalization Program	The objective of this program is to contribute to redevelopment and revitalization of downtown or traditional commercial corridor properties.	Property that is, or property adjacent to, a historic resource or a brownfield property. Actions such as alteration, construction, improvement, addition of machinery, engineering, are eligible for funding.	Projects evaluated based on the community location, use, design, reasonableness of cost, and other factors related to the projected success and impact.	The redevelopment or revitalization of downtown areas or commercial corridor properties that could include GI stormwater improvements.	Grants, loans or other economic assistance, dependent on available funds and need.		Continuous	517-373-9808
MEDC Public Spaces, Community Places	The objective of this program is to create or activate public or community space.	Local units of government or 501(c)(3) organizations are eligible.	Projects evaluated based on the community location, use, design, reasonableness of cost, and other factors related to the projected success and impact.	Green infrastructure improvements that would enhance public space could be funded through this grant.	Up to $50,000	50% match with matching funds from the applicant or raised through public crowdfunding campaign if the full fundraising goal is reached.	Continuous	517-373-9808
MICHIGAN DEPARTMENT OF TRANSPORTATION								
See: www.michigan.gov/mdot/0,1607,7-151-9621_17216_18231---,00.html								
Michigan Transportation Alternatives Program	The objective of this program is to fund projects that increase and improve Michigan's transportation system. Projects can include facilities for pedestrians and bicyclists, viewing areas, historic preservation and rehabilitation, and environmental mitigation efforts.	County road commissions, cities, villages, regional transportation authorities, transit agencies, state and federal natural resource or public land agencies, and tribal governments are eligible.	Project should be identified as a result of a community's Complete Streets stakeholder involvement process and be part of community improvement or economic development plans.	Grants can be applied to treating or reducing storm water runoff from transportation facilities and structures.	$16,500,000 awarded annually	20% minimum match	Continuous	Visit website.
FEDERAL FUNDING								
See: https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities								
United States Department of Agriculture (USDA) National Urban and Community Forestry Program	Under the U.S. Forest Service, this program's objectives are to establish sustainable community forests that improve the public's health, well-being, and economic vitality, and create resilient ecosystems for present and future generations.	Contact the local Forest Service regional office for current availability and type of grants.	When funds are available, cost-share grants support urban and community forestry projects that have national and multistate application and impact.	Street trees and tree boxes can be included as part of a sustainable urban forest.	Funding is variable and dependent on availability and type of grant.	Matching requirements are dependent on grant and should be discussed with the local Forest Service office.	Contact local Forest Service regional office for availability and type of grants.	Kathleen Atkinson 414-297-3600

PRIVATE FOUNDATIONS								
Fred A. and Barbara M. Erb Family Foundation Grants	The objective of this program is to pursue improved water quality in the Great Lakes basin, especially the watersheds impacting Metro Detroit and Bayfield, Ontario, through the elimination of polluted run-off and other threats, resiliency to climate change, and individual and institutional stewardship.	To be eligible for a grant, the organization must be recognized as tax-exempt under section 501(c)(3) of the Internal Revenue Code (not a private foundation), have a current financial audit conducted by an independent certified public accountant (or financial review in some cases), have had total revenues of at least $100,000 for the preceding year, and in policy and practice the organization must not discriminate based on age, race, creed, gender, gender identity, religion, sexual orientation, and ethnicity.	Project promotes green stormwater infrastructure to achieve community development as well as water goal. Focused on Wayne, Oakland, and Macomb counties of Michigan, as well as the watersheds impacting those areas. Generally the foundation does not provide support directly to individuals or units of government, nor for loans, grants to support religious activities, capital projects, research (unless solicited by the Foundation), fundraising events, or conferences.	A non-profit organization such as Clinton River Watershed Council or educational institution such as Oakland Community College could be the fiduciary.	Dependent of size and scope of organizational and program budget and anticipated program impact.		Continuous	Jodee Raines 248-498-2501 jraines@erbff.org
Ralph C. Wilson Jr. Foundation Healthy Communities Grants	The objective of this program is to support community design and access to space, and programs that support healthy living; improving non-profit productivity and innovation; and economic development levers that spur regional growth, innovation and equity.	Federal 501(c)(3) tax-exempt organizations, government entities, or school districts and universities located within Western New York or Southeast Michigan (Wayne, Oakland, Macomb, Monroe, Washtenaw, St Clair and Livingston counties).	Grant cannot be construed to be a taxable expenditure (Section 4945 Internal Revenue Code). Visionary projects that are also feasible and realistic are preferred as well as those by established organizations with a record of success. The Foundation does not make grants to individuals, fundraising social events, conferences or exhibits.	Green infrastructure as part of community design can be included in the grant.	Varies depending on grant.	Varies depending on grant.	Continuous	313-885-1895 info@ralphcwilsonjrfoundation.org
Community Foundation for Southeast Michigan	The objective of this program is to support effective program and project ideas that can improve life in southeast Michigan, specifically in Wayne, Oakland, Macomb, Monroe, Washtenaw, St. Clair and Livingston counties.	Federal 501(c)(3) tax-exempt organizations, government entities, or school districts and universities headquartered in SE Michigan. Grants are for a specific project within the organization. Organization must have a certified financial audit.	Organizations are prioritized based on sustainability, regional impact, how the funds will be leveraged, and collaboration between multiple entities (nonprofit and/or government).	Green infrastructure to improve quality of life in the area can be funded by this program.	$5,000-$1 million awarded depending on available funds. Typically projects range from $30,000-$75,000.		Continuous, but prefer on or shortly before: February 15, May 15, August 15, or November 15	313-961-6675

APPENDIX C
PLANT MATERIAL RECOMMENDATIONS

Grass, Perennial, and Shrub Plant Material Recommendations

Vegetation Type	Genus	Species	Common Name	Height	Width	Bloom Time	Early Season Bloom (Feb-June)	Late Season Bloom (June-Oct)	Bloom Color	Fall Color	Winter Interest	Showy in Fall	Native to US	Inundation Tolerance	Drought Tolerance	Hydrologic Zone Elevation	Light Requirements	Salinity Tolerance
Grass/Grass-Likes	*Carex*	*flaccosperma*	Blue Wood Sedge	6-10"	6-12"	May - June	✓	X	Green, White	Green	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*flaccosperma var. glaucodea*	Blue Wood Sedge	6-10"	6-12"	May - June	✓	X	Wheat	Green	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*laxiculmis*	Bunny Blue Sedge	8-12"	8-12"	May - June	✓	X	Blue, Green	Green	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*laxiculmis 'Hobb'*	Bunny Blue® *(Spreading Sedge)*	8-12"	12-16"	May - June	✓	X	Silver, Blue	Green	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*morrowii*	Japanese Sedge	1-3'	2'	April - July	✓	X	Green, Yellow	Gold, Tan	X	✓	X	Seasonal	High	Lowest/ Middle/ Outer	Part Sun - Shade	High
Grass/Grass-Likes	*Carex*	*morrowii 'Variegata'*	Japanese Sedge	1.00-1.50'	1.50-2.00'	April - July	✓	X	Brown	Green, White	X	✓	X	Seasonal	High	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*morrowii 'Ice Dance'*	Japanese Sedge	12-15"	12-18"	April - July	✓	X	Brown	Green	X	✓	X	Seasonal	High	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*morrowii 'Ice Ballet'*	Japanese Sedge	9-12"	12-24"	April - July	✓	X	Brown	Green	X	✓	X	Seasonal	Medium	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*morrowii 'Silver Sceptre'*	Japanese Sedge	9-12"	12-18"	April - July	✓	X	Brown	Green, White	X	✓	X	Seasonal	High	Lowest/ Middle	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*pensylvanica*	Pennsylvania Sedge (*Oak Sedge*)	6-12"	6-12"	May	✓	X	Green, Brown	Gold, Tan	X	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Part Shade - Full Shade	High
Grass/Grass-Likes	*Carex*	*stricta*	Tussock Sedge	1-3'	1-2'	May - June	✓	X	Red, Brown	Green	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	Medium
Grass/Grass-Likes	*Carex*	*vulpinoidea*	Fox Sedge	1-3'	1-2'	May - July	✓	X	Green	Gold, Tan	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Grass/Grass-Likes	*Chasmanthium*	*latifolium*	Northern Sea Oats (*Inland Sea Oats, River Oats*)	2.00-5.00'	1.00-2.50'	Aug - Sept	X	✓	Green	Gold, Tan	✓	✓	✓	X	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Grass/Grass-Likes	*Chasmanthium*	*latifolium 'River Mist'*	Northern Sea Oats	2.00-3.00'	2.00-3.00'	Aug - Sept	X	✓	Silver, White	Gold, Tan	✓	✓	✓	X	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Grass/Grass-Likes	*Dennstaedtia*	*punctilobula*	Hay-scented Fern	1.50-2.00'	2.00-3.00'	X	X	X	Green	Yellow	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Part Shade - Shade	High
Grass/Grass-Likes	*Deschampia*	*cespitosa 'Goldtau'*	Tufted Hair Grass	12-24"	24-30"	July - Sept	X	✓	Dark Green, Gold, Yellow	Gold, Yellow	✓	✓	X	Seasonal	Medium	Lowest/ Middle	Part Shade - Shade	High
Grass/Grass-Likes	*Deschampia*	*cespitosa 'Schottland'*	Scottish Tufted Hair Grass	3.00-4.00'	3.00-4.00'	May - June	✓	X	Green, Tan	Tan	X	✓	X	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	Medium
Grass/Grass-Likes	*Deschampia*	*cespitosa 'Pixie Fountain'*	Tufted Hair Grass	1.50-2.00'	1.00-1.50'	July - Sept	X	✓	Silver, White, Brown	Brown	✓	✓	X	X	Medium	Lowest/ Middle	Part Shade	High
Grass/Grass-Likes	*Deschampia*	*cespitosa 'Tardiflora'*	Tufted Hair Grass	2.00-3.00	2.00-3.00	July - Sept	X	✓	Green, Gold, Purple, Silver	Tan	✓	✓	X	X	Medium	Lowest/ Middle	Part Shade	High
Grass/Grass-Likes	*Festuca*	*glauca 'Elijah Blue'*	Blue Fescue	10-14"	6-9"	June - July	X	✓	Green, Purple	Blue	✓	✓	X	X	High	Middle/ Outer	Full Sun	High
Grass/Grass-Likes	*Festuca*	*glauca Beyond Blue™*	Blue Fescue	10-12"	15-18"	June - July	X	✓	Tan	Blue	✓	✓	X	X	High	Middle/ Outer	Full Sun	High
Grass/Grass-Likes	*Helictotrichon*	*sempervirens*	Blue Oat Grass	24-36"	24-36"	June	X	✓	Blue, Brown	Gold, Tan	X	✓	X	X	Medium	Middle/ Outer	Full Sun	Medium
Grass/Grass-Likes	*Helictotrichon*	*sempervirens 'Saphiresprudel'*	Blue Oat Grass	24-36"	18-24"	May - June	✓	X	Blue, Green	Blue, Brown, Tan	X	✓	X	X	High	Middle/ Outer	Full Sun	Medium
Grass/Grass-Likes	*Leymus*	*arenarius 'Blue Dune'*	Blue Lyme Grass (Sand ryegrass)	2.00-3.00'	2.00-3.00'	May - Aug	✓	X	Green, Blue	Blue, Gray, Tan	✓	✓	X	X	High	Lowest/ Middle/ Outer	Full Sun	High
Grass/Grass-Likes	*Pennisetum*	*alopecuroides 'Burgundy Bunny'*	Dwarf Fountain Grass	1.00-1.50'	1.00-1.50'	Aug - Oct	X	✓	White	Burgundy, Beige	✓	✓	X	Seasonal	High	Lowest/ Middle/ Outer	Full Sun	Medium
Grass/Grass-Likes	*Sorghastrum (Andropogon)*	*nutans*	Indian Grass	3.00-5.00'	1.00-2.00'	Sep - Feb	X	✓	Tan, Yellow	Orange, Yellow	✓	✓	✓	X	High	Middle/ Outer	Full Sun	High
Grass/Grass-Likes	*Sorghastrum (Andropogon)*	*nutans 'Indian Steel'*	Indian Grass	3.00-5.00'	2.00-3.00'	Aug - Sept	X	✓	Tan, Yellow	Yellow, Gold	✓	✓	✓	X	Medium	Middle/ Outer	Full Sun	High
Grass/Grass-Likes	*Sorghastrum (Andropogon)*	*nutans 'Sioux Blue'*	Indian Grass	3.00-5.00'	2.00-3.00'	Aug - Feb	X	✓	Tan, Yellow	Yellow, Gold	✓	✓	✓	X	Medium	Middle/ Outer	Full Sun	High
Herbaceous	*Amsonia*	*hubrichtii*	Blue Star	2.00-3.00'	2.00-3.00'	Apr - May	✓	X	White, Blue	Gold	X	✓	✓	X	High	Middle/ Outer	Full Sun - Part Shade	High

Grass, Perennial, and Shrub Plant Material Recommendations

Vegetation Type	Genus	Species	Common Name	Height	Width	Bloom Time	Early Season Bloom (Feb-June)	Late Season Bloom (June-Oct)	Bloom Color	Fall Color	Winter Interest	Showy in Fall	Native to US	Inundation Tolerance	Drought Tolerance	Hydrologic Zone Elevation	Light Requirements	Salinity Tolerance
Herbaceous	*Amsonia*	*'Blue Ice'*	Blue Star	1.00-1.50'	1.00-1.50'	May	✓	X	Lavender, Blue	Yellow	X	✓	✓	X	High	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Anemone (Anemonidium)*	*canadensis (canadense)*	Meadow Anemone (Windflower, Canada Anemone, Roundleaf Anemone)	1.00-2.00'	2.00-2.50'	Apr - June	✓	X	White	X	X	X	✓	Seasonal	Low	Lowest/ Middle	Part Shade	High
Herbaceous	*Aquilegia*	*canadensis 'Corbett'*	Columbine	15-18"	9-12"	Apr - May	✓	X	Yellow	X	X	X	✓	Seasonal	Medium	Middle/ Outer	Part Shade - Shade	High
Herbaceous	*Aquilegia*	*canadensis 'Little Lanterns'*	Columbine (Canadian Columbine, Dwarf Wild Columbine)	9-10"	9-12"	Apr - May	✓	X	Red, Yellow	X	X	X	✓	Seasonal	High	Middle/ Outer	Part Shade - Shade	High
Herbaceous	*Asclepias*	*tuberosa*	Butterfly Weed	1.00-2.50'	1.00-1.50'	June - Aug	X	✓	Yellow, Orange	X	X	X	✓	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Astilbe*	*sp.*	Astilbe	1.00-3.00'	1.00-3.00'	May - July	✓	X	Red, Pink, White, Purple	X	X	X	✓	X	Low	Lowest/ Middle	Part Shade - Shade	High
Herbaceous	*Baptisia*	*australis var. Minor*	Blue False Indigo	1.50-2.00'	1.50-2.00'	May - June	✓	X	Purple, Blue	X	X	X	✓	X	High	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Calamintha*	*nepeta* subsp. *nepeta*	Calamint	1.00-1.50'	1.00-2.00'	June - Sep	X	✓	White, Purple	White, Purple	X	X	X	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Calamintha*	*nepeta ssp. glandulosa 'White Cloud'*	Lesser Calamint	1.00-2.00'	1.00-2.00'	June - Oct	X	✓	White	White	X	X	X	X	High	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Calamintha*	*nepeta 'Montrose White'*	Calamint	1.00-1.50'	1.00-1.50'	June - Oct	X	✓	White	White	X	X	X	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Coreopsis*	*grandiflora 'Baby Sun'*	Large-flowered Tickseed	20"	20"	June - Sep	✓	X	Yellow, Gold, Burgundy	X	X	X	✓	X	High	Outer	Full Sun	High
Herbaceous	*Coreopsis*	*grandiflora 'Early Sunrise'*	Large-flowered Tickseed	1.50-2.00'	1.50-2.00'	May - Aug	✓	X	Yellow	X	X	X	✓	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Coreopsis*	*grandiflora 'Sunfire'*	Large-flowered Tickseed (Butter Daisy)	18"	18-20"	May - Aug	✓	X	Yellow, Gold, Burgundy	X	X	X	✓	X	High	Outer	Full Sun	High
Herbaceous	*Coreopsis*	*grandiflora 'Sunray'*	Large-flowered Tickseed (Threadleaf Coreopsis)	1.50-2.00'	1.00-1.50'	June - Sep	X	✓	Yellow	X	X	X	✓	X	High	Outer	Full Sun	High
Herbaceous	*Coreopsis*	*lanceolata 'Sterntaler'*	Lance-leaf Tickseed	9"	9-12"	May - July	✓	X	Yellow	X	X	X	✓	X	High	Outer	Full Sun	High
Herbaceous	*Coreopsis*	*verticillata 'Moonbeam'*	Whorled Tickseed (Threadleaf Coreopsis)	1.50-2.00'	1.50-2.00'	Jun - Aug	X	✓	Yellow	X	X	X	✓	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Coreopsis*	*verticillata 'Zagreb'*	Whorled Tickseed (Threadleaf Coreopsis)	1.00-1.50'	1.00-1.50'	May - June	X	✓	Yellow	X	X	X	✓	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Coreopsis*	*verticillata 'Route 66'*	Whorled Tickseed (Threadleaf Coreopsis)	24-28"	24-28"	Jun - Sep	X	✓	Yellow, Red	Yellow, Red	X	X	✓	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Echinacea*	*purpurea 'Evening Glow'*	Purple Coneflower (Eastern Purple Coneflower)	2.00-3.00'	1.00-2.00'	July - Aug	X	✓	Purple, Red, White, Yellow	X	X	X	X	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Herbaceous	*Echinacea*	*purpurea 'Magnus'*	Purple Coneflower (Eastern Purple Coneflower)	2.50-3.00'	1.00-1.50'	Jun - Aug	X	✓	Rose purple	X	X	X	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Herbaceous	*Echinacea*	*purpurea 'White Swan'*	Purple Coneflower (Eastern Purple Coneflower)	2.00-3.00'	1.00-2.00'	Jun - Aug	X	✓	White, Copper, Orrange	X	X	X	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Herbaceous	*Echinacea*	*purpurea 'Ruby Star'*	Purple Coneflower (Eastern Purple Coneflower)	2.00-3.00'	1.50-2.00'	July - Aug	X	✓	Purple	X	X	X	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Herbaceous	*Echinacea*	*purpurea 'Green Envy'*	Purple Coneflower (Eastern Purple Coneflower)	2.00-3.00'	1.50-2.00'	July - Aug	X	✓	Green, Purple	X	X	X	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Herbaceous	*Eranthis*	*hyemalis*	Winter Aconite	3-6"	3-6"	Mar - Apr	✓	X	Yellow	X	X	X	X	X	High	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Eupatorium (Eutrochium)*	*dubium 'Little Joe'*	Joe Pye Weed	3.00-4.00'	1.00-3.00'	July - Sept	X	✓	Purple, Pink	Purple, Pink	X	X	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Eupatorium (Eutrochium)*	*purpureum ssp. Maculatum 'Gateway'*	Joe Pye Weed	4.00-5.00'	3.00-5.00'	July - Sept	X	✓	Pink	Pink	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Eupatorium (Eutrochium)*	*purpureum 'Phantom'*	Joe Pye Weed	2.00-4.00'	1.00-2.00'	July - Sept	X	✓	Pink, Red	Pink, Red	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun - Part Shade	High

Grass, Perennial, and Shrub Plant Material Recommendations

Vegetation Type	Genus	Species	Common Name	Height	Width	Bloom Time	Early Season Bloom (Feb-June)	Late Season Bloom (June-Oct)	Bloom Color	Fall Color	Winter Interest	Showy in Fall	Native to US	Inundation Tolerance	Drought Tolerance	Hydrologic Zone Elevation	Light Requirements	Salinity Tolerance
Herbaceous	*Eupatorium (Eutrochium)*	*purpureum 'Purple Bush'*	Joe Pye Weed (Sweet Joe Pye Weed)	5.00-7.00'	2.00-4.00'	July - Sept	X	✓	Purple, Pink	Purple, Pink	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Geranium*	*maculatum 'Album'*	Wild Geranium (Spotted Geranium, Cranesbill)	12-24"	12-24"	Mar - Jul	✓	X	White, Purple, Pink	X	X	X	✓	Seasonal	High	Lower/ Middle/ Outer	Part Shade - Full Shade	High
Herbaceous	*Helleborus*	*niger*	Hellebore (Christmas Rose)	9-12"	12-18"	Feb - Mar	X	✓	White, Pink	X	✓	X	X	X	High	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Hemercallis (Lilium)*	*spp.*	Daylily	1.00-3.00'	1.00-2.00'	May - Sep	X	✓	Yellow, Orange, Red	Yellow, Orange, Red	X	X	X	Seasonal	Medium	Middle/ Outer	Part Shade	Low
Herbaceous	*Heuchera*	*americana 'Dale's Strain'*	Coral Bells (American alumroot)	18"	18"	June - Sep	X	✓	White	White	X	X	✓	X	Medium	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Heuchera*	*americana 'Green Spice'*	Coral Bells (American alumroot)	18"	18"	June - Sep	X	✓	White	White	X	X	✓	X	Medium	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Heuchera*	*americana 'Marvelous Marble'*	Coral Bells (American alumroot)	8-12"	12"	May - Aug	✓	X	Green, Purple	X	X	X	✓	X	Medium	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Hibiscus*	*coccineus*	Scarlet Rose Hibiscus / Mallow	3.00-6.00'	2.00-3.00'	June - Sep	X	✓	Red	Red	X	X	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Hibiscus*	*moscheutos*	Hardy Hibiscus (Swamp Rose Mallow)	2-3'	1-2'	July - Sept	X	✓	Red, Pink, White	Red, Pink, White	X	X	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Hibiscus*	*Cranberry Crush'*	Hardy Hibiscus (Swamp Rose Mallow)	3.00-4.00'	3.00-4.00'	July - Sept	X	✓	Red	Red	X	X	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Hibiscus*	*moscheutos 'Luna Red'*	Hardy Hibiscus (Swamp Rose Mallow)	2.00-3.00'	1.50-2.00'	July - Sept	X	✓	Burgundy Red	Burgundy Red	X	X	✓	Seasonal	Medium	Lowest/ Middle	Full Sun	High
Herbaceous	*Iris*	*versicolor*	Blue Flag (Northern Blue Flag)	2.00-2.50'	2.00-2.50'	May - July	✓	X	Purple, Blue	X	X	X	✓	Regular	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Leucanthemum*	*sp.*	Shasta Daisy	3.00-4.00'	2.00-3.00'	July - Sept	X	✓	White	X	X	X	X	X	Medium	Lowest/ Middle	Full Sun	High
Herbaceous	*Liatris*	*spicata 'Kobold'*	Blazing Star	2.00-2.50'	0.50-1.00'	July - Aug	X	✓	Purple	X	X	X	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun	High
Herbaceous	*Liatris*	*spicata 'Gayfeather'*	Spike Gayfeather	3.00-5.00'	2.00'	July - Aug	X	✓	Purple, Pink	X	X	X	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Monarda*	*bradburiana*	Eastern Bee Balm	1.00-2.00'	1.00-2.00'	May	✓	X	Purple, Pink, White	X	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Monarda*	*didyma 'Coral Reef'*	Bee Balm (Bergamot, Oswego Tea)	2.00-2.50'	3.00'	July - Aug	X	✓	Coral-Pink	X	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Monarda*	*didyma 'Jacob Cline'*	Bee Balm (Bergamot, Oswego Tea)	3.00-5.00'	2.00'	July - Aug	X	✓	Red	X	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Monarda*	*didyma 'Marshall's Delight'*	Bee Balm (Bergamot, Oswego Tea)	2.00-4.00'	2.00'	July - Aug	X	✓	Rose-Pink	X	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun	High
Herbaceous	*Monarda*	*fistulosa*	Wild Bergamot (Lavendar Bee Balm)	2.00-4.00'	2.00-3.00'	July - Sept	X	✓	Pink, Lavender	Pink, Lavender	X	X	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Narcissus*	*minor 'Little Gem'*	Trumpet Daffodil	4-5"	3-6"	Mar - Apr	✓	X	Yellow	X	X	X	X	X	Medium	Middle/ Outer	Full Sun - Part Shade	Low
Herbaceous	*Oenothera*	*fruticosa 'Fyrverkeri'*	Sundrops	1.00-1.50'	1.00-1.50'	May - Jun	✓	X	Yellow	Purple, Brown, Red	X	✓	✓	Seasonal	High	Lowest/ Middle	Full Sun	High
Herbaceous	*Oenothera*	*fruticosa 'Fireworks'*	Sundrops (Evening Primrose)	15-18"	12-18"	June	✓	X	Yellow	Bronze, Red	X	✓	✓	Seasonal	High	Lowest/ Middle	Full Sun	High
Herbaceous	*Oenothera*	*perennis*	Little Evening-Primrose (Small Sundrops)	12-23"	12-18"	May - Aug	✓	X	Yellow	X	X	X	✓	Seasonal	High	Lowest/ Middle	Full Sun	High
Herbaceous	*Packera*	*aurea*	Golden Ragwort (Golden Groundsel, Squaw Weed)	6-30"	6-18"	April	✓	X	Yellow	X	✓	X	✓	Regular	Low	Lowest/ Middle	Full Sun - Part Shade	High
Herbaceous	*Perovskia*	*'Longin'*	Russian Sage	3.00-4.00'	2.00-3.00'	Jun - Sept	X	✓	Blue	Blue	X	X	X	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Perovskia*	*atriplicifolia 'Little Spire'*	Russian Sage	1.50-2.00'	1.50-2.00'	Jun - frost	X	✓	Violet-Blue	Violet-Blue	X	X	X	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Perovskia*	*atriplicifolia 'Lacey Blue'*	Dwarf Russian Sage	18-20"	18-23"	July - Sept	X	✓	Violet-Blue	Violet-Blue	X	X	X	X	High	Outer	Full Sun	High
Herbaceous	*Phlox*	*paniculata 'David'*	Garden Phlox (Phlox)	3.00-4.00'	2.00-3.00'	July - Sept	X	✓	White	White	X	X	✓	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Phlox*	*paniculata 'David's Lavendar'*	Garden Phlox (Phlox)	3.00-4.00'	2.00-3.00'	July - Sept	X	✓	Lavender	Lavender	X	✓	✓	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	High

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Herbaceous	*Phlox*	*paniculata 'Jeana'*	Garden Phlox (Phlox)	4.00-5.00'	2.00-3.00'	Aug - Oct	X	✓	Pink	Pink	X	✓	✓	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Phlox*	*paniculata 'Blue Paradise'*	Garden Phlox (Phlox)	2.00-3.00'	2.00'	July - Aug	X	✓	Violet-Blue	X	X	X	✓	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Phlox*	*paniculata 'Shortwood'*	Garden Phlox (Phlox)	3.00-4.00'	2.00-3.00'	July - Sept	X	✓	Pink	Pink	X	✓	✓	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Physostegia*	*virginiana 'Vivid'*	Obedient Plant	1.00-2.00'	1.00-1.50'	June - Sep	X	✓	Pink	Pink	X	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun	High
Herbaceous	*Physostegia*	*virginiana 'Miss Manners'*	Obedient Plant	2.00-2.50'	2.00-2.50'	June - Sep	X	✓	White	White	X	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun	High
Herbaceous	*Rudbeckia*	*fulgida* var. *sullivantii 'Goldsturm'*	Black-eyed Susan (Orange Coneflower)	2.00-3.00'	1.00-2.00'	June - Sep	X	✓	Yellow	Yellow	X	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun	Medium
Herbaceous	*Rudbeckia*	*fulgida* var. *'Deamii'*	Black-eyed Susan (Orange Coneflower)	3.00'	2.00'	Aug - Oct	X	✓	Gold, Yellow	Gold, Yellow	X	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun	Medium
Herbaceous	*Rudbeckia*	*hirta 'Indian Summer'*	Black-eyed Susan (Gloriosa Daisy)	2.00-3.00'	1.00-2.00'	Jun - frost	X	✓	Yellow, Red, Bronze, Orange, Bicolors	Yellow, Red, Bronze, Orange, Bicolors	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	Medium
Herbaceous	*Rudbeckia*	*hirta 'Cherry Brandy'*	Black-eyed Susan (Gloriosa Daisy)	20-24"	12-16"	July - Sept	X	✓	Red	Red	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	Medium
Herbaceous	*Rudbeckia*	*hirta 'Prairie Sun'*	Black-eyed Susan	2.50-3.00'	1.50-2.00'	Jun - frost	X	✓	Yellow, Orange	Yellow, Orange	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	Medium
Herbaceous	*Rudbeckia*	*subtomentosa 'Henry Eilers'*	Sweet Coneflower	3.00-5.00'	1.00-2.00'	July - Sept	X	✓	Yellow	Yellow	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun	Medium
Herbaceous	*Rudbeckia*	*subtomentosa 'Little Henry'*	Sweet Coneflower (Sweet Black-eyed Susan)	3.00-4.00'	2.00'	August	X	✓	Yellow	X	X	✓	✓	Seasonal	Medium	Lowest / Middle	Full Sun - Part Shade	Medium
Herbaceous	*Rudbeckia*	*triloba*	Brown-eyed Susan	2.00-3.00'	1.00-1.50'	July - Oct	X	✓	Yellow	Yellow	X	✓	✓	Seasonal	Medium	Lowest / Middle	Full Sun	Medium
Herbaceous	*Rudbeckia*	*triloba 'Prairie Glow'*	Brown-eyed Susan	3.00-4.00'	1-2'	July - Oct	X	✓	Yellow, Red-Orange	Yellow, Red-Orange	X	✓	✓	Seasonal	Medium	Lowest / Middle	Full Sun	Medium
Herbaceous	*Sedum*	*rupestre 'Angelina'*	Stonecrop (Sedum)	6-10"	8-12"	May - Oct	✓	X	Chartreuse, Gold, Yellow	Orange, Red	✓	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	High
Herbaceous	*Sedum*	*ternatum*	Three-leaved Stonecrop (Sedum)	3-6"	6-9"	May - Jun	✓	X	White	X	✓	X	✓	Seasonal	Medium	Lowest / Middle	Full Sun - Part Shade	High
Herbaceous	*Sedum*	*ternatum 'Larinem Park'*	Three-leaved Stonecrop (Shale Barrens, Whorled Sedum)	2-6"	12-18"	April - May	✓	X	White	X	✓	X	✓	Seasonal	Medium	Lowest / Middle	Full Sun - Part Shade	High
Herbaceous	*Sedum*	*x 'Autumn Joy'*	Stonecrop (Sedum)	1.00-1.50'	2.00-3.00'	April - June	✓	X	Pink	Copper, Red	X	X	✓	Seasonal	High	Middle/ Outer	Full Sun	High
Herbaceous	*Sedum*	*x 'Autumn Fire'*	Stonecrop (Sedum)	2.00-3.00'	2.00'	August	X	✓	Rose-Pink	Bronze, Red	✓	X	✓	Seasonal	High	Middle/ Outer	Full Sun	High
Herbaceous	*Solidago*	*rugosa*	Roughleaf Goldenrod (Wrinkleleaf goldenrod, Roughstem goldenrod)	3.00-6.00'	3.00-6.00'	September	X	✓	Yellow	Yellow	X	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun	High
Herbaceous	*Solidago*	*rugosa 'Fireworks'*	Rough Goldenrod	2.50-3.00'	2.50-3.00'	Sept - Oct	X	✓	Yellow	Yellow	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun	High
Herbaceous	*Solidago*	*sphacelata*	Goldenrod (Autumn Goldenrod)	1.00-1.50'	1.00-1.50'	Aug - Sept	X	✓	Yellow	Yellow	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun	High
Herbaceous	*Solidago*	*sphacelata 'Golden Fleece'*	Goldenrod (Autumn Goldenrod)	18-24"	24-36"	Aug - Sept	X	✓	Gold, Yellow	Gold, Yellow	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Herbaceous	*Solidago*	*x 'Little Lemon'*	Goldenrod	12-18"	18-24"	Aug - Sept	X	✓	Yellow	Yellow	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun	High
Herbaceous	*Thermopsis*	*villosa (caroliniana)*	Carolina Lupine (Aaron's rod)	3.00-5.00'	2.00-3.00'	July	X	✓	Yellow	X	X	X	✓	X	High	Middle/ Outer	Full Sun	High
Herbaceous	*Vernonia*	*fasciculata*	Prairie Ironweed (Smooth Ironweed)	2.00-4.00'	1.50-3.00'	July - Sept	X	✓	Purple	Purple	X	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun	High
Herbaceous	*Vernonia*	*lettermanii 'Iron Butterfly'*	Ironweed	30-36"	30-36"	Aug - Oct	X	✓	Purple	Purple	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	High
Herbaceous	*Vernonia*	Southern Cross'	Ironweed	2.50-3.00'	2.50-3.00'	Aug - Sept	X	✓	Purple	Purple	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	High
Herbaceous	*Vernonia*	*noveboracensis*	New York Ironweed	4.00-6.00'	3.00-4.00'	Aug - Sept	X	✓	Purple	Purple	X	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun	High

Grass, Perennial, and Shrub Plant Material Recommendations

Vegetation Type	Genus	Species	Common Name	Height	Width	Bloom Time	Early Season Bloom (Feb-June)	Late Season Bloom (June-Oct)	Bloom Color	Fall Color	Winter Interest	Showy in Fall	Native to US	Inundation Tolerance	Drought Tolerance	Hydrologic Zone Elevation	Light Requirements	Salinity Tolerance
Herbaceous	*Veronica*	*spicata* *'Glory'* ROYAL CANDLES	Spiked Speedwell	9-12"	6-9"	June - Aug	X	✓	Dark Violet-Blue	X	X	X	X	Seasonal	Low	Middle	Full Sun	Medium
Herbaceous	*Veronica*	*spicata* *'Rotfuchs'* RED FOX	Spiked Speedwell	1.00-1.50'	1.00-1.50'	June - Aug	X	✓	Pink, Red	X	X	X	X	Seasonal	Low	Middle	Full Sun	Medium
Herbaceous	*Veronica*	*spicata* 'Noah Williams'	Speedwell	1.50-2.00'	1.00-1.50'	June - Aug	X	✓	White	X	X	X	X	Seasonal	Low	Middle	Full Sun	Medium
Shrubs	*Aronia*	*arbutifolia*	Red Chokeberry (Chokeberry)	6.00-10.00'	3.00-5.00'	May	✓	X	White	Red	✓	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Aronia*	*arbutifolia* *'Brilliantissima'*	Red Chokeberry (Chokeberry)	6.00-8.00'	3.00-4.00'	April	✓	X	White	Red	✓	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Aronia*	*melanocarpa* *'Viking'*	Black Chokeberry (Chokeberry)	3.00-6.00'	3.00-6.00'	May	✓	X	White	Red	✓	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Aronia*	*melanocarpa* *'Autumn Magic'*	Black Chokeberry (Chokeberry)	3.00-6.00'	4.00-7.00'	May	✓	X	White	Red	✓	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Aronia*	*melanocarpa* var. *'Elata'*	Black Chokeberry (Chokeberry)	5.00-8.00'	6.00-10.00'	May	✓	X	White	Red	✓	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Buxus*	*sempervirens* *'Suffruticosa'*	English Boxwood (Boxwood)	2.00-3.00'	2.00-4.00'	April - May	✓	X	Green, Cream	Green (Broadleaf Evergreen)	✓	✓	X	X	Medium	Middle/ Outer	Full Sun - Shade	High
Shrubs	*Buxus*	*sempervirens* *'Variegata'*	Boxwood	3.00-5.00'	3.00-4.00'	April - May	✓	X	White, Green	Green (Broadleaf Evergreen)	✓	✓	X	X	Medium	Middle/ Outer	Full Sun - Shade	High
Shrubs	*Buxus*	*sempervirens* *'Fastigiata'*	Boxwood	10.00-12.00'	4.00-5.00'	April - May	✓	X	White	Green (Broadleaf Evergreen)	✓	✓	X	X	Medium	Middle/ Outer	Full Sun - Shade	High
Shrubs	*Buxus*	*sempervirens* *'Vardar Valley'*	Boxwood	2.00-3.00'	4.00-5.00'	April - May	✓	X	Green, Yellow	Green (Broadleaf Evergreen)	✓	✓	X	X	Medium	Middle/ Outer	Full Sun - Shade	High
Shrubs	*Clethra*	*alnifolia* *'Ruby Spice'*	Sweet Pepperbush (Summersweet)	4.00-6.00'	3.00-5.00'	July - Aug	X	✓	Rose-Pink	Yellow, Orange	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Clethra*	*alnifolia* *'Hummingbird'*	Sweet Pepperbush (Summersweet)	2.00-4.00'	3.00-5.00'	July - Aug	X	✓	White	Yellow, Orange	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Clethra*	*alnifolia* *'Sixteen Candles'*	Sweet Pepperbush (Summersweet)	4.00-5.00'	2.00-3.00'	July - Aug	X	✓	White	Yellow, Orange	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Comptonia*	*peregrina*	Sweet Fern	2.00-5.00'	4.00-8.00'	April - May	✓	X	Yellow, Green	X	X	X	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Diervilla*	*lonicera*	Northern Bush Honeysuckle	1.00-3.00'	1.00-3.00'	June - Aug	X	✓	Yellow, Red, Orange, Purple	Yellow, Red	X	✓	✓	X	High	Middle/ Outer	Part Shade - Shade	Medium
Shrubs	*Diervilla*	*'Copper'*	Dwarf Bush Honeysuckle	2.00-3.00'	2.00-3.00'	June	X	✓	Yellow	Bronze, Orange, Red	X	✓	✓	X	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Shrubs	*Hamamelis*	*virginiana* *'Little Suzie'*	Witch Hazel	4.00-5.00'	4.00-5.00'	Oct - Dec	X	✓	Yellow	Soft Yellow	✓	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Hamamelis*	*virginiana* *'Harvest Moon'*	Witch Hazel	15.00-20.00'	10.00-15.00'	Sept - Nov	X	✓	Yellow	Yellow, Gold	✓	✓	✓	Seasonal	Low	Middle	Full Sun	High
Shrubs	*Hydrangea*	*quercifolia* *'Alice'*	Oakleaf Hydrangea	5.00-8.00'	5.00-8.00'	Jun - July	X	✓	White, Pink	Bronze, Maroon, Purple	✓	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Hydrangea*	*quercifolia* *'Snow Queen'*	Oakleaf Hydrangea	4.00-6.00'	6.00-8.00'	May - July	X	✓	White, Pink	Bronze, Maroon, Purple	✓	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Hydrangea*	*quercifolia* *'Amethyst'*	Oakleaf Hydrangea	5.00-6.00'	4.00-5.00'	May - July	X	✓	White	Red, Maroon	X	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Hydrangea*	*quercifolia* *'Ruby Slippers'*	Oakleaf Hydrangea	3.00-4.00'	4.00-5.00'	Jun - July	X	✓	White, Deep Pink	Mahogany	X	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Hydrangea*	*quercifolia* *'Pee Wee'*	Oakleaf Hydrangea	3.00-4.00'	2.50-3.00'	Jun - July	X	✓	White, Pink	Bronze, Maroon, Purple	✓	✓	✓	Seasonal	Low	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Hypericum*	*densiflorum* *'Buttercup'*	St. John's Wort	1.00-6.00'	1.00-5.00'	Jun - Aug	X	✓	Yellow	Green, Orange, Yellow	X	X	✓	Seasonal	Medium	Middle	Full Sun	High
Shrubs	*Hypericum*	*frondosum* *'Sunburst'*	Golden St. John's Wort	3.00-4.00'	3.00-4.00'	June - July	X	✓	Yellow	Red, Brown, Maroon	X	✓	✓	Seasonal	Medium	Middle	Full Sun - Part Shade	High
Shrubs	*Hypericum*	*kalmianum* *'Gemo'*	Kalm St. John's Wort	2.00-3.00'	2.00-3.00'	July - Aug	X	✓	Yellow	Yellow, Green	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun	High
Shrubs	*Hypericum*	*kalmianum* *'Ames'*	Kalm St. John's Wort	2.00-3.00'	2.00-3.00'	July - Aug	X	✓	Yellow	Gold, Yellow	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Hypericum*	*kalmianum* 'Deppe' SUNNY BOULEVARD	Kalm St. John's Wort	2.00-3.00'	2.00-4.00'	July - Aug	X	✓	Yellow	Gold, Yellow	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High

Grass, Perennial, and Shrub Plant Material Recommendations

Vegetation Type	Genus	Species	Common Name	Height	Width	Bloom Time	Early Season Bloom (Feb-June)	Late Season Bloom (June-Oct)	Bloom Color	Fall Color	Winter Interest	Showy in Fall	Native to US	Inundation Tolerance	Drought Tolerance	Hydrologic Zone Elevation	Light Requirements	Salinity Tolerance
Shrubs	*Hypericum*	*kalmianum 'Blue Velvet'*	Kalm St. John's Wort	2.00-2.50'	2.50-3.00'	July - Aug	X	✓	Yellow	Gold, Yellow	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun	High
Shrubs	*Hypericum*	*prolificum*	Shrubby St. John's Wort	1.00-5.00'	1.00-4.00'	June - Aug	X	✓	Yellow	Gold, Yellow	X	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Ilex*	*verticillata 'Winter Red'*	Winterberry (Holly)	6.00-8.00'	6.00-8.00'	June - July	X	✓	White	Red, Maroon	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Ilex*	*verticillata* 'Nana' RED SPRITE	Winterberry (Holly)	2.50-3.00'	2.50-3.00'	June - July	X	✓	White	Red, Maroon	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Ilex*	*verticillata 'Maryland Beauty'*	Winterberry (Holly)	5.00-7.00'	5.00-7.00'	May	✓	X	Green, White	Red, Maroon	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Ilex*	*verticillata 'Southern Gentleman'*	Winterberry (Holly)	6.00'	3.00-5.00'	Apr - May	✓	X	White	Yellow-Green, Purple, Bronze	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Juniperus*	*horizontalis 'Blue Chip'*	Creeping Juniper	6-9"	96-120"	X	X	X	X	Blue, Green (Needled Evergreen)	✓	✓	✓	X	High	Middle/ Outer	Full Sun	High
Shrubs	*Juniperus*	*horizontalis 'Wiltonii'*	Creeping Juniper	4-6"	72-96"	X	X	X	X	Silver-Blue, Purple, Green (Needled Evergreen)	✓	X	✓	X	High	Middle/ Outer	Full Sun	High
Shrubs	*Juniperus*	*horizontalis 'Bar Harbor'*	Creeping Juniper	9-12"	60-72"	X	X	X	X	Silver-Blue, Purple, Green (Needled Evergreen)	✓	X	✓	X	High	Middle/ Outer	Full Sun	High
Shrubs	*Juniperus*	*horizontalis 'Blue Rug'*	Creeping Juniper	4-6"	72-96"	X	X	X	X	Silver-Blue, Purple, Green (Needled Evergreen)	✓	X	✓	X	High	Middle/ Outer	Full Sun	High
Shrubs	*Juniperus*	*virginiana 'Grey Owl'*	Red Cedar	2.00-3.00'	4.00-6.00'	X	X	X	X	Silver-Gray, Green (Needled Evergreen)	✓	✓	✓	X	High	Middle/ Outer	Full Sun	High
Shrubs	*Juniperus*	*virginiana 'Taylor'*	Red Cedar	15.00-20.00'	3.00-4.00'	X	X	X	X	Silver-Gray, Bronze (Needled Evergreen)	✓	✓	✓	X	High	Middle/ Outer	Full Sun	High
Shrubs	*Juniperus*	*virginiana 'Burkii'*	Red Cedar	10.00-25.00'	4.00-10.00'	X	X	X	X	Blue-Silver, Purple (Needled Evergreen)	✓	✓	✓	X	High	Middle/ Outer	Full Sun	High
Shrubs	*Myrica (Morella)*	*pensylvanica 'Morton'*	Bayberry (Northern Bayberry)	4.00-5.00'	5.00-7.00'	May	✓	X	Yellow, Green	Gray-Green (Semi-Evergreen)	✓	X	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Myrica (Morella)*	*pensylvanica 'Morton' Silver Sprite™*	Bayberry (Silver Sprite Bayberry, Northern Bayberry)	5.00'	6.00'	X	✓	X	X	Green (Semi-Evergreen)	✓	X	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Physocarpus*	*opulifolius 'Little Devil'*	Ninebark	3.00-4.00'	3.00-4.00'	May - June	✓	X	White, Pink	Red, Maroon	✓	✓	✓	Seasonal	High	Lowest/Middle/Outer	Full Sun - Part Shade	Medium
Shrubs	*Potentilla (Dasiphora)*	*fruticosa 'Coronation Triumph'*	Shrubby Cinquefoil	2.00-3.00'	3.00-4.00'	June - Oct	X	✓	Yellow	X	✓	X	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Potentilla (Dasiphora)*	*fruticosa 'Abbotswood'*	Shrubby Cinquefoil	1.50-3.00'	1.50-3.00'	June - Oct	X	✓	White	X	✓	X	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Potentilla (Dasiphora)*	*fruticosa 'Pink Beauty'*	Shrubby Cinquefoil	3.00'	3.00'	June - Oct	X	✓	Pink	X	✓	X	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Potentilla (Dasiphora)*	*fruticosa 'Tangerine'*	Shrubby Cinquefoil	1.50-3.00'	1.50-3.00'	June - Oct	X	✓	Yellow, Orange	Yellow, Orange	✓	X	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Rhus*	*aromatica* 'Gro-Low'	Fragrant Sumac	1.50-2.00'	6.00-8.00'	April - May	✓	X	Yellow	Red, Orange	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun	High
Shrubs	*Rosa*	*carolina*	Carolina Rose (Pasture Rose)	3.00-6.00'	5.00-10.00'	May	✓	X	Pink	Red	X	✓	✓	X	Medium	Lowest/ Middle	Full Sun	High
Shrubs	*Salix*	*integra 'Hakuro-nishiki'*	Dappled Willow (Dappled Japanese Willow, Variegated Willow)	4.00-6.00'	5.00-7.00'	Mar - Apr	✓	X	Pink, White, Green	Red	✓	X	X	Seasonal	Low	Lowest/ Middle	Full Sun	High
Shrubs	*Viburnum*	*dentatum* MUFFIN 'Chistom' BLUE	Arrowwood Viburnum	3.00-5.00'	3.00-5.00'	May - June	✓	X	White, Blue	Orange, Maroon, Purple	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*dentatum* JOE 'KLMseventeen' LITTLE	Arrowwood Viburnum	4.00-5.00'	4.00-5.00'	May - June	✓	X	White, Blue	Orange, Maroon, Purple	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*dentatum 'Blue Blaze'*	Arrowwood Viburnum	5.00-6.00'	5.00-6.00'	April	✓	X	White	Red	X	✓	✓	Seasonal	Medium	Middle	Full Sun - Part Shade	High

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Shrubs	*Viburnum*	*dentatum* *'Chicago Lustre™'*	Arrowwood Viburnum	8.00-10.00'	8.00-10.00'	Apr - June	✓	X	White, Blue	Purple	X	✓	✓	Seasonal	Medium	Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*lantana* *'Aureum'*	Golden Wayfaringtree Viburnum	6.00'	6.00'	May	✓	X	White	Gold, Yellow	X	✓	✓	X	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*lantana* *'Mohican'*	Wayfaringtree Viburnum	7.00-8.00'	7.00-10.00'	May	✓	X	White	Red, Purple	X	✓	✓	X	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*lentago*	Nannyberry Viburnum	14.00-16.00'	6.00-12.00'	May	✓	X	White	Green-yellow, Red-purple	X	✓	✓	Seasonal	Low	Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*nudum* 'Bulk' BRANDYWINE	Possumhaw Viburnum (Smooth Witherod)	5.00-12.00'	5.00-12.00'	Apr - May	✓	X	White	Red, Maroon	✓	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*nudum* *'Winterthur'*	Possumhaw Viburnum (Smooth Witherod)	5.00-12.00'	5.00-12.00'	Apr - May	✓	X	White	Red-Purple, Maroon	X	✓	✓	Seasonal	Medium	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*prunifolium*	Blackhaw Viburnum	12.00-15.00'	6.00-12.00'	May - June	✓	X	White	Red, Purple	X	✓	✓	X	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*prunifolium* 'McKRouge' Forest Rouge®	Blackhaw Viburnum	8.00-10.00'	6.00-8.00'	May	✓	X	White	Maroon	✓	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun	High
Shrubs	*Viburnum*	*prunifolium* *'Summer Magic'*	Blackhaw Viburnum	6.00-10.00'	8.00-15.00'	Apr - June	✓	X	White	Red, Maroon	X	✓	✓	X	High	Middle/ Outer	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*seiboldii* *'Wavecrest'*	Wayfaringtree Viburnum (Variegated Wayfaringtree Viburnum)	15.00-18.00'	15.00-18.00'	May	✓	X	White	Dark Red	X	✓	✓	X	Low	Lowest/ Middle	Full Sun - Part Shade	High
Shrubs	*Viburnum*	*trilobum* *'Alfredo'*	American Cranberry Bush	6.00-12.00'	6.00-12.00'	Apr - June	✓	X	White	Maroon, Red	✓	✓	✓	Regular	Low	Lowest/ Middle/ Outer	Full Sun - Part Shade	Medium

Tree Plant Material Recommendations

Genus	Species	Common Name	Frequency of Planting	Size	Form	Height	Width	Branching Density	Foliage Texture	Bloom Time	Early Season Bloom	Late Season Bloom	Bloom Color	Fall Color	Winter Interest	Showy in Fall	Native to US	Inundation Tolerance	Drought Tolerance	Hydrologic Zone Elevation	Light Requirement	Salinity Tolerance
Acer	*griseum*	Paperbark Maple	Sparingly	Small	Round	20-30'	15-25'	Dense	Coarse	April	✓	X	Green	Red	✓	Yes	X	X	Medium	Outer	Full Sun - Part Shade	Medium
Acer	*buergerianum*	Trident Maple	Sparingly	Small	Round	20-30'	20-30'	Dense	Fine	Apr - May	✓	X	Green, Yellow	Red, Orange, Yellow	✓	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Acer	*campestre*	Hedge Maple	Sparingly	Medium	Oval	25-35'	25-35'	Dense	Coarse	Apr - May	✓	X	Yellow, Green	Yellow, Gold, Orange	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Acer	*truncatum*	Purpleblow Maple (*Shantung Maple*)	N/A	Medium	Round	20-25'	15-20'	Open	Fine	April	✓	X	Green, Yellow	Red, Orange, Yellow, Purple	X	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Amelanchier	*canadensis*	Canadian Serviceberry (*Shadblow Serviceberry*)	N/A	Small	Round	25-30'	15-20'	Open	Fine	Apr - May	✓	X	White	Red, Orange	X	✓	✓	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	High
Amelanchier	*x grandiflora 'Autumn Brilliance'*	Apple Serviceberry	Frequently	Small	Oval	15-25'	15-25'	Open	Fine	April	✓	X	White	Red, Orange	X	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Amelanchier	*x grandiflora*	Serviceberry	Frequently	Small	Oval / Vase	15-25'	15-25'	Dense	Fine	April	✓	X	Pink, White	Red, Orange	X	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Amelanchier	*x grandiflora 'Robin Hill'*	Serviceberry	Frequently	Small	Oval	15-25'	15-25'	Dense	Fine	April	✓	X	Pink, White	Red, Orange	X	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Amelanchier	*x grandiflora 'Autumn Sunset'*	Serviceberry	Frequently	Small	Oval	15-25'	15-25'	Dense	Fine	April	✓	X	White	Red, Orange	X	✓	X	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	Medium
Amelanchier	*x grandiflora 'Cumulus'*	Serviceberry	Frequently	Small	Oval	20-30'	15-20'	Dense	Fine	April	✓	X	White	Red, Orange	X	✓	X	Seasonal	Medium	Lower/ Middle	Full Sun - Part Shade	Medium
Amelanchier	*x grandiflora 'Princess Diana'*	Serviceberry	Frequently	Small	Round	15-20'	12-15'	Open	Fine	April	✓	X	White	Red, Yellow, Orange	X	✓	X	Seasonal	Medium	Lower/ Middle	Full Sun - Part Shade	Medium
Betula	*lenta*	Black Birch (*Sweet Birch, Cherry Birch*)	Sparingly	Large	Oval / Round	40-55'	35-45'	Open	Fine	Apr - May	✓	X	Red, Yellow, Green, Brown	Yellow	✓	✓	✓	Seasonal	Medium	Middle/ Outer	Part Shade - Full Shade	Medium
Betula	*nigra*	River Birch	Sparingly	Medium	Oval / Pyramidal	40-50'	25-35'	Dense	Fine	Apr - May	✓	X	Brown	Yellow	✓	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	Medium / Low
Betula	*nigra 'Heritage'*	River Birch	Sparingly	Medium	Oval	40-50'	25-35'	Dense	Fine	Apr - May	✓	X	Brown	Yellow	✓	✓	✓	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun - Part Shade	Medium / Low
Carya	*glabra*	Pignut Hickory	Sparingly	Large	Round	50-100'	30-40'	Open	Coarse	April	✓	X	Yellow, Green, Brown	Yellow	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun - Full Shade	High
Carya	*ovata*	Shagbark Hickory	Sparingly	Large	Oval	70-120'	50-70'	Open	Fine	Mar - June	✓	X	Green, Brown	Yellow	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Full Shade	Medium
Celtis	*laevigata*	Sugarberry	Sparingly	Large	Round	60-80'	60-80'	Dense	Coarse	Apr - May	✓	X	Green	Yellow	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Celtis	*laevigata 'All Season'*	All Seasons' Sugarberry (*'All Seasons' Sugar Hackberry*)	Sparingly	Large	Round / Vase	40-60'	35-55'	Dense	Coarse	Apr - May	✓	X	Green	Yellow	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Celtis	*laevigata 'Magnifica'*	Sugarberry	Sparingly	Large	Oval / Vase	60-80'	60-80'	Dense	Coarse	Apr - May	✓	X	Green	Yellow	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	High
Celtis	*occidentalis*	Common Hackberry	Sparingly	Large	Oval	40-60'	40-60'	Dense	Coarse	Apr - May	✓	X	Green	Yellow	X	✓	✓	Extended	High	Lower / Middle	Full Sun - Part Shade	Medium
Chamaecyparis	*thyoides*	Atlantic White Cedar	N/A	Large	Columnar	40-75'	5-20'	Open	Fine	Mar - May	✓	X	Green	Green	✓	✓	✓	Seasonal	Low	Lowest/ Middle	Part Shade	Medium
Chionanthus	*virginicus*	Fringetree	N/A	Small	Round	12-20'	12-20'	Open	Fine	May - June	✓	X	White	Yellow	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Low
Chionanthus	*retusus*	Chinese Fringetree	Moderately	Small	Round	10-20'	10-20'	Dense	Coarse	May - June	✓	X	White	Yellow	X	✓	X	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	Low
Chionanthus	*retusus 'Tokyo Tower'*	Chinese Fringetree	Moderately	Small	Columnar	12-15'	4-6'	Dense	Coarse	May - June	✓	X	White	Yellow	X	✓	X	Seasonal	Low	Middle/ Outer	Full Sun - Part Shade	Low
Cladrastis	*kentukea*	Yellowwood	Moderately	Medium	Round	30-50'	40-55'	Dense	Coarse	May	✓	X	White, Pink	Yellow	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun	High

Tree Plant Material Recommendations

Genus	Species	Common Name	Frequency of Planting	Size	Form	Height	Width	Branching Density	Foliage Texture	Bloom Time	Early Season Bloom	Late Season Bloom	Bloom Color	Fall Color	Winter Interest	Showy in Fall	Native to US	Inundation Tolerance	Drought Tolerance	Hydrologic Zone Elevation	Light Requirement	Salinity Tolerance
Cornus	*kousa*	Kousa Dogwood	N/A	Small	Oval / Round	15-20'	15-20'	Dense	Coarse	April to May	✓	X	Pink	Yellow, Red, Purple	X	✓	X	X	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Cornus	*kousa 'Fireworks'*	Kousa Dogwood	N/A	Small	Oval	15-20'	15-20'	Dense	Coarse	April to May	✓	X	Pink	Yellow, Red, Purple	X	✓	X	X	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Cornus	*kousa 'Satomi'*	Kousa Dogwood	N/A	Small	Oval	12-20'	12-20'	Dense	Coarse	May - June	✓	X	Pink	Red	X	✓	X	X	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Cornus	*kousa var. Chinensis*	Chinese Dogwood	N/A	Small	Vase / Round	15-30'	15-30'	Dense	Coarse	May - June	✓	X	White	Red	X	✓	X	X	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Crataegus	*crus-galli*	Cockspur Hawthorn	Moderately	Medium	Oval / Round	20-35'	25-35'	Dense	Coarse	May - June	✓	X	White, Pink	Red, Orange	✓	✓	✓	Seasonal	High	Lower/ Middle/ Outer	Full Sun	High
Crataegus	*crus-galli 'Inermis'*	Cockspur Hawthorn	Moderately	Medium	Oval / Round	20-35'	25-35'	Dense	Coarse	May - June	✓	X	White, Pink	Red, Orange	✓	✓	✓	Seasonal	High	Lower/ Middle/ Outer	Full Sun	High
Crataegus	*phaenopyrum*	Washington Hawthorn	Moderately	Small	Round	25-30'	25-30'	Dense	Coarse	June	✓	X	White	Red, Orange, Yellow	✓	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	Medium
Crataegus	*punctata*	Dotted Hawthorn	Moderately	Small	Round	20-30'	20-30'	Dense	Coarse	May	✓	X	White	Red	✓	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	Medium
Crataegus	*punctata 'Ohio Pioneer'*	Dotted Hawthorn	Moderately	Small	Round	20-30'	20-30'	Dense	Coarse	May	✓	X	White	Red	✓	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	Medium
Ginkgo	*biloba (male only)*	Maidenhair Tree	Moderately	Large	Columnar	40-50'	20-30'	Open	Coarse	April	✓	X	Green (male)	Yellow	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	High
Ginkgo	*biloba 'Autumn Gold' (male only)*	Maidenhair Tree	Moderately	Large	Columnar	40-50'	20-30'	Open	Coarse	April	✓	X	Green (male)	Yellow	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	High
Ginkgo	*biloba 'Magyar' (male only)*	Maidenhair Tree	Moderately	Large	Columnar	40-60'	20-30'	Open	Coarse	April	✓	X	Green (male)	Yellow	X	✓	X	Seasonal	High	Lower/ Middle/ Outer	Full Sun	Medium
Ginkgo	*biloba 'Princeton Sentry' (male only)*	Maidenhair Tree	Moderately	Large	Columnar	40-50'	20-30'	Open	Coarse	April	✓	X	Green (male)	Yellow	X	✓	X	Seasonal	High	Lower/ Middle/ Outer	Full Sun	Medium
Gleditsia	*triacanthos*	Honeylocust	Moderately	Large	Round / Vase	35-45'	25-35'	Open	Fine	May - June	✓	X	Green, White	Yellow	X	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Full Sun	High
Gleditsia	*triacanthos 'Inermis'*	Honeylocust	Moderately	Large	Round	35-45'	25-35'	Open	Fine	May - June	✓	X	Green, White	Yellow	X	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Full Sun	High
Gymnocladus	*dioicus (male only)*	Kentucky Coffeetree	Moderately	Large	Oval	60-80'	40-55'	Open	Fine	May - June	✓	X	White	Yellow	X	✓	✓	no	High	Middle/ Outer	Full Sun	Medium
Juniperus	*chinensis*	Chinese Juniper	Moderately	Large	Columnar	15-20'	4-6'	Dense	Fine	X	✓	X	Green	Green	✓	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun	High
Juniperus	*chinensis 'Keteleeri'*	Chinese Juniper	Moderately	Large	Columnar	15-20'	4-6'	Dense	Fine	X	✓	X	Green	Green	✓	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun	High
Juniperus	*virginiana*	Eastern Red Cedar	Frequently	Medium	Columnar	30-50'	10-20'	Dense	Fine	X	✓	X	Green	Green	✓	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Full Sun	High
Juniperus	*virginiana 'Princeton Sentry'*	Eastern Red Cedar	Frequently	Medium	Columnar	30-50'	10-20'	Dense	Fine	X	✓	X	Green	Green	✓	✓	✓	Seasonal	High	Lowest/ Middle/ Outer	Full Sun	High
Koelreuteria	*paniculata*	Goldenraintree	Sparingly	Medium	Round / Vase	20-30'	4-7'	Dense	Coarse	June - July	X	✓	Yellow	Yellow	X	✓	X	Extended	High	Middle/ Outer	Full Sun	Medium
Koelreuteria	*paniculata 'Fastigiata'*	Goldenraintree	Sparingly	Medium	Columnar	20-30'	4-7'	Dense	Coarse	June - July	X	✓	Yellow	Yellow	X	✓	X	Extended	High	Middle/ Outer	Full Sun	Medium
Liquidambar	*styraciflua*	American Sweetgum	Moderately	Large	Oval / Round	60-80'	40-60'	Dense	Coarse	Apr - May	✓	X	Yellow, Green	Yellow, Red, Orange, Purple	X	✓	✓	Extended	Medium	Middle/ Outer	Full Sun	Medium
Liriodendron	*tulipifera*	Tulip Tree	Moderately	Large	Oval / Pyramidal	60-90'	20-50'	Dense	Coarse	May - June	✓	X	Yellow, Orange	Yellow, Gold	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Low
Liriodendron	*tulipifera 'Fastigiatum'*	Tulip Tree	Moderately	Large	Columnar	60-90'	20-50'	Dense	Coarse	May - June	✓	X	Yellow, Orange	Yellow, Gold	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun - Part Shade	Low

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Nyssa	*sylvatica*	Blackgum (*Black Tupelo, Sour Gum*)	Moderately	Large	Oval / Pyramidal	40-50'	30-40'	Open	Coarse	May - June	✓	X	Green, White	Orange, Yellow, Purple, Red	X	✓	✓	Extended	High	Lowest/ Middle	Full Sun	Medium
Nyssa	*sylvatica 'Wildfire'*	Blackgum (*Black Tupelo, Sour Gum*)	Moderately	Large	Oval / Pyramidal	40-50'	30-40'	Open	Coarse	May - June	✓	X	Green, White	Orange, Yellow, Purple, Red	X	✓	✓	Extended	High	Lowest/ Middle	Full Sun	Medium
Oxydendrum	*arboreum*	Sourwood (*Sorrel*)	N/A	Medium	Round	20-50'	10-25'	Dense	Coarse	June - July	X	✓	White	Red, Maroon	X	✓	✓	X	Medium	Middle/ Outer	Full Sun - Part Shade	Medium
Platanus	*x acerifolia*	London Planetree	Moderately	Large	Round	70-85'	50-70'	Dense	Coarse	April	✓	X	Red	Yellow	✓	✓	X	Extended	High	Lowest/ Middle/ Outer	Full Sun	Medium
Platanus	*x acerifolia 'Bloodgood'*	London Planetree	Moderately	Large	Round	70-85'	50-70'	Dense	Coarse	April	✓	X	Red	Yellow	✓	✓	X	Extended	High	Lowest/ Middle/ Outer	Full Sun	Medium
Quercus	*acutissima*	Sawtooth Oak	N/A	Large	Round	40-60'	40-60'	Dense	Coarse	Mar - Apr	✓	X	Yellow, Green	Gold, Brown	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	Medium
Quercus	*alba*	White Oak	Sparingly	Large	Round	50-80'	50-80'	Dense	Coarse	May	✓	X	Yellow, Green	Brown, Red	X	✓	✓	Seasonal	Medium	Middle/ Outer	Full Sun	High
Quercus	*imbricaria*	Shingle Oak	Moderately	Large	Pyramidal / Round	40-60'	40-60'	Open	Coarse	April	✓	X	Yellow, Green	Red, Yellow, Brown	X	✓	✓	Extended	High	Middle/ Outer	Full Sun	High
Quercus	*macrocarpa*	Bur Oak (*Mossycup Oak*)	Moderately	Large	Round	60-80'	60-80'	Dense	Coarse	April	✓	X	Yellow, Green	Yellow, Brown	X	✓	✓	Extended	High	Middle/ Outer	Full Sun	High
Quercus	*muehlenbergii*	Chinkapin Oak (*Chinquapin Oak*)	Moderately	Large	Round	40-60'	50-70'	Dense	Coarse	April	✓	X	Yellow, Green	Yellow, Brown	X	✓	✓	X	High	Middle/ Outer	Full Sun	Medium
Quercus	*palustris*	Pin Oak	Sparingly	Large	Oval / Pyramidal	50-75'	35-40'	Dense	Coarse	April	✓	X	Brown	Red	X	✓	✓	Extended	Medium	Lowest/ Middle/ Outer	Full Sun	Medium
Quercus	*palustris 'Crownright'*	Pin Oak	Sparingly	Large	Oval	50-75'	35-40'	Dense	Coarse	April	✓	X	Brown	Red	X	✓	✓	Extended	Medium	Lowest/ Middle/ Outer	Full Sun	Low
Quercus	*palustris 'Pringreen'*	Green Pillar Pin Oak	Sparingly	Large	Columnar	50-60'	12-15'	Dense	Coarse	April	✓	X	Green	Red, Scarlet	X	✓	✓	Extended	Medium	Lowest/ Middle	Full Sun	Low
Quercus	*palustris 'Sovereign'*	Pin Oak	Sparingly	Large	Oval	50-75'	35-40'	Dense	Coarse	April	✓	X	Brown	Red, Brown, Orange	X	✓	✓	Extended	Medium	Lowest/ Middle/ Outer	Full Sun	Low
Quercus	*phellos*	Willow Oak	Moderately	Large	Oval / Round	40-75'	25-50'	Dense	Coarse	April	✓	X	Yellow, Green	Yellow, Gold, Brown	X	✓	✓	Extended	High	Lowest/ Middle	Full Sun	High
Quercus	*robur*	English Oak	Moderately	Large	Round	50-60'	10-20'	Dense	Coarse	April	✓	X	Yellow, Green	Green	X	✓	X	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun	High
Quercus	*robur 'Fastigiata'*	English Oak	Moderately	Large	Columnar	50-60'	10-20'	Dense	Coarse	April	✓	X	Yellow, Green	Green	X	✓	X	Seasonal	Medium	Lowest/ Middle/ Outer	Full Sun	High
Quercus	*robur x alba 'Crimschmidt'*	Crimson Spire Oak	Moderately	Large	Columnar	40-45'	10-15'	Dense	Coarse	April	✓	X	Yellow, Green	Red	X	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun	High
Quercus	*robur 'Attention'*	English Oak	Moderately	Large	Columnar	40-70'	10-70'	Dense	Coarse	April	✓	X	Yellow, Green	Yellow, Brown	X	✓	X	Seasonal	Medium	Middle/ Outer	Full Sun	High
Quercus	*rubra*	Red Oak	Sparingly	Large	Round	50-75'	50-75'	Dense	Coarse	May	✓	X	Yellow, Green	Brown, Red	X	✓	✓	X	Medium	Middle/ Outer	Full Sun	High
Quercus	*shumardii*	Shumard Oak	Moderately	Large	Pyramidal / Round	40-60'	30-40'	Dense	Coarse	April	✓	X	Green	Red, Brown	X	✓	✓	Seasonal	High	Middle/ Outer	Full Sun	Medium
Quercus	*x warei*	Regal Prince Oak	Moderately	Large	Columnar / Oval	40-60'	20-25'	Dense	Coarse	April	✓	X	Yellow, Green	Yellow, Brown	X	✓	✓	Seasonal	High	Lower/ Middle/ Outer	Full Sun	Medium
Quercus	*x warei 'Long Regal Prince'*	Regal Prince Oak	Moderately	Large	Columnar / Oval	40-60'	20-25'	Dense	Coarse	April	✓	X	Yellow, Green	Yellow, Brown	X	✓	✓	Seasonal	High	Lower/ Middle/ Outer	Full Sun	Medium
Quercus	*x warei 'Nadler Kindred Spirit'*	Kindred Spirit Oak	Moderately	Large	Columnar	30-35'	20-25'	Dense	Coarse	April	✓	X	Green	Yellow, Brown	✓	✓	✓	Seasonal	High	Lower/ Middle/ Outer	Full Sun	Medium

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Syringa	*reticulata*	Japanese Tree Lilac	Frequently	Small	Oval / Round	20-25'	15-20'	Dense	Coarse	May - June	X	✓	White	Yellow, Gold	✓	✓	X	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Syringa	*reticulata 'Ivory Silk'*	Japanese Tree Lilac	Frequently	Small	Oval / Round	20-25'	15-20'	Dense	Coarse	May - June	X	✓	White	Yellow, Gold	✓	✓	X	Seasonal	High	Middle/ Outer	Full Sun - Part Shade	High
Syringa	*reticulata 'Summer Snow'*	Japanese Tree Lilac	Frequently	Small	Round	20-30'	20-25'	Dense	Coarse	June	X	✓	White	X	✓	X	X	Seasonal	Medium	Middle/ Outer	Full Sun	High
Syringa	*reticulata 'Regent'*	Japanese Tree Lilac	Frequently	Small	Oval	25-30'	15-25'	Dense	Coarse	June	X	✓	Cream	X	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	High
Taxodium	*distichum*	Bald Cypress	Moderately	Large	Pyramidal	50-70'	20-45'	Dense	Fine	X	X	X	Brown	Orange, Brown	X	✓	✓	Extended	Medium	Lowest/ Middle	Full Sun	Medium
Zelkova	*serrata*	Japanese Zelkova	Moderately	Large	Vase	60-80'	40-50'	Dense	Fine	Mar - Apr	✓	X	Green	Orange, Bronze	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	Medium
Zelkova	*serrata 'Green Vase'*	Japanese Zelkova	Moderately	Large	Vase	60-80'	40-50'	Dense	Fine	Mar - Apr	✓	X	Green	Orange, Bronze	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	Medium
Zelkova	*serrata 'Halka'*	Japanese Zelkova	Moderately	Large	Vase	40-50'	25-30'	Open	Fine	Mar - Apr	✓	X	Green	Yellow	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	Medium
Zelkova	*serrata 'Village Green'*	Japanese Zelkova *(Sawleaf Zelkova)*	Moderately	Large	Vase	50-60'	30-50'	Dense	Fine	Mar - Apr	✓	X	Green	Copper, Red	X	✓	X	Seasonal	High	Middle/ Outer	Full Sun	Medium



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