Design Summary Memorandum

325 Blake Road Restoration and Redevelopment

Regional Stormwater Improvements and Greenway Enhancement

Hopkins, MN
March 30, 2023

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1. Executive Summary

Located adjacent to Minnehaha Creek, the *325 Blake Road Regional Stormwater and Greenway and Cottageville Park Phase II Riparian Restoration Project* is a multi-purpose project being developed to achieve key water quality and recreational goals of Minnehaha Creek Watershed District, along with several other public partners and the greater community. The project features a regional stormwater management facility that treats runoff from several hundred acres of land, the completion of the Minnehaha Creek Greenway, water-centric recreational opportunities, and is co-located with a mixed-use, transit oriented development.

Minnehaha Creek Watershed District has partnered with HDR, Inc., Damon-Farber Landscape Architects, and Inter-Fluve for the detailed design of the public realm development. Design goals include:

- Regionalizing stormwater runoff to improve the water quality of Minnehaha Creek and downstream waterbodies;
- Providing visual and physical access to a previously hidden portion of the creek;
- Performing ecological conservation, and restoration of riparian, upland, and wetland habitats in a highly urbanized corridor;
- Increasing recreational opportunities associated with the creek;
- Completing the Minnehaha Creek Greenway by providing improved trail connections for watercraft, pedestrians, and cyclists.

The regional stormwater management facility consists of two stormwater detention ponds separated by a weir wall, located between the Minnehaha Creek Greenway Trail to the east, and a mixed-use private development to the west. The detention ponds are controlled by a multi-stage outlet structure that includes a low-flow orifice and a high-flow weir opening that drain through a box culvert, with another box culvert located underneath the adjacent trail serving as an auxiliary overflow device. Through coordination with the prospective developer, *Alatus, LLC*, the detention ponds and retaining wall infrastructure also feature a wet well and pump that discharges stormwater through manufactured stormwater treatment devices and into a cascade on the west side of the mixed-use development. The cascade provides additional stormwater treatment, ultimately discharging back into the detention ponds for recirculation and further water quality enhancement.

Visual and physical access to the creek and recreational opportunities are provided by several aspects of the project design. The Minnehaha Creek Greenway Trail is situated between the regional stormwater management ponds and the creek. Key design features include a trailhead and overlook off the Cedar Lake LRT Regional Trail, a landing for watercraft using Minnehaha Creek that incorporates picnic areas and hammock poles, a pedestrian bridge to a nature-based play area in the triangular lot north of the creek and adjacent to Lake Street, and a gateway plaza to the Minnehaha Creek Greenway situated at the greenway’s hinge point at Blake Road and Lake Street.

2. Project Introduction

Minnehaha Creek Watershed District (MCWD or the District), in partnership with the City of Hopkins (City) and several other public and private partners, is leading an effort to coordinate the planning, design, and redevelopment of the almost 17-acre parcel at 325 Blake Road, three accompanying smaller parcels at 415 Blake Road, 1308 Lake Street, and 1312 Lake Street, and an adjacent City-owned outlot in Hopkins, Minnesota.

Previously developed as industrial, commercial, or residential properties, these parcels are currently vacant. Adjoining each other, they form a combined site of nearly 18 acres (collectively known as the site). The parcel at 325 Blake Road formerly housed a large cold storage facility with extensive outdoor parking for tractor-trailer trucks. The parcel was purchased by MCWD in 2011 and the cold storage facility and parking lots were demolished in 2018. Situated across the creek from Cottageville Park, the other parcel on Blake Road is wedged between the creek, Blake Road, and Lake Street. It had formerly contained a commercial structure which hindered access and obscured views of the creek as thoroughly as the adjacent cold storage facility. The two parcels and City-owned outlet on Lake Street are also adjacent to the creek and were occupied by single-family residences before they were purchased and removed by the District. Consequently, access to the creek and public enjoyment of the waterway had been inhibited by their former adjacent land uses. All four parcels have now been cleared with only remnant vegetation remaining, creating the potential for unfettered access to the creek. In addition to these platted parcels, there is also one very small outlot sandwiched between the Lake Street bridge and the former residential properties that is included as part of the site.

Officially known as the *325 Blake Road Regional Stormwater and Greenway and Cottageville Park Phase II Riparian Restoration Project (the project)*, the District is creating a transformative, water-centric development on this site adjacent to Minnehaha Creek premised on its vision of Balanced Urban Ecology. This process includes:

- Regionalizing stormwater runoff to improve the water quality of Minnehaha Creek and downstream waterbodies;
- Providing visual and physical access to a previously hidden portion of the creek;
- Performing ecological conservation, and restoration of riparian, upland, and wetland habitats in a highly urbanized corridor;
- Increasing recreational opportunities associated with the creek;
- Completing the Minnehaha Creek Greenway by providing improved trail connections for watercraft, pedestrians, and cyclists.

Complementing the District's goals were additional goals of the City, including the desire to develop the site as a relatively high-density transit-oriented residential and commercial development.

This report documents the detailed design phase of the project which builds on the schematic design phase completed in 2021. The detailed design involves advancing the "Alatus

Alternative” from schematic design. This option includes full build out of the development, recreational/preservation features in the riparian corridor and two detention ponds separated by a weir wall, which receive regional stormwater runoff from the Powell Road and Lake Street subwatersheds adjacent to the site. The project adopted a goal of treating stormwater from the first flush of pollutants, associated with the 1.25-inch storm event. The stormwater ponds were originally designed with sufficient water quality volume available to meet this objective; however the proposed development schematic encroached on the ponds as originally designed. In partnership with the prospective developer, MCWD negotiated an alternative stormwater treatment process, which pumps and treats stormwater from the ponds to a location within the development where further water quality treatment occurs, compensating for pond encroachments and enhancing stormwater treatment by providing additional upland BMPs, increasing aeration, and providing recirculation to create a robust stormwater treatment train.

In addition to the regional stormwater management, the project incorporates several key design elements adding to the recreational opportunities of the site. The design includes a trailhead and overlook off the Cedar Lake LRT Regional Trail, a landing for watercraft using Minnehaha Creek that incorporates picnic areas and hammock poles, a pedestrian bridge to a nature-based play area in the triangular lot north of the creek and adjacent to Lake Street, and a gateway plaza to the Minnehaha Creek Greenway situated at the greenway’s hinge point at Blake Road and Lake Street. Elements of project design, construction, long-term operation, maintenance, and monitoring are detailed within this memorandum or the references cited.

Further information related to project planning and early stages of project coordination, outreach, and conceptual design are contained in the *Schematic Design Memorandum,* dated September 3, 2021. Community engagement and outreach has continued to occur throughout detailed design; the process and findings of which are summarized in separate deliverables submitted to MCWD.

3. Site Information

325 Blake Road is located at the southeast quadrant of the Blake Road North (CSAH 20) and Lake Street Northeast intersection; less than ¼-mile from both State Highway 7 to the north and Excelsior Boulevard (CSAH 3) to the south, and within one mile east of State Highway 169. The property is bounded by approximately 1,100-feet of Minnehaha Creek, 1,100-feet of Blake Road, and 1,200-feet of the Cedar Lake LRT Regional Trail and the future Southwest Light Rail Transit (SWLRT) corridor.

The project is situated in the lower Minnehaha Creek watershed, approximately 7.3 river miles downstream of Gray's Bay dam on Lake Minnetonka where the headwaters of Minnehaha Creek are formed, and approximately 11.5 river miles upstream of Lake Hiawatha. Minnehaha Creek's confluence with the Mississippi River is located roughly 13.9 river miles downstream of the project site. Six key influences define the character of the site and its potential for redevelopment. As detailed below, the key influences are: context, parcelization, land use, land cover, transportation, and utilities.

3.1 Context

The factor most influencing the character and development potential of the site is its context as defined by three regional patterns—patterns of nature, mobility, and development. Three corridors generated by these patterns converge on the site, forming the boundaries of the site's triangular shape (see *Figure 3.1: Regional Patterns.)*

Figure 3.1: Regional Patterns. *Three regional patterns exert strong influences on the character of the site and its potential for development.*

The dominant pattern that underlies the other two is the natural pattern created by the topography and hydrology of the Minnehaha Creek Watershed. Minnehaha Creek forms the site's northern and eastern edge, creating a strong, not easily crossed barrier. Only the Lake Street and Blake Road bridges offer access between the site and properties to its north and east. The site sits along a segment of Minnehaha Creek that is being ecologically restored to become a recreational attraction, including conservation efforts as part of this project's design. As the mid-point of the greenway, the site could become an ideal gateway to the greenway and the creek's recreational amenities. As Minnehaha Creek drains the surrounding landscape, it makes the site an ideal location for regional stormwater management.

Regionally, the site is situated in the City of Hopkins, a near western suburb of Minneapolis. The southern edge of the site is mostly impenetrable, defined by the existing Cedar Lake LRT Regional Trail and an existing freight rail line that funnel any crossing to properties south of the site to Blake Road. The new double-track Southwest LRT line will parallel the trail and rail lines, reinforcing the barrier until a bicycle/pedestrian underpass is constructed in the future, forming a connection that is currently planned near Minnehaha Creek's flow under the Cedar Lake LRT Regional Trail. Despite the present barrier, the trail and the LRT facilitate regional mobility. Geographically defined by its location as an attractive midpoint between the residential and commercial opportunities located in the expanding western suburbs and the inviting commercial center of the state, downtown Minneapolis, with its bustling business and vibrant residential districts. Consequently, the LRT station proposed at Blake Road will promote access to the site, creating a destination for residential, commercial, and recreational development.

The site's western edge is formed by Blake Road, a busy four-lane collector with access to the site only at 2nd Street, where it is controlled by a signalized intersection, and Lake Street which controls access to Blake Road only with a 2-way stop sign on Lake Street. The site's western edge is semi-permeable, providing access to the larger pattern of urban development that will influence the character of the site's own development.

Since the beginning of the project, it was anticipated that the confluence of the three regional patterns on the site would affect the layout and character of the site's design. As the development process continued, and as the initial phase culminated during the Design Charrette, it became increasingly obvious that the influence of regional natural patterns as represented by Minnehaha Creek would create an edge along the creek that would be dominated by natural features. Similarly, the edge influenced by regional patterns of mobility would create an edge responsive to the Cedar Lake LRT Regional Trail and the Blake Road LRT Station. The edge adjacent to Blake Road would be most influenced by existing and proposed urban development resulting in the concentration of buildings along that western edge of the site. (See *Figure 3.2: Site Influences.)*

Figure 3.2: Site Influences. The layout and character of each edge of the site will be heavily and distinctly influenced by one of the regional patterns.

3.2 Parcelization

The project site is comprised of four parcels and one outlot that total 17.81 acres (see *Figure 3.3: Site Parcels*).

- Parcel A: 325 Blake Road N consists of 16.84 acres, including nearly 1.5 acres of riparian woodland buffer along 1,100 feet of Minnehaha Creek.
- Parcel B: 415 Blake Road N consists of approximately 0.48 acres of an open site wedged between the creek, Blake Road, and Lake Street. The parcel slopes to 150 feet of Minnehaha Creek frontage.
- Parcel C: Outlot. A small 0.16-acre outlot owned by the City of Hopkins, located across Minnehaha Creek from the primary parcel with a narrow riparian woodland buffer has approximately 100 feet of creek frontage.
- Parcel D: 1308 Lake Street NE consists of 0.14 acres, located across Minnehaha Creek from the primary parcel, a mostly open, former residential, parcel with a narrow riparian woodland buffer along 50 feet of Minnehaha Creek.
- Parcel E: 1312 Lake Street NE consists of 0.19 acres, located across Minnehaha Creek from the primary parcel, a mostly open, former residential property with a narrow riparian woodland buffer along 50 feet of Minnehaha Creek.

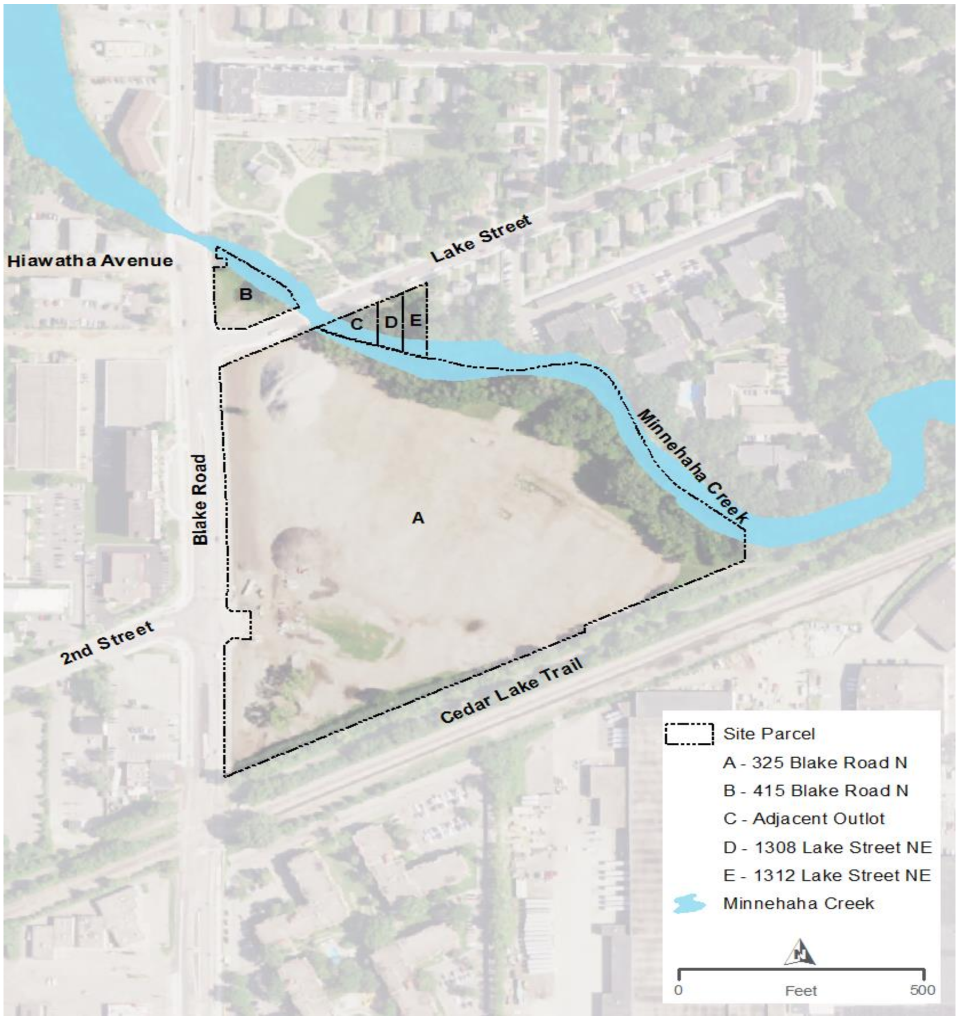


Figure 3.3: Site Parcels. The site is composed of five adjoining, mostly vacant, parcels.

3.3 Land Use

The site is located near the middle of the Minnehaha Creek Greenway; a restored and revitalized ecological and recreational corridor of Minnehaha Creek that meanders through portions of Hopkins and St. Louis Park. Nearby land use includes residential, commercial, industrial, institutional, and transportation infrastructure all of which complement the proposed mixed-use development envisioned by the City. Existing significant landmarks and attractions nearby, including Downtown Hopkins (1.5 miles southwest), Knollwood Mall (0.5 miles north), Cottageville Park (located across the creek from the site), Minnehaha Creek Preserve (0.75 miles east), and Methodist Hospital (1.0 miles east), make the location particularly attractive to commercial and residential development.

3.4 Land Cover

Before the site was cleared for stormwater management and redevelopment, the primary site had been occupied by a cold storage facility. The demolition of that facility in 2018 provided the opportunity to repurpose the parcel in accordance with the vision of MCWD and the City. The cold storage facility consisted of a 6.3-acre building and 5.7 acres of adjacent parking and driving surfaces, which combined to cover 12 acres of land with impervious surface. The majority of the current site is vacant with aggregate surfacing and sparse vegetation with a wooded riparian buffer covering roughly 1.5 acres along Minnehaha Creek. The district is also storing two large stockpiles of crushed concrete/pavement in the northwest corner of the site. This material will be sold to a local contractor or sourced by the developer's contractor during development. Remaining outlot parcels are also vacant covered with mostly grass and scattered older trees. With the exception of maintaining a vegetative buffer along the creek, the prior impervious landcover will allow redevelopment to proceed through regulatory requirements for redevelopment, which are typically less stringent than the requirements for undeveloped sites.

3.5 Transportation

Providing transportation access and mobility is key to the successful redevelopment of the site. Two of the site's three sides are flanked by transportation corridors, providing it with excellent access and mobility. To the west is Blake Road. Classified as a Major Collector by the City of Hopkins' 2040 Comprehensive Plan, it has an average annual daily traffic (AADT) of approximately 12,200 vehicles. It operates as a significant north-south corridor for local vehicular traffic and active transportation connecting the site to the metropolitan region and locally to destinations along Blake Road, Excelsior Boulevard to the south, and Minnesota Highway 7 to the north. It supports bus routes and its sidewalks will provide the "last mile" for pedestrians walking between the site and the future Blake Road LRT Station.

The south edge of the site is flanked by a multimodal transportation corridor. The corridor is comprised of three parallel facilities. The closest to the site is Cedar Lake LRT Regional Trail. It is an active transportation facility managed by Three Rivers Park District to promote walking, bicycling, skating, and—as allowed by law—selected forms of electrically powered mobility. It promises to be a significant commuting and recreational connection drawing bicyclists and other active transportation users to and from the site. The trail extends west to downtown Hopkins where it connects to several other trails that serve the western suburbs. Similarly, it extends east into Minneapolis and that city's extensive trail system. Consequently, the Cedar Lake LRT Regional Trail provides a level of service for active transportation users similar to that which Blake Road provides motorists—access to the larger metropolitan region.

Offset south approximately 70 feet and parallel to the trail is an active single track freight railroad. It acts primarily as a barrier, blocking access between the site and locations south of the train tracks and funneling any crossing to Blake Road.

Parallel to the railroad and offset an additional 50 feet south will be the location of the double-track Southwest Light Rail Transit (SWLRT) line. Like the tracks for freight trains, the rails for the SWLRT line will hinder access and mobility, relegating crossings to Blake Road until a bicycle/pedestrian trail underpass is constructed in the future, forming a connection that is currently planned near Minnehaha Creek's flow under the Cedar Lake LRT Regional Trail. Currently under construction, the SWLRT will include a transit station in the southwest quadrant of the intersection of the LRT tracks and Blake Road. With the addition of a tunnel under Blake Road and traffic signals at 2nd Street, pedestrian access between the site and the Blake Road

Station will be excellent, making the site a prime location for Transit Oriented Development (TOD).

Minnehaha Creek borders the east side of the 325 Blake Road parcel. Although not a traditional transportation corridor, the creek is considered a water trail for recreational watercraft. As a water trail, it provides people with a purely recreational mode of transportation to destinations south of the site. Until the future bicycle/pedestrian trail underpass is constructed, opportunities to safely cross the transportation facilities that flank the south side of the site will be limited.

3.6 Utilities

According to a survey performed in January 2021, utilities associated with the 325 Blake Road parcel include inactive sanitary sewer and natural gas utility lines located near the north edge of the site, which connect to utility mains under Lake Street. Storm sewers from Lake Street and Powell Road are currently bulkheaded, but designed to discharge onto the site from the north and southeast edges of the site, respectively. Two sampling wells are located within the main parcel. Public utilities, including overhead electric lines, underground electric lines, underground communication lines, and similar utilities are located along Blake Road, Lake Street, and near the Cedar Lake LRT Regional Trail. Overhead utilities adjacent to the site currently detract from the site’s visual quality. It is anticipated that all overhead utilities will be buried during the site’s redevelopment. The survey does not show any utilities within the proposed stormwater management area except the monitoring wells, which will be removed or abandoned during construction.

MCWD has been coordinating utility impacts and relocations with design support and input from the HDR Team. Besides storm sewer modifications and the sampling well removals, no utility removals or relocations are anticipated by MCWD project construction and any required relocations are being coordinated with the utility owners in advance of construction.

4. Existing Information

4.1 Prior Studies and Information

Since the project's initiation in 2013, several studies, models, and reports have been developed that assess and document key findings related to stormwater management at the project. *Table 4.1* contains a list of major items referenced throughout the project design.

Data Description	Data Source	Date of Record
Assessment of pollutant loading, biology, and habitat	DRAFT Stormwater Management Feasibility Study for 325 Blake Road North, Hopkins, MN	July 2013
Summary of pollutant loading estimates	325 Blake Road Market Analysis Pollutant Loading Study	Nov. 2013
Groundwater and geotechnical parameters	Baseflow Restoration in Minnehaha Creek Watershed with Stormwater Infiltration report	2013
Hopkins Lift Station L27 storm sewer design update memo	Hopkins Lift Station L27 Storm Sewer Design Update Memo	Aug. 2015
Powell Road storm sewer diversion record drawings	Powell Road Storm Sewer Diversion Project Record Plans	Nov. 2015
Runoff volume estimates and groundwater elevations	Storm Water Treatment Concepts at 325 Blake Road Technical Memorandum	Jan. 2016
Regulatory floodplains	Flood Insurance Rate Map (FIRM) Panel 342	Nov. 2016
Soil boring records	DRAFT Phase I Environmental Site Assessment, Appendix H	Aug. 2017
Water quality monitoring results	Powell Rd. and Lake St. Water Quality Analysis Technical Memorandum	Aug. 2018
Prior Utility Demolition	Hopkins Cold Storage Demolition Project	Jul. 2018
Runoff volume estimates and modeled pollutant loading	325 Blake Water Resources Concept Analysis	Oct. 2019
Tree survey	STN Tree Survey	Jan. 2020
Topographic survey	ALTA/NSPS Land Title Survey	Jan. 2020
Lake Street storm sewer diversion record drawings	HIS Contract D – Lift Station L27, Meters M123A & M123B	Mar. 2020
Wetland Delineation	Stantec Consulting Services 325 Blake Road Site Wetland Delineation Report	Nov. 2021
Minnehaha Creek hydrology and hydraulics	Lower Watershed 100-year XP-SWMM Model	--
Powell Road subwatershed hydrology and hydraulics	Powell Road Diversion HydroCAD Model	--

Table 4.1: Summary of Data Acquired. Studies, models, reports, record plans, models, and other data are critical to project planning and design.

The studies and information included evaluations of regional subwatershed sizes and land covers, surface water and groundwater characteristics, potential for pollutant reduction via regional stormwater management BMPs, potential stormwater BMP schematics, and estimated project costs. Consideration was given to these studies, and the results leveraged as appropriate in context with current discussion and knowledge of the site.

4.2 Stormwater Drainage

The regional stormwater that will be treated by the project's proposed stormwater management facility is largely driven by two storm sewer diversion structures that direct water towards the Site. The stormwater diversion was first initiated by the District in 2013 and includes the diversion of two regional drainage areas to the Site:

- Powell Road subwatershed, which primarily consists of impervious industrial land use with nearby residential and ball fields. The Powell Road subwatershed drains 226 acres of regional stormwater runoff to the Site.
- Lake Street subwatershed, which primarily consists of impervious transportation land use. The Lake Street subwatershed drains 30.3 acres of regional stormwater runoff to the Site.

The Powell Road and Lake Street diversions are first-flush diversions. As such, they were constructed to divert runoff from smaller storms as well as the first flush from larger storms, which contain the majority of pollutants (see *Figure 4.1: Storm Sewer Diversions*). When the diversions reach capacity, the remaining overflow continues downstream in the mainline storm sewer piping and does not flow to the Site.

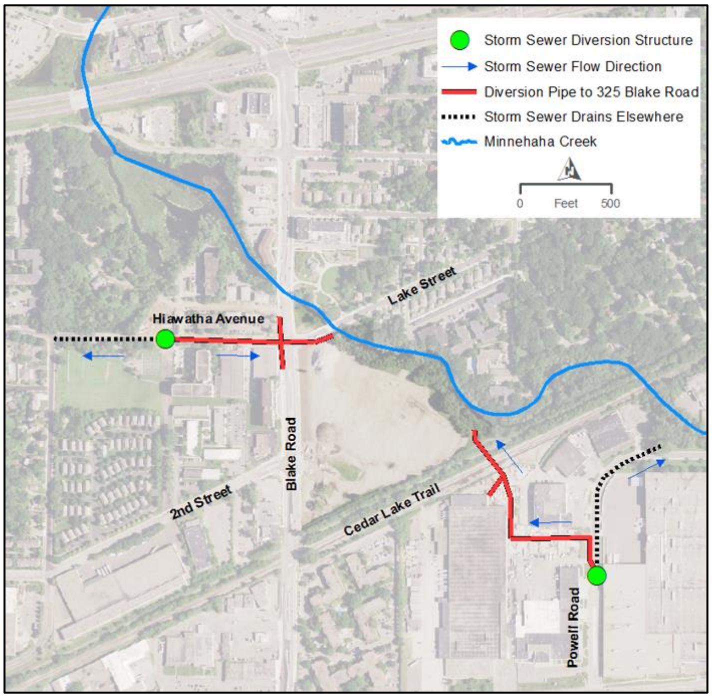


Figure 4.1: Storm Sewer Diversions. Stormwater collected from Powell Road and Lake Street is diverted to the site. When the diversions reach capacity, excess runoff discharges to separate locations.

Site stormwater runoff originates from local high points at the property’s border with Lake Street, Blake Road, and the Cedar Lake LRT Regional Trail. These boundaries’ conditions range from approximate elevations between 909’ to 912’ at Lake Street, 912’ to 919’ along Blake Road, and 911’ to 919’ along the Cedar Lake LRT Regional Trail. Each site boundary begins with a relatively steep slope down to the property, which transitions to a relatively flat (approximately 1 to 3 percent) grade across the majority of the site, sloping gradually toward Minnehaha Creek.

The importance of stormwater management associated with the project is emphasized by the regional drainage systems described above, along with the close proximity of the project to Minnehaha Creek. As an integral part of the regional greenway, the project offers a unique opportunity to showcase stormwater management, provide visual access to Minnehaha Creek, and develop Balanced Urban Ecology.

An overview of the Powell Road and Lake Street storm sewer diversions are provided in the following sections and a more detailed review of field visits and available documentation on the diversions is included in *Appendix F*.

4.2.1 POWELL ROAD DIVERSION

According to the District’s HydroCAD model and review of record drawings, the Powell Road Diversion consists of a series of storm sewer pipes that drain approximately 226 acres of land. The HydroCAD model was modified by HDR to reflect the diversion condition shown in the Powell Road Diversion construction record drawings (Wenck, 2015). The Powell Road subwatershed is predominantly characterized by developed industrial and residential land use, with minor areas of developed turf grasses (e.g., baseball fields, parks, and landscaped areas).

The Powell Road Diversion structure consists of a 10-ft diameter drainage structure with a 48” reinforced concrete pipe (RCP) inlet. A series of stoplogs function as a weir, diverting stormwater runoff from the inlet pipe toward the project. The top of the stoplogs is located at elevation 903.5’, where water will spill over and travel directly to Minnehaha Creek via the original Powell Road storm pipe. A 6” PVC drain is located at elevation 895.01’. The structure features a sump with an invert elevation 891.96, allowing approximately 3.05’ of sediment storage below the PVC drain at full storage capacity. The pipe outlet that diverts water to the project from the diversion structure is situated at elevation 901.06’. The pipe outlet from the most downstream pipe discharging onto the property is situated at invert elevation 898.40’.

4.2.2 LAKE STREET DIVERSION

The Lake Diversion consists of a series of storm sewer pipes that drain approximately 30.3 acres of land, according to the District’s HydroCAD model. The Lake Street subwatershed is predominantly characterized by developed commercial and high-density residential land uses with minimal pervious surfaces.

According to the Lake Street Diversion Record Drawings, the diversion structure consists of an 8-ft diameter drainage structure with a 30” RCP inlet. A concrete weir constructed inside the structure diverts water from the inlet pipe toward the project. The top of the concrete weir is located at elevation 902.4’. Stormwater would potentially reverse flow over the weir and into the other drainage system at this elevation. The Lake Street Diversion storm sewer drains toward the Site, into a 6-ft diameter manhole with a floor elevation slightly below 897.85 according to the as-built drawings, although the floor elevation is not explicitly recorded. A 12” RC weeper pipe (currently bulkheaded) was constructed from this manhole to allow drainage to daylight onto the Site at elevation 897.25’. The as-built drawings indicate that the downstream pipes and structures were under water at the time of construction, and standing water was present in the upstream pipes. The storm sewer pipes downstream of the diversion structure feature slopes as low as 0.06% which may result in sedimentation in the pipes regardless of the outlet configuration.

4.3 Minnehaha Creek

The project is bound to the northeast by a reach of Minnehaha Creek that is relatively stable, featuring a wooded riparian buffer along the creek corridor. This reach of Minnehaha Creek is impaired for Chloride, Fecal Coliform (*E. Coli*), Dissolved Oxygen (DO), Macroinvertebrates Bioassessments, and Fish Bioassessments. A TMDL report is approved for Chlorides and Fecal Coliform, while the remaining impairments have a target TMDL completion year of 2024, according to MPCA’s 2022 impaired waters list. Lake Hiawatha, a prominent downstream waterbody that receives flow from Minnehaha Creek, is listed as impaired for Nutrients with a TMDL report that was approved by the U.S. Environmental Protection Agency (EPA) in 2014.

Minnehaha Creek originates from Gray’s Bay Dam and meanders throughout the watershed to the stream’s confluence with the Mississippi River. Flow in Minnehaha Creek is highly variable and subject to rapid fluctuations, which can exacerbate flow-related impairments and stream stability challenges. Stormwater management at the project considered this variability, assuming that it would not be uncommon for flow rates through this reach to be as low as 10 cubic feet per second (cfs) or to exceed flows up to and above 300 cfs.

Two stream gages were consulted to determine flow characteristics within Minnehaha Creek. One of the stream gages, located upstream of the project at Gray’s Bay Dam, is owned by the United States Geological Survey (USGS) and operated in cooperation with the District. The other stream gage, located downstream of the project at Hiawatha Avenue, is operated by the USGS. Information obtained from stream gage observations confirmed the assumptions that flows in the creek can range from lower than 10 cfs, to higher than 300 cfs, as demonstrated during the historic flooding that occurred in 2014.

A warm season duration analysis was performed to further evaluate flow rates in Minnehaha Creek. The average daily flows at 50% exceedance during warm seasons range from approximately 34 cfs to 93 cfs. The latter value (93 cfs) provides an estimate for the seasonally high peak flow rate in the creek that is exceeded 50% of the time.

Minnehaha Creek’s floodway features regulatory floodplains in the vicinity of the project. Near the midpoint of the Site, a narrow floodplain exists on the inside of a stream meander. Near the downstream end of the project, a larger floodplain exists adjacent to the Powell Road diversion’s outlet pipe. This floodplain specifically is a critical design and planning feature, located adjacent to a programmed area of the project. The regulatory flood elevation in this area is estimated to be slightly lower than elevation 899’.

4.4 Geotechnical Investigations

4.4.1 SOIL PROFILE AND GROUNDWATER

Soil borings were obtained for prior site studies in 1997 and in May 2013 and May 2014. Five soil borings were collected in January 2022 as part of this project. Soil borings were fairly consistent in showing that soils on the property primarily consist of medium to coarse sand and gravel, with trace amounts of silt and clay. In some locations, soils near the ground surface are comprised of fill, consisting of topsoil and organic sandy silt. The dominant sand and gravel soil texture is typical below that layer with thin sporadic layers of soft clay before transitioning back to sand and gravel at depths greater than 8 to 10 feet. Two of the soil borings were advanced to bedrock near the proposed pedestrian bridge location. Bedrock was encountered at approximately elevation 730.

The January 2022 soil borings encountered groundwater between elevations 894 and 897. In May 2013, the groundwater elevation was observed between elevations 889.0 and 891.5 in locations near the proposed stormwater pond. In May 2014, the groundwater elevation was observed at elevation 897.9 near the proposed stormwater pond. The dates of these soil borings were compared to precipitation and stream stage obtained from the stream gages discussed above. The data indicates that groundwater at the site is subject to fluctuation in response to precipitation and likely follows the stage of Minnehaha Creek. Although the soil textures are conducive to infiltration practices, the highly variable depth to groundwater would limit the performance of infiltration BMPs near the elevation of Minnehaha Creek and the Powell Road and Lake Street storm sewer flowline elevations.

A study performed by the University of Minnesota indicates potential for reverse flow from Minnehaha Creek into the riparian groundwater system, although the flow reversals would have minimal impact to the groundwater system. Soil cores indicate that the surficial aquifer in the project area is overlain by 7 to 12 feet of sandy clay fill material. The aquifer consists of sandy glacial outwash with silt, interspersed with gravel.

Appendix D provides additional detail on the geotechnical data reviewed and analysis completed to inform design.

4.5 Related Projects

Design of the mixed-use development of the Site is ongoing; performed concurrently with the District’s public realm design. This approach allows for collaborative planning, design, construction, and long-term operation and maintenance (O&M).

The design adjacent to the Site’s public realm provides for residential and commercial development in response to the construction of the Southwest LRT line and the location of a transit station near the southwest corner of the site. As proposed, the Alatus design includes an iconic 15-story building, several midrise buildings, and townhomes. The taller structures flank Blake Road, with one mid-rise structure extending along the Cedar Lake LRT Regional Trail.

The main roadway through the development forms an arc and coupled with a cascading water feature running from the junction of 2nd Street and Blake Road, it draws people—residents and visitors—to ponds, restaurants, and related amenities. In addition to the road, there are several pedestrian arteries that open the site up and encourage movement between structures. A boat house is situated as a terminal view down one of these pedestrian arteries off of Blake Road. Another off of the Cedar Lake LRT Regional Trail turns into a woonerf, or shared street, for, bicycles, scooters, and cars. All of the development's off-street parking is hidden inside occupied buildings. Although parking is extensive, the design intends to minimize the presence of active traffic within the development. Buildings and the open spaces between them will dominate the landscape.

The mixed-use development adjoins the public realm at the restaurants and surrounding areas. The interface between the developments features a vertical wall, maximizing space for both the public realm and the mixed-use development. The restaurant design includes balconies that overlook the ponds, providing another opportunity for water-centric experience. A boat house is proposed near the restaurants, adjacent to the north stormwater pond. The boat house will include a wet well and a stormwater pump, which intakes stormwater from the pond and discharges into the cascading water feature near the west edge of the Site. The pumped stormwater (first treated by the stormwater ponds and pre-treatment) would be filtered by cartridge filters to further improve the water quality prior to discharge to the top of the cascade. The filtered runoff would then be aerated as it drains down the cascade, ultimately discharging back into the stormwater ponds for additional treatment and recirculation.

5. Design Approach and Analysis

5.1 Stormwater

5.1.1 REGULATORY CRITERIA

Stormwater management and design considerations are governed by various local and state agencies. The primary regulatory criteria influencing design of the project includes:

- MCWD Rules
- City of Hopkins Code and Ordinances
- Minnesota Pollution Control Agency's National Pollutant Discharge Elimination System (NPDES) Regulations
- Lake Hiawatha Total Maximum Daily Load (TMDL) Report

Regulatory criteria for the developed portion of the Site will be adhered to as part of the Site's development process. For regulatory purposes, the Site is considered redevelopment rather than new development, as the 6.3-acre cold storage facility and 5.3-acre parking area previously occupied the Site.

MCWD's volume control rules vary depending not only on the status of development or redevelopment, but based on the size of the site, the amount of disturbance, and the reduction in impervious surface. Because this project size is greater than 5 acres and disturbs more than 40% of the site, the stormwater management plan must meet the volume control requirements in subsection 3(c) of the volume control rule, requiring abstraction of the first one inch of rainfall from the site's impervious surface.

5.1.2 WATER QUALITY GOALS

In addition to the regulatory design criteria, non-regulatory design goals or objectives to provide regional stormwater treatment have been identified that apply to project planning, programming, and design. The treatment objectives are based on water quality monitoring results, prior studies, regional plans, and industry best practices.

This reach of Minnehaha Creek is impaired for Chlorides, Fecal Coliform, Dissolved Oxygen (DO), Macroinvertebrates Bioassessments, and Fish Bioassessments. A TMDL report is approved for Chlorides and Fecal Coliform, while the remaining impairments have a target TMDL completion year of 2024, according to MPCA's 2022 impaired waters list.

Downstream of the Site is Lake Hiawatha, which has an approved TMDL for nutrients. The Lake Hiawatha TMDL indicates that the average growing season total phosphorus (TP) cumulative watershed load delivered from Minnehaha Creek to Lake Hiawatha is approximately 6,463 pounds. A reduction of 1,907 pounds (29.5% reduction) would be required to achieve the target loading capacity of 4,556 pounds from Minnehaha Creek to Lake Hiawatha.

The 325 Blake Road Restoration and Redevelopment Project has been cited as an opportunity to reduce phosphorus loading to Lake Hiawatha. Estimated pollutant loads to the Site were modeled using MIDS Calculator and are summarized in *Table 5.1: Modeled Pollutant Loading*.

Parameter	Lake Street Diversion	Powell Road Diversion	325 Blake Road North	Total
Total Phosphorus (lbs/yr)	52	165	20	237
Total Suspended Solids (lbs/yr)	9,520	29,915	3,538	42,973

Table 5.1: Modeled Pollutant Loading. Of the estimated 237 pounds of TP and 42,973 pounds of total suspended solids (TSS) delivered to the site, the Powell Road Diversion accounts for approximately 70% of the total pollutant loading.

Prior to this study, the District performed pollutant monitoring in 2016 and 2017, summarized in the *Powell Rd. and Lake St. Water Quality Analysis Technical Memorandum (MCWD, 2018)*. The memorandum describes a TP load of 6.2 lbs/yr from the Lake Street Diversion and 207 lbs/yr from the Powell Road Diversion, although the measured TP loads only occurred between April and October in 2016, potentially underestimating the annual total. The report concludes that particulate phosphorus concentrations are higher than expected from the Powell Road subwatershed, and lower than expected from the Lake Street subwatershed, though the combined annual TP load was greater than expected.

The monitoring results also show that the particulate phosphorus load from the Powell Road subwatershed comprises 90% of the TP on an average annual basis. Stormwater BMPs, including those designed for the project, are typically more effective at removing particulate phosphorus than dissolved phosphorus.

5.1.3 KEY SITE STORMWATER ELEVATIONS

The elevations of Minnehaha Creek, groundwater, and stormwater inflows are key factors in the approach to stormwater design. Existing grade for the majority of the site is between elevation 907’ to 910’. Within roughly 100 feet of the creek, the site features a more gentle grade towards the creek which steepens at the creek bank.

The Powell Road diversion storm sewer enters the site at elevation 898.40’ and the Lake Street diversion storm sewer enters the site at elevation 897.25’, roughly 10 feet below the majority of the site’s existing grade. Backflow from these diversion storm sewers into mainline storm sewer systems would occur near elevation 901’. Groundwater elevations have been recorded between elevations 889.0’ to 898.0’. The creek water surface varies along the site but can vary between elevations 893’ to 899’, depending on creek flow (see *Figure 5.1: Key Elevations*).

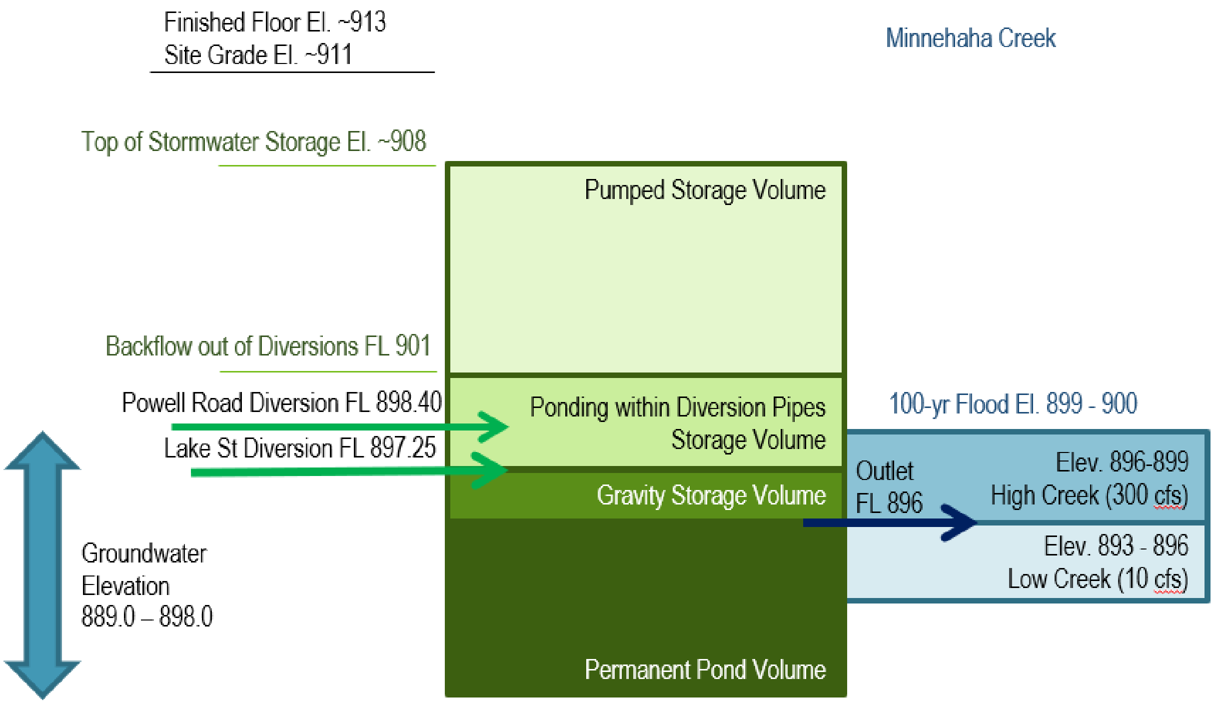


Figure 5.1: Key Elevations. A conceptual sketch of the site elevations demonstrates their significance to stormwater treatment limitations, opportunities, and storage considerations.

Because the storm sewer diversion outfalls are situated in close proximity to groundwater and creek water surface elevations, infiltration as a potential stormwater treatment option was eliminated. The site water elevations are favorable for a stormwater pond, which would have its normal water surface at approximately elevation 896.2’ (north pond) and 897.0’ (south pond), and be partially sustained by groundwater.

5.1.4 STORM SEWER DESIGN

The existing Powell Road Diversion storm sewer drains onto the property through a 36-in RCP, which enters a manhole and redirects flow toward Minnehaha Creek. The proposed design removes the manhole and drains runoff from the Powell Road Diversion into the south pond through a 36-in RCP at invert elevation 897.0. Prior to discharging into the stormwater pond, the storm sewer drains through a 6’ x 12’ Nutrient Separating Baffle Box (NSBB) hydrodynamic separator to provide pre-treatment. The NSBB is designed to reduce nitrogen, phosphorus, total suspended solids, and to capture trash and floatables.

The existing Lake Street Diversion storm sewer drains onto the property through a 42-inch RCP, which drains through a 12-in weeper pipe which is currently bulkheaded. The proposed design extends the 42-in RCP to the north pond. Prior to discharging runoff into the stormwater pond, this storm sewer drains through an 8’ x 16’ NSBB and ultimately discharges into the north pond at invert elevation 896.2.

5.1.5 STORMWATER POND DESIGN

Prior studies, regulatory requirements, and District goals were considered as factors guiding stormwater management design goals. Best practices published in the Minnesota Stormwater Manual as well as other local regulatory programs were followed and resulted in the preliminary design of a regional stormwater pond. The size of the pond, including surface area, depth, and water quality volume, were optimized to achieve regional water quality goals to the extent practicable. A summary of the design goals used in the layout, sizing and design of a regional stormwater treatment pond with no pumped or upland stormwater treatment is presented below in *Table 5.2: Stormwater Pond Design and Performance Goals.*

Parameter	Design Goal	Status
Location	Avoid wetlands, floodplains, and buffers	✓ Goal Achieved
Permanent Pool	Volume 1,800 cubic feet per acre of drainage area	x Maximum Extent Practicable[1]
	Depth between 3 and 10 feet	✓ Goal Achieved
	Install liner for contamination, karst, or flow restriction	x Not Applicable
Water Quality Pool	Volume equal to 1” times impervious surfaces	x Maximum Extent Practicable[2]
Inlets	Provide stabilized inlet areas for high flow conditions	✓ Goal Achieved
Outlets	Discharge < 5.66 cfs per acre of pond surface area	✓ Goal Achieved
	Provide energy dissipation	✓ Goal Achieved
	Provide emergency spillway	✓ Goal Achieved
	Located to prevent short-circuiting	✓ Goal Achieved
	Prevent discharge of floating debris	✓ Goal Achieved
Performance	Maintain or reduce stormwater volume	✓ Goal Achieved
	Maintain or reduce peak flow rates	✓ Goal Achieved
	Reduce TP and TSS loading	✓ Goal Achieved
Maintenance	Provide maintenance access bench	✓ Goal Achieved
Safety	Provide 35’ offset between pond and water supply wells	✓ Goal Achieved
	Incorporate public safety features (e.g., wetland safety bench)	✓ Goal Achieved

Table 5.2: Stormwater Pond Design and Performance Goals. This table will continue to be reviewed as detailed design is developed to meet these design and performance goals.

[1] *Permanent pool volume goal is maximized based on the selected development scenario. Achieving the explicit numerical goal would require over 50% of the property be occupied by a single pond.*

[2] *On-site and regional impervious surfaces are pre-developed. Spatial constraints limit the ability to achieve this explicit numerical goal. The proposed design provides water quality treatment equal to the runoff discharged to the site associated with a the 1.25” rainfall event, which exceeds the water quality (first flush) storm event of 1.1” based on water quality monitoring results.*

The project uses two stormwater ponds separated by a sheet pile concrete-capped weir wall with openings designed at elevation 897.0’ and the top of the wall designed at elevation 898.0’. The weir wall creates two separate cells for the stormwater pond, with the south cell receiving runoff from the Powell Road subwatershed, and the north cell receiving runoff from the Lake Street subwatershed. The south pond is designed with a permanent pool elevation of 897.0, and the north pond is designed with a permanent pool elevation of 896.2’. When runoff from Powell Road subwatershed occurs, stormwater will flow through the south pond and drain over the top of the weir wall. As the pond reaches and exceeds elevation 897.0’, the water surface elevation will flow through (or over) the weir wall and the two ponds will have a combined water surface.

The pond outlet structure adjoins the weir wall and is designed as a 40’ (L) x 10’ (W) concrete structure, allowing for multi-stage (low- and high-flow control) outlets. The objective of the outlet structure is to restrict “first-flush” outflow from the ponds sufficiently to allow settlement of sediments and pollutants and then provide overflow capacity for larger magnitude storm events without engaging the auxiliary overflow culvert. The outlet structure is designed with fiberglass steel grating located above the outlets, surrounded by a safety railing. This allows the District to maintain and access the structure but also provides pedestrian access from the trail to the outlet structure where they can safely overlook the stormwater ponds and weir wall.

The outlet structure is designed to intake water from the north pond using a submerged 24-in orifice, located at invert elevation 893.5’. The submerged orifice allows water to enter the structure without being blocked by floating debris at the permanent pool elevation. Inside the structure, a concrete wall with a series of stoplogs is proposed to provide control of the permanent pool elevation. A 4-in diameter orifice is designed in one of the stoplogs, which functions as the low-flow outlet control. As the pond receives runoff and the water surface increases, the 4-in diameter orifice continues to control discharge until the water surface reaches elevation 900.25’. At this elevation, a series of weir openings are designed near the top of the concrete outlet structure. The weir openings are located within both cells of the stormwater pond and each opening features a 2’ height and variable lengths that total 40’. Three weir openings are proposed at the outlet structure’s interface with the south pond, and three weir openings are proposed at the outlet structure’s interface with the north pond to provide overflow discharge when the capacity of the 4-in orifice is exceeded. The weir openings provide high-flow outlet control for storm events that exceed water quality or first-flush storm events. Incorporating several weir openings reduces the risk of the openings becoming clogged and allows the outlet structure to be supported by concrete walls on the interior to enhance structural integrity. For extreme storm events, an auxiliary overflow culvert is set to the north of the outlet structure to provide additional discharge capacity prior to the pond being overtopped.

A 4’ (H) x 6’ (W) box culvert conveys outflow from the drainage structure and is sized to accommodate potential outflow from the overflow weirs. The box culvert discharges into a plunge pool and outlet channel, ultimately draining to Minnehaha Creek. A riprap apron with a coarse filter layer is proposed at the downstream end of the culvert to dissipate energy and reduce risk of scour. The outlet channel will be finished with surface cover consistent with the surrounding site to minimize visual impacts. The channel and culvert will be excavated into the bank and plantings will be provided to visually screen the outlet. Safety bars will be installed on the downstream end to prevent access into the culvert from the downstream side.

5.1.6 ALATUS STORMWATER OFFSET (STORMWATER CASCADE)

The stormwater ponds interact with the upland mixed-use development via a developer constructed stormwater cascade system. The cascade system consists of a wet well and pump located in a boat house (designed by Alatus) located adjacent to the north pond. Stormwater from the pond will be pumped through a filtration system and discharged at the top of a constructed stormwater cascade which includes pools, weirs, infiltration, and vegetative measures as stormwater flows through the 670-foot long channel through the development and back into the south pond for additional detention and recirculation. This pumped stormwater design allows for the mixed-use development to occupy sufficient space on site to meet development goals, while compensating for reductions of water quality volume in the stormwater ponds. The stormwater cascade is being designed by the Alatus development; Figure 5.2 displays an overview of the in-progress design. Treatment effectiveness of the cascade combined with the regional pond is presented in Section 5.2.

Figure 5.2: Regional Stormwater Cascade. A masterplan overview of the regional stormwater cascade relative to the stormwater pond. Stormwater is pumped from the north pond through a filtration system, discharging to the upstream end of the cascade where it flows through a constructed channel with pools, weirs, and plantings prior to discharge into the south pond.

5.2 Stormwater Modeling Results

5.2.1 SITE HYDROLOGY AND HYDRAULICS

The District's Powell Road Diversion HydroCAD model was modified to account for as-built conditions, and to incorporate the design and construction of the Lake Street Diversion, and the proposed design of the Site. The HydroCAD model determines peak flow rates and stormwater runoff volumes discharged to the Site from regional storm sewer diversion networks, and from the proposed stormwater ponds. Design storm depths used in the model are summarized in *Table 5.3: Modeled Design Storm Depths*. These rainfall depths were used for the site hydrologic and hydraulic modeling described throughout this section.

Design Storm	Modeled Rainfall Depth
1.25-in, 24-hour	1.25”
2-year, 24-hour	2.86”
10-year, 24-hour	4.30”
100-year, 24-hour	5.90”

Table 5.3: Modeled Design Storm Depths. Rainfall depths from the Powell Road Subwatershed model were assumed for this analysis.

Peak flow and runoff volume modeling results are documented for various design storms (see *Table 5.4: Regional Subwatershed HydroCAD Modeling Results)*.

Design Storm	Lake Street Diversion		Powell Road Diversion	
	Runoff Volume (ac-ft)	Peak Flow Rate (cfs)	Runoff Volume (ac-ft)	Peak Flow Rate (cfs)
1.25-in, 24-hour	1.8	23.2	6.2	19.5
2-year, 24-hour	4.7	37.6	13.8	31.5
10-year, 24-hour	7.1	42.0	22.8	35.5
100-year, 24-hour	9.5	43.4	29.3	36.8

Table 5.4: Regional Subwatershed HydroCAD Modeling Results. Peak flow rates and stormwater runoff volumes were modeled for the regional storm sewers draining onto the site.

Existing and proposed conditions were modeled to demonstrate stormwater runoff benefits of project development. This comparison was performed for the design storms as shown in *Table 5.5: Existing vs. Proposed HydroCAD Modeling Results*. This analysis indicates that stormwater runoff volumes to Minnehaha Creek are decreased by 3 to 11%, and peak flow rates are decreased by approximately 51 to 87% based on the design storm event. This analysis does not account for groundwater flow patterns, which can have an influence on site hydrology and hydraulics. Site hydrologic and hydraulic model outputs are contained in *Appendix A*.

Design Storm	Existing Conditions[1]		Proposed Conditions	
	Runoff Volume (ac-ft)	Peak Flow Rate (cfs)	Runoff Volume (ac-ft)	Peak Flow Rate (cfs)
1.25-in, 24-hour	8.7	45.3	8.4	5.8
2-year, 24-hour	22.3	123.0	22.2	35.8
10-year, 24-hour	36.3	169.7	32.7	72.6
100-year, 24-hour	48.3	214.1	43.1	104.1

Table 5.5: Existing vs. Proposed HydroCAD Modeling Results. Peak flow rates and stormwater runoff volumes were modeled for the regional storm sewers draining onto the site, along with the 325 Blake Road North parcel.

[1] *Existing conditions assume that both regional diversions are constructed, operable, and online without any downstream stormwater BMPs.*

Peak flow rates and stormwater runoff volumes are significantly reduced by the stormwater BMPs designed for the project. The stormwater pond’s water surface elevations associated with the design storms will impact features of the project and the surrounding environment, including regional storm sewers, Minnehaha Creek, building floor and basement elevations, trail grades, etc. Water surface elevations are influenced by inflows to the stormwater ponds and the multi-stage outlet structure. The water surface elevations associated with the modeled design storms are tabulated in *Table 5.6: Stormwater Pond Water Surface Elevations*.

Design Storm	Peak Water Surface Elevation[1]
1.25-in, 24-hour	900.3’
2-year, 24-hour	900.7’
10-year, 24-hour	901.0’
100-year, 24-hour	901.1’

Table 5.6: Stormwater Pond Water Surface Elevations. The pond’s water surface elevation ranges from 900.3’ to 901.1’.

[1] Peak elevation assumes all outlets are fully functional without clogs or reduced capacity, and the pump to the developer’s cascade feature is operating at 1,200 gpm.

5.2.2 MINNEHAHA CREEK HYDROLOGY AND HYDRAULICS

The District’s Lower Watershed XP-SWMM model was run to determine water surface elevations (WSEs) corresponding to the Minnehaha Creek flow rates documented above. The WSEs were reviewed near the upstream end of the project, near the project’s midpoint, and near the downstream end of the project. WSEs reported by the model are tabulated below (see *Table 5.7: Minnehaha Creek Modeled Water Surface Elevations*).

Flow Scenario	Upstream End	Midpoint	Downstream End
Low *(WSE at 10 cfs)*	897.2’	895.5’	893.6’
Average *(WSE at 93 cfs)*	898.0’	896.5’	894.8’
High *(WSE at 300 cfs)*	899.2’	897.6’	896.2’

Table 5.7: Minnehaha Creek Modeled Water Surface Elevations. Variations between low flows, average daily flows, and high flows provide context for the design of recreational opportunities, bridges, and pond outlets.

Inter-Fluve collected survey data of the Minnehaha Creek floodplain, banks, and bed during project design. A HEC-RAS model was developed to support hydraulic modeling of the creek to evaluate impacts of the design on flood magnitude flows. The 100-year floodplain boundary developed by the HEC-RAS model is included on project drawings and was used to avoid grading within the floodplain extents and confirm the bridge was set above the 100-year flood profile and document a “no-rise” certification. The no-rise memo and modeling results are provided in *Appendix B*.

5.2.3 SITE WATER QUALITY MODELING

The project has a water quality volume design goal of treating 8.0 ac-ft of stormwater runoff from regional storm sewer diversions in accordance with planning and schematic design objectives. *Table 5.8: Water Quality Volume Tracker* on the following page shows stormwater runoff parameters from the development, the compensatory runoff volume required for development encroachment on the stormwater ponds, and the water quality provided by the cascade used to compensate for decreased storage in the stormwater ponds.

ALATUS DEVELOPMENT RUNOFF ANALYSIS	Impervious Surface		Required Stormwater Abstraction Volume[1]		Provided Stormwater Abstraction Volume[2]		Compensatory Volume Managed by Cascade[3]	
	sf	ac	cf	ac-ft	cf	ac-ft	cf	ac-ft
	398,574	9.15	33,215	0.76	35,763	0.82	-2,548	-0.06

1 *Equals 1 inch times the impervious surface created by the project*

2 *Refer to MCWD Stormwater Management Rule, Appendix A, for credit calculation*

3 *Compensatory Volume = Volume Required - Volume Provided. Negative value indicates the required abstraction value has been met, so Cascade Volume is only being used to compensate for regional stormwater pond volume loss caused by the development encroachment.*

POND WATER QUALITY ANALYSIS	Design Volume Goal[1]		Baseline Alternative[2]		Water Quality Volume Provided[3]		Compensatory Pond Volume Required[4]	
	cf	ac-ft	cf	ac-ft	cf	ac-ft	cf	ac-ft
	348,480	8.00	368,193	8.45	181,137	4.16	167,343	3.84

1 *Based on the Lake Street and Powell Road subwatershed runoff volumes, associated with the 1.25", 24-hr storm event in HydroCAD. Exceeds Regulatory requirements*

2 *Baseline alternative consists of a stormwater pond as designed during schematic design, if the public realm portion of the site were constructed without adjacent development.4*

3 *Water quality volume based on HydroCAD stage/storage, between the low-flow elevations (896.2' north pond, 897.0' south pond) and overflow elevation (900.25').*

4 *Compensatory Volume = Volume Goal – Water Quality Volume Provided, i.e. additional volume needed to meet water quality goal.*

POND/CASCADE WATER QUALITY SUMMARY	Total Design BMP Volume Required[1]		Pond Water Quality Volume Provided[2]		Cascade Treatment Volume[3]		Treatment Volume Check[4]	
	cf	ac-ft	cf	ac-ft	cf	ac-ft	cf	ac-ft
	345,932	7.94	181,137	4.16	297,515	6.83	132,720	3.05

1 *Total Volume = Pond Design Volume Goal + Compensatory Volume Managed by Cascade. The stated goal exceeds regulatory requirements.*

2 *Value equal to the water quality volume indicated in the Pond Water Quality Analysis above.*

3 *Cascade Volume provided by HydroCAD model during the 1.25", 24-hr storm event, using 1,200 gpm pump rate over 48-hours with "on" and "off" elevations. Pump design in progress by Alatus, anticipated to be continuously run. Pumped discharge filtered by Contech Jellyfish, Phosphosorb, and vegetated channel in series, recirculated.*

4 *Treatment Volume Check = Pond and Cascade Volume Provided - Design BMP Volume Required to meet project goal. Positive value indicates goal achieved, in excess.*

Table 5.8: Water Quality Volume Tracker. The water quality pool in the stormwater ponds occurs between elevation 896.2' (permanent pool elevation) and 900.25' (primary high-flow outlet elevation) in the north pond, and between 897.0' (permanent pool elevation) and 900.25' in the south pond.

Table 5.8 shows that on a volumetric basis, the developed scenario regional pond with the stormwater cascade meets design volume goals established at the outset of this project. The original pond treatment volume of 8 ac-ft is reduced to 4.16 ac-ft due to the walls on the western end of the development. However, the 3.84 ac-ft of pond treatment volume loss is offset by the treatment volume provided by the development's stormwater cascade as it continuously pumps 1,200 gpm of regional stormwater through its own treatment measures. The compensatory volume provided by the cascade was computed over a 48-hour period; in reality, the regional stormwater cascade is continuously pumping regional stormwater so provides continual stormwater treatment outside the 48-hour window.

The treatment effectiveness of the entire regional stormwater system (regional pond + cascade) was evaluated through development of a water quality model. Water quality modeling was performed (*Table 5.9: Water Quality Modeling Results*) for the project using MIDS Calculator, which estimates annual runoff volumes and pollutant loading to the site. Pollutants modeled include TSS, particulate phosphorus, dissolved phosphorus, and total phosphorus. Stormwater BMPs modeled include:

- Regional Pond System
    - Nutrient Separating Baffle Boxes (NSBBs) providing pre-treatment upstream of the north and south stormwater ponds. NSBBs are certified to remove 50% TSS and have published removal rates up to 20% TP removal and 90% TSS removal based on site-specific characteristics. Removal rates of 45% TSS and 10% TP were assumed in the MIDS Calculator model.
    - Stormwater ponds at Design Level 1, per the Minnesota Stormwater Manual.
- Regional Cascade System (pumped from pond)
    - Jellyfish Cartridge Filter which remove 80% TSS and 50% TP on average, according to the Minnesota Stormwater Manual.
    - Phosphosorb media filters which remove 85% TSS, 50% particulate phosphorus, and 32% dissolved phosphorus according to the Minnesota Stormwater Manual.(see discussion below)
    - Tree Trench System (part of pumped cascade system), which receive direct runoff from the mixed-use development and can receive overflow from the cascade during high-flow conditions.
    - Lined and vegetated, pool and weir cascade channel.

The design team explored several options for reducing dissolved phosphorous, which is not removed by settlement and requires a filtering media to capture phosphorous in its dissolved state. Initially, iron-enhanced sand filter (IESF) bags were reviewed for use within the downstream end of the stormwater pond outlet chamber. To function effectively the IESF bags need to dry out when there is no outflow. The District collected creek stage data near the outlet structure starting on June 14, 2022 with readings extending to July 8, 2022 which showed creek elevations under normal flow conditions varying from 895.9 to 896.2. The invert elevation of the pond outlet culvert is at 895.5, meaning the IESF bags would likely be submerged for long periods under normal flow conditions. While the size of the outlet chamber was well suited to a series of IESF weirs, the limited elevation difference was not. A solution was then developed with the Alatus design team where a chamber containing Phosphosorb media filters would be constructed as part of the filtering system associated with the regional cascade. This solution is what is reflected in the MIDS model and is being advanced and coordinated as part of the regional cascade design.

	Lake Street Diversion	Powell Road Diversion	325 Blake Road N	Overall
TSS Load Inflow (lbs/yr)	9,520	29,915	3,538	42,973
TSS Load Outflow (lbs/yr)	--	--	--	49
TSS Load Removed (lbs/yr)	--	--	--	42,924
TSS Reduction %	--	--	--	99.9%
Particulate P Inflow (lbs/yr)	28.8	90.6	10.7	130.1
Particulate P Outflow (lbs/yr)	--	--	--	1.4
Particulate P Removed (lbs/yr)	--	--	--	128.7
Particulate P Reduction %	--	--	--	98.9%
Dissolved P Inflow (lbs/yr)	23.6	74.1	8.8	106.5
Dissolved P Outflow (lbs/yr)	--	--	--	59.9
Dissolved P Removed (lbs/yr)	--	--	--	46.6
Dissolved P Reduction %	--	--	--	43.8%
TP Load Inflow (lbs/yr)	52.4	164.7	19.5	236.6
TP Load Outflow (lbs/yr)	--	--	--	61.3
TP Removed (lbs/yr)	--	--	--	175.3
TP Reduction %	--	--	--	74.1%
Inflow Volume (ac-ft/yr)	64.2	201.8	23.9	293.5
Outflow Volume (ac-ft/yr)	--	--	--	293.5

Table 5.9: Water Quality Modeling Results. The treatment train approach used at the project is capable of removing approximately 42,924 lbs/yr TSS and 175.3 lbs/yr TP.

The water quality modeling results summarized in Table 5.9 show that the combined regional pond and cascade system are very effective at removal of TSS and Particulate P. Dissolved P is more difficult to remove without fully infiltrating stormwater, however the addition of the Phosphosorb media in the stormwater cascade treatment syste, provides an estimated 32% reduction in Dissolved P, with additional Dissolved P removal occurring in the tree trench system of the proposed development that results in approximately 44% Dissolved P removal. Overall, the modeling results show the system provides a 74.1% reduction in TP, which could be exceeded if the system supplies a greater ratio of Particulate P to Dissolved P. This issue is discussed in more detail in Section 5.2.4 – Sampled Water Quality Data Evaluation. The water quality model and this evaluation do not account for the recycled flow through stormwater treatment train, which is anticipated to result in greater pollutant removal performance than indicated in this report.

5.2.4 SAMPLED WATER QUALITY DATA EVALUATION

Stormwater runoff and water quality modeling results were compared with the District's water quality analysis performed for the Powell Road and Lake Street subwatersheds in 2016 and 2017. The analysis identified several key parameters describing the pollutant profile of each subwatershed:

- The average TP concentration was 0.609 mg/L at Powell Road, and 0.142 mg/L at Lake Street.
- 90% of TP at Powell Road consisted of particulate phosphorus, while 64% of TP at Lake Street consisted of particulate phosphorus.
- The measured TP load was 207 lbs/yr at Powell Road and 6.2 lbs/yr at Lake Street.

The measured TP load from both subwatersheds combined was approximately 213.2 lbs/yr, which closely aligns with the modeled TP load of 217.1 lbs/yr. Model results show higher TP loading from Lake Street when compared to measured results, but a lower TP loading from Powell Road when compared to measured results. Despite the minor discrepancy from each subwatershed, the aggregate results demonstrate confidence in the model's accuracy.

A mass balance was performed using pollutant concentrations identified in the water quality analysis and annual runoff volumes identified in the water quality model. The results estimated 24.8 lbs/yr TP loading from Lake Street and 340 lbs/yr TP loading from Powell Road. The estimated Lake Street TP loading was within the sampled/modeled range, but the estimated Powell Road loading significantly exceeded the sampled/modeled range due to the average TP concentration at Powell Road nearly doubling the expected value.

If the sampling data is predictive of future pollutant loading parameters, then the high TP concentration (0.601 mg/L at Powell Road) and the high ratio of particulate phosphorus (90% particulate at Powell Road) would result in a greater amount of TSS and TP removed by the project than indicated in the model. As such, the water quality modeling results may be conservative as the particle size distribution and runoff pollutant concentrations are not customizable in the model.

5.2.5 CASCADE BENEFITS AND TREATMENT POTENTIAL

Water from the stormwater ponds is continuously pumped to the stormwater cascade, which allows the project to surpass its volume-based water quality goals. The cascade effectively creates a continuous stormwater treatment train, providing multiple benefits to the project's water quality performance:

- Stormwater is pumped through a Jellyfish Cartridge Filter, which removes an average of 80% TSS and 50% TP according to the Minnesota Stormwater Manual. The filtration mechanism of this BMP provides a different style of stormwater treatment than the NSSBs and the stormwater ponds.
- Stormwater discharges through Phosphosorb media, which removes an average of 85% TSS, 50% particulate phosphorus, and 32% dissolved phosphorus according to the Minnesota Stormwater Manual. The dissolved phosphorus removal mechanic is relatively unique to the Phosphosorb media, as only a minor amount of dissolved phosphorus is removed through other processes (i.e., tree trench system).
- Stormwater is discharged from the Jellyfish Cartridge Filter into a partially vegetated swale, where plant roots uptake stormwater pollutants. As stormwater flows through the swale, aeration occurs which provides benefits to dissolved oxygen concentration, ammonium concentration, pH, and metal concentrations.

Stormwater pumped to the cascade is ultimately returned to the south pond and continuously recirculates, creating a constant treatment train effect. This dynamic is currently not represented in the water quality modeling documented in Table 5.9 because the water quality models do not allow for continuous/circular stormwater routing. As such, the water quality performance of the site is expected to exceed the water quality benefits indicated by the model.

The pump rate from the stormwater ponds to the cascade is approximately 2.68 cfs. As a continuously run system, the cascade will cycle nearly five times the modeled runoff volume produced by the subwatersheds between April and October. As such, the pollutant loading from Powell Road and Lake Street subwatersheds was used to calculate the cascade’s treatment potential, assuming that runoff between April and October is recycled through the system four times per year on average, allowing for pump maintenance. This calculation determined that the cascade on its own is capable of removing 212.2 lbs/yr TP and 39,910 lbs/yr TSS.

5.3 Geotechnical Analysis

A geotechnical analysis was performed to evaluate the slope stability and seepage gradients of the pond embankment and foundation soils. The analysis also included evaluation of the foundation conditions at the pedestrian bridge, weir wall, and outlet structure. To support the geotechnical analysis, a subsurface investigation was completed to gather site-specific geotechnical data. This investigation was completed in January 2022 and results are summarized in the geotechnical memorandum in *Appendix D*.

5.3.1 GEOTECHNICAL SITE INVESTIGATION

The January 2022 geotechnical site investigation was completed by American Engineering. The objectives of this investigation were to:

- Determine soil and rock stratigraphy across the project site as well as the characteristics of the typical soils encountered.
- Gain a better knowledge of groundwater conditions.
- Determine soil material parameters based on field and laboratory testing for use in final design.

- Assess the degree of variability of the encountered soils based on field and laboratory testing.

The geotechnical investigation included:

- One standard penetration test (SPT) boring drilled to a depth of 35 feet below ground surface (BGS)
    - Installation of a two-inch diameter PVC cased well with 5-foot screen, located at the depth interval from 30 to 35 feet BGS
    - Development of the well
    - Slug test completed within the well
- Two SPT borings at the proposed edge of the ponds drilled to 50 feet BGS.
- Two SPT borings drilled to bedrock (assumed to be 80 feet) near the proposed bridge abutments.
- Perform laboratory testing on representative soil samples collected from the investigation.

The soil borings and lab testing as well as previously collected soil data were used to review slope stability and seepage and establish limitations for side slopes and develop a seepage collection system (french drain). Foundation conditions were reviewed for structural analysis and advising on potential settlement and piling needs. Detailed descriptions of the supporting data and analysis is provided in *Appendix D*.

5.4 Structural Analysis and Design

Structural analysis and design was completed for the:

- **Weir Wall**: The main wall structure is a steel PZ-27 sheetpile structure. A combination cast-in-place and precast wall cap was designed to provide an aesthetic top that provides a unique overflow feature as well as discourage public access to the top of wall. The concrete wall cap has a variable crest elevation which will be achieved by providing a consistent cast-in-place top section and then placing pre-cast blocks on top and anchoring them using a combination of dowel anchors and a steel cable turnbuckle system. This configuration will improve constructability and top of wall consistency.
- **Outlet Structure**: The outlet structure is a cast-in place vault that is partially underground, partially above ground, and partially submerged. Due to its size and proximity to the trail its design evolved to accommodate the public and provide an outlook for the pond. The top of the structure will have fiberglass grating panels, with several lockable hatches to allow the District to access stoplogs and inspect the interior of the structure. The outlet structure includes several openings to regulate and convey pond outflow that have been coordinated with hydraulic design.
- **Pedestrian Bridge Abutments**: The pedestrian bridge abutments were designed with input from Contech (local pre-fab bridge supplier) on required loadings and geometric requirements. Steel H-Piles were designed to support the bridge and given the proximity of bedrock will be driven so the bridge is ultimately supported on the underlying bedrock.

5.4.1 CODES AND STANDARDS

The following codes and standards were used in the structural analysis and design:

- International Building Code 2018
- Minnesota Building Code 2020
- Reinforced Concrete ACI318-14 & ACI350-06
- Minimum Design Loads for Buildings and Other Structures ASCE7-16
- American Institute of Steel Construction AISC
    - Manual of Steel Construction, 14th Ed.
- American Welding Society D1.4

5.4.2 MATERIAL STRENGTH

The following material strengths are used in the structural design:

- Structural steel: 50 ksi
- Reinforcing steel: 60 ksi
- Concrete: 4,000 psi at 28 days
- Steel sheet pile (pz-27): 50 ksi
- Steel h-piles: 50 ksi

5.5 Trailhead and Overlook

To pull regional trail users into the site and explore its recreational opportunities an inviting trailhead and overlook was designed as a transition from the Cedar Lake LRT Regional Trail. The trailhead design includes raised planters, block seating, a drinking fountain, bicycle storage and repair areas, and an interpretive kiosk. The trailhead is finished with permeable pavers to differentiate it from the rest of the trail and is set among trees to provide shade and wind protection.

5.6 Trail and Pedestrian Bridge Design

A bituminous trail was designed between Minnehaha Creek and the proposed stormwater ponds, providing connections between the Cedar Lake LRT Regional Trail, the Minnehaha Creek Greenway, Cottageville Park, and recreational features of the project. The trail consists of a 10-foot wide bituminous surface with 1 foot of aggregate shoulder on each side. The cross slope of the trail is 1.5%, with maximum slopes of 3:1 (H:V) outside of the 1-foot shoulders. The trail alignment is designed to fit the existing topography and conserve the creek's riparian corridor, including mature trees, to the extent practical.

The trail features a graded path that transitions to a constructed ramp over the east slope of the north pond, connecting to the traversable outlet structure overlooking the stormwater ponds. Near the north edge of the property, the trail includes a pedestrian bridge over Minnehaha Creek, connecting the trail to a nature-based play area across the creek and offering pedestrians a place to spend time overlooking the creek.

The pedestrian bridge consists of a galvanized steel frame with a concrete deck, restricting access to pedestrians and light vehicles. The 105-foot long bridge was set extend bank to bank and minimize fill above the creek banks. The low-beam elevation is set above the 100-year floodplain and grading will not impact the nearby wetland. The bridge extends over an existing wetland on the north bank that is perched on a small floodplain bench. Variations in bridge alignment were reviewed to avoid the bridge location above the wetland but would either require removal of the expansive oak trees that are a key part of the nature-based play area or would impact the adjacent residential property to the east.

5.7 The Landing

The Landing is designed as a stop for people venturing along the creek and the greenway trails, located along a south bank of Minnehaha Creek. Surfaced with stone/sand mix developed using a grab sample from the site to replicate channel bank material, this area can serve as a transfer location between land and water recreation. The Landing includes a picnic area, canoe storage, informal seating, and creek access.

5.8 Nature-Based Play Area

A project outlot is designed as a nature-based play area, which provides a connection between the regional trail and Cottageville Park. This location effectively ties the development with the larger community, and the community with the development. The play area features log stacks, play boulders, precast concrete acorns, benches, tables, and seating areas. Wood fiber surfacing gives the ground a soft finish, while short trails of crushed stone offer access to seating areas closer to the creek.

5.9 Gateway to Greenway

A gateway overlook to the Minnehaha Creek Greenway is designed on a parcel located at the greenway’s hinge point at Blake Road and Lake Street. The gateway design includes a sheltering plaza to obscure the sound of traffic, surrounded by a pergola. A future public art space is proposed in the center of the plaza, which will be seeded with pollinator vegetation during construction. Hanging bench seating will be mounted to the overlook pergola. The overlook is finished with decorative concrete paving, and non-decorative concrete paving allows controlled pedestrian access down to overlook area in close proximity to the creek.

5.10 Interpretive Themes

The design team developed four interpretive themes based upon the rich cultural and natural history existent on site, and around the regional stormwater treatment system that will bring water quality improvements to Minnehaha Creek.

These themes were developed with the community and have been vetted through additional public engagement. Some of the interpretative themes will be displayed using more traditional signage, but the majority will be conveyed through text and images integrated within the proposed site elements. See the *Appendix G* for renderings of interpretive concepts and messaging.

6. Opinion of Probable Cost

The construction materials and features from the proposed design were tabulated to follow the proposed bid list that the contractor will use and quantities and probable costs estimated. The AutoCAD-based linework, grading and surfacing models, and pipe network models were used to estimate quantities for most major construction features within the project site.

Costs were estimated using several sources, including recent MnDOT average bid prices, RSMeans cost heavy construction cost reference (localized for the metro area), vendor pricing, and prior design/construction experience/references.

Preliminary cost estimates carried several contingencies, which were combined and reduced to a 15% markup on the estimated construction costs to reflect the volatility in the construction market which continues to increase pricing.

A cost summary based on major construction features is provided on the following page (see *Table 6.1: Opinion of Probable Costs*). A more detailed cost estimate table is provided as *Appendix E*.

Construction Item	Cost
General Conditions	$827,809
Demolition	$141,059
Earthwork	$1,254,587
Utilities	$460,334
Structures	$1,220,116
Electrical	$201,960
Surfacing	$949,286
Furnishings	$311,593
Vegetation	$330,530
Total Construction Estimate	$5,697,273
Stormwater Breakout	
General Conditions	$827,809
Stormwater	$2,335,300
Public Realm	$2,534,164

Table 6.1: Opinion of Probable Costs. Construction items and associated costs associated with the District managed portion of the 325 Blake Road site.

The schematic design cost estimate was $5.48M, the 60% cost estimate was $5.44M, the 90% cost estimate is $5.22M and the 100% cost estimate is $5.7M due to the continued escalation of material pricing and some additional features added to the pergola. The project continues to carry a 15% contingency due to volatility in the construction market.

Additional cost considerations for project construction are summarized as follows:

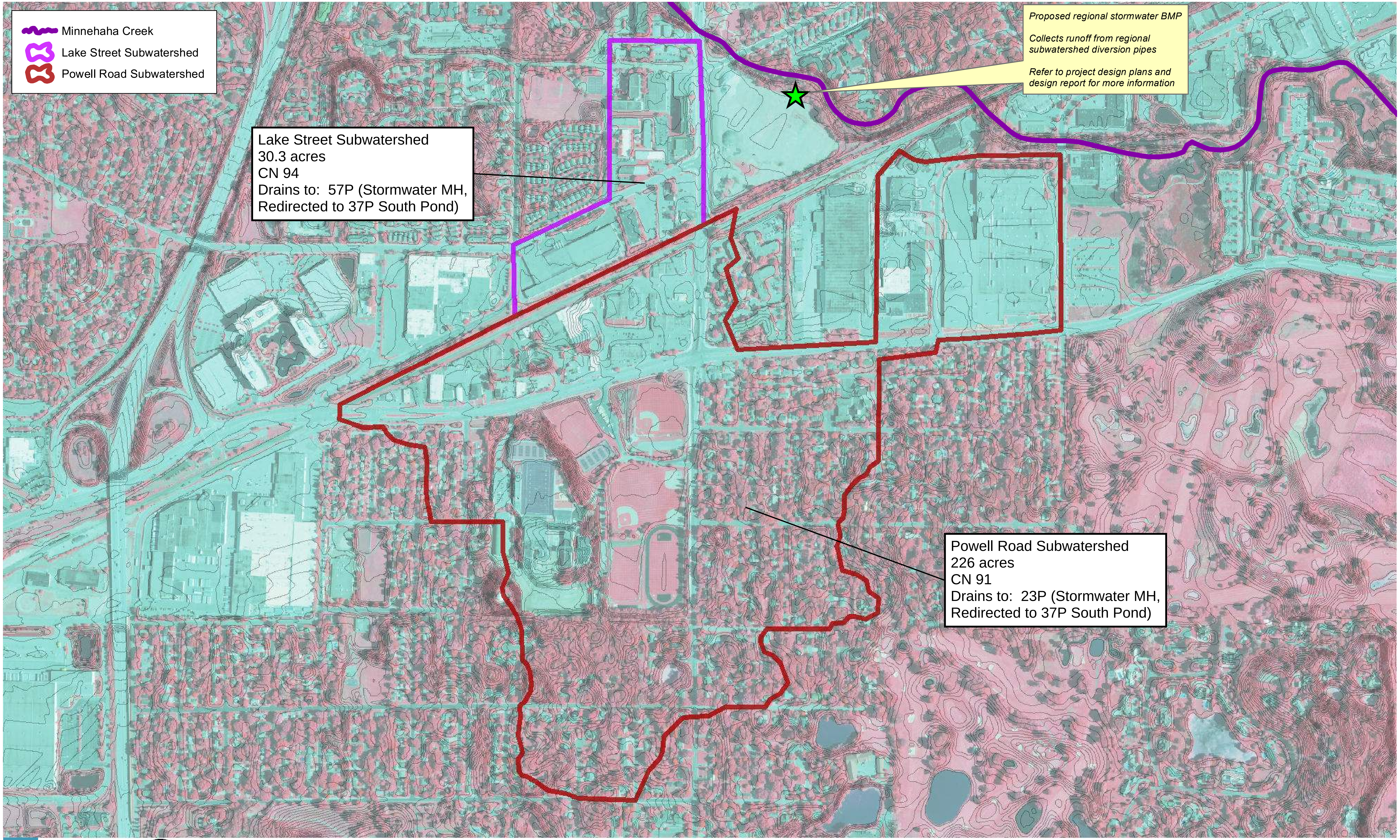
- The costs are reflective of the construction areas shown within the work limits on the project drawings (attached separately).
- Pond/stormwater costs versus public realm costs were approximately 50%/50%.
- The entire western pond edge is comprised of walls, which are assumed to be solely an Alatus cost. The earthwork cost could fluctuate depending on how much material the Alatus contractor excavates to install the western hard edge.
- The construction schedule and conditions will be influenced by the Alatus project phasing. The project carries a potential risk of delay if the Alatus contractor falls behind

in construction of the hard edge. This issue is being reviewed with the District as the project goes to bidding

- Timing of bid could also influence construction costs, the ideal time to bid is late fall/early winter and the project will carry a risk for higher pricing the later the bid package goes out. The cost risk could be mitigated through a more flexible schedule and incentives that would provide potential bidders more flexibility and/or motivation to maintain efficiency.

Appendix A

Site Hydrology and Hydraulics Model Outputs



Proposed regional stormwater BMP

Collects runoff from regional subwatershed diversion pipes

Refer to project design plans and design report for more information

Lake Street Subwatershed
30.3 acres
CN 94
Drains to: 57P (Stormwater MH, Redirected to 37P South Pond)

Powell Road Subwatershed
226 acres
CN 91
Drains to: 23P (Stormwater MH, Redirected to 37P South Pond)

MINNEHAHA CREEK WATERSHED DISTRICT

0 Feet 1,000

325 BLAKE ROAD

REGIONAL SUBWATERSHED MAP

STORMWATER POLLUTION PREVENTION PLAN

PATH: \\MSPE-GIS-FILE\GISPROJ\MCWD\10268112\7.2_WIP\MAP_DOCS\DRAFT\WORKING\DRAINAGE AREAS.MXD - USER: MRYAN - DATE: 6/8/2022

Drainage Area	Total Area (Acres)	Impervious Area (Acres)	Pervious Area (Acres)	Drains To
STRT	0.391	0.26	0.131	Blake Road N Storm Sewer
CITY	0.201	0.201	0	Blake Road N Storm Sewer
BLDG1	1.603	1.276	0.327	To Infiltration SW
ST-SW	0.739	0.685	0.054	To Infiltration SW
BLDG3	0.95	0.87	0.08	To Infiltration SE
BLDG4	1.609	1.401	0.208	To Infiltration SE
CY	0.19	0.107	0.083	To infiltration CYS
TT	0.232	0.059	0.173	To Infiltration CYW
BLDG2	0.91	0.91	0	To Infiltration NW1
BLDG5	0.53	0.51	0.02	To Infiltration NW1
TH1	0.99	0.779	0.211	To Infiltration N2
CY2	0.219	0.078	0.141	To Infiltration CYN
Rest	0.271	0.254	0.017	To Raingardens 34P
ST-51	0.82	0.691	0.129	STMH51 TO Regional Pond N
ST-52	0.484	0.355	0.129	STMH52 TO Regional Pond N
ST-53	1.036	0.754	0.282	STMH53 TO Regional Pond N
16S	0.279	0.142	0.137	To Upper Channel 45P
47S	0.203	0.041	0.162	To Middle Channel 46P
48S	0.465	0.101	0.364	To Lower Channel 27P
SP	0.323	0.2	0.123	To Regional Pond S 37P
NP	0.428	0.265	0.163	To Regional Pond N 79P

LEGEND

▦	DENOTES AREAS DRAINING DIRECTLY TO REGIONAL BASINS UNTREATED
▨	DENOTES AREAS DRAINING DIRECTLY TO BLAKE ROAD
▤	DENOTES PROPOSED PERVIOUS PAVEMENT
■	DENOTES PROPOSED IMPERVIOUS SURFACE

325 BLAKE ROAD N

HOPKINS, MN

ALATUS LLC

80 S 8th ST. STE. 4155
MINNEAPOLIS, MN 55402

LOUCKS

PLANNING
CIVIL ENGINEERING
LAND SURVEYING
LANDSCAPE ARCHITECTURE
ENVIRONMENTAL

7200 Hemlock Lane, Suite 300
Maple Grove, MN 55369
763.424.5505
www.loucksinc.com

DF/ DAMON FARBER LANDSCAPE ARCHITECTS
310 South 4th Avenue Suite 7050
Minneapolis, MN 55415 p: 612.332.7522

CADD QUALIFICATION

SUBMITTAL/REVISIONS

10/22/21	PUD SUBMITTAL
10/29/21	CITY RESUBMITTAL
11/08/21	CITY COMMENTS
11/15/21	CITY RESUBMITTAL
01/21/21	PRICING SET
03/30/22	GRANT APPLICATION
06/03/22	DESIGN DEVELOPMENT
06/13/22	CHECK SET FOR FRANA
06/13/22	PFA GRANT SUBMITTAL
06/30/22	PFA GRANT UPDATE
07/08/22	FOUNDATION PERMIT SET
08/05/22	WATERSHED SUBMITTAL
09/05/22	WATERSHED COMMENTS
09/16/22	ISSUE FOR PERMIT SET
11/16/22	RFI 021 S. DRIVEWAY CURB
12/21/22	IFC SET - ASI 1

PROFESSIONAL SIGNATURE

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Michael J. St. Martin - PE

License No.	24440
Date	09-16-2022

QUALITY CONTROL

Loucks Project No.	20503A
Project Lead	MJS
Drawn By	NWC
Checked By	MJS
Review Date	09-16-2022

SHEET INDEX

C1-1A-D	EX. CONDITIONS PLAN
C1-2A-D	DEMOLITION PLAN
C2-1A-D	SITE PLAN
C3-1A-D	GRADING PLAN
C3-2A-D	SWPPP PLAN
C3-3	SWPPP NOTES
C4-1A-D	SANI. AND WATERMAIN
C4-2A-D	STORM SEWER
C8-1-C8-3	DETAIL SHEET

PROPOSED DRAINAGE PLAN

H2-1

Plotted: 12 / 22 / 2022 4:26 PM W:\2020\20503A\HYDROLOGY\CAD\PROPOSED Drainage Plan-regional Pond

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-yr	Type II 24-hr		Default	24.00	1	2.50	2
2	1.25-inch	Type II 24-hr		Default	24.00	1	1.25	2
3	2-yr Atlas 14	Type II 24-hr		Default	24.00	1	2.86	2
4	10-yr	Type II 24-hr		Default	24.00	1	4.30	2
5	100-yr	Type II 24-hr		Default	24.00	1	5.90	2

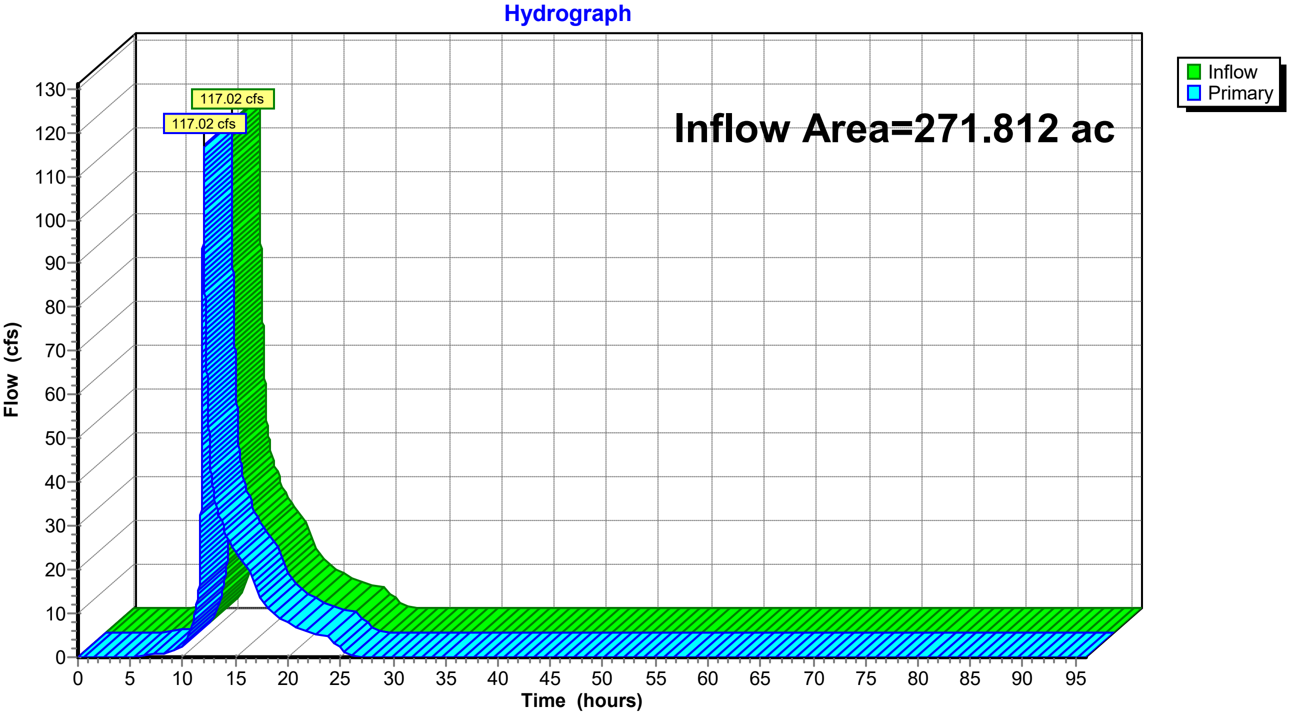
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 55.38% Impervious, Inflow Depth = 0.94" for 1-yr event
Inflow = 117.02 cfs @ 11.98 hrs, Volume= 21.301 af
Primary = 117.02 cfs @ 11.98 hrs, Volume= 21.301 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



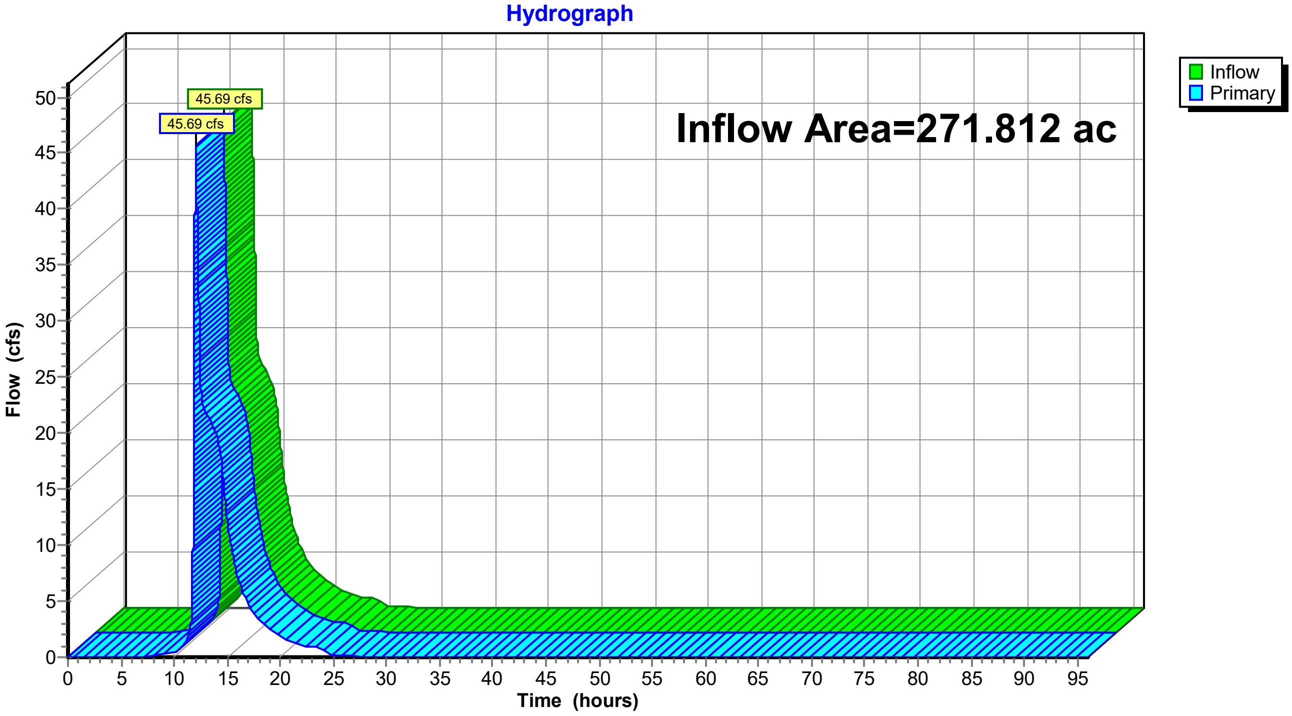
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 55.38% Impervious, Inflow Depth = 0.39" for 1.25-inch event
Inflow = 45.69 cfs @ 12.01 hrs, Volume= 8.730 af
Primary = 45.69 cfs @ 12.01 hrs, Volume= 8.730 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



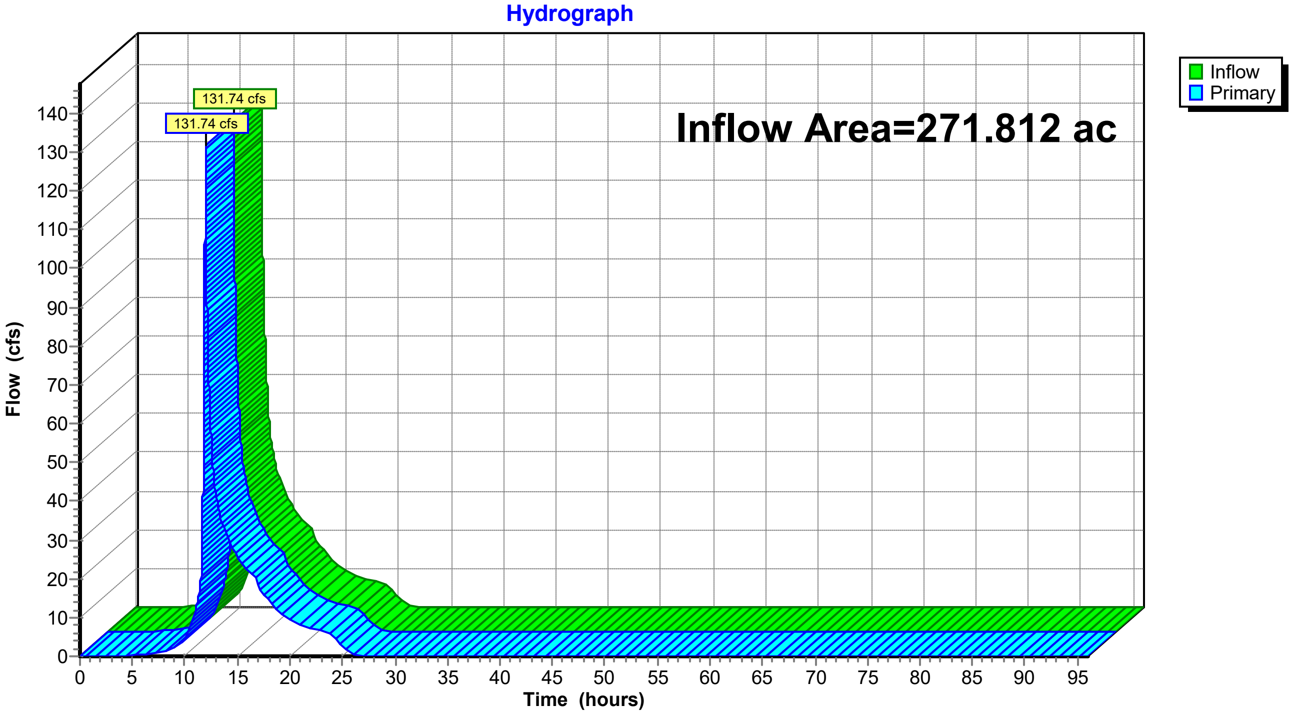
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 55.38% Impervious, Inflow Depth = 1.09" for 2-yr Atlas 14 event
Inflow = 131.74 cfs @ 11.98 hrs, Volume= 24.686 af
Primary = 131.74 cfs @ 11.98 hrs, Volume= 24.686 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



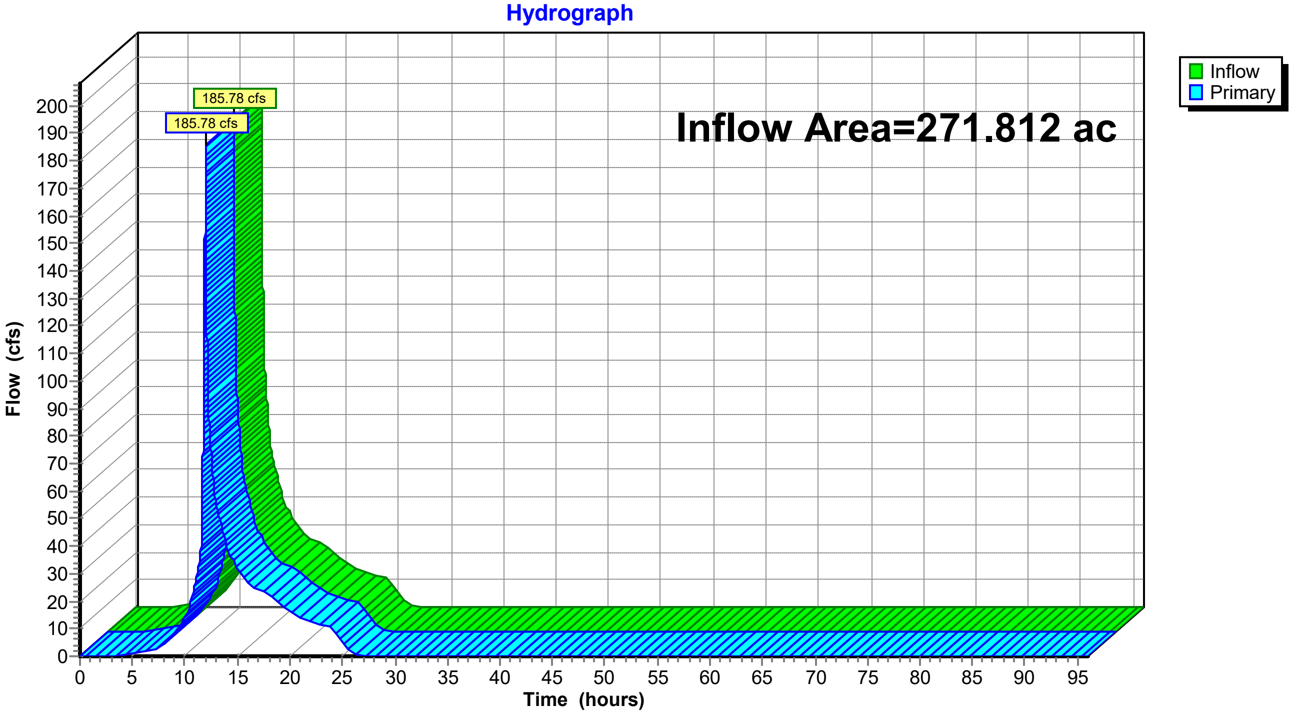
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 55.38% Impervious, Inflow Depth = 1.65" for 10-yr event
Inflow = 185.78 cfs @ 11.98 hrs, Volume= 37.268 af
Primary = 185.78 cfs @ 11.98 hrs, Volume= 37.268 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



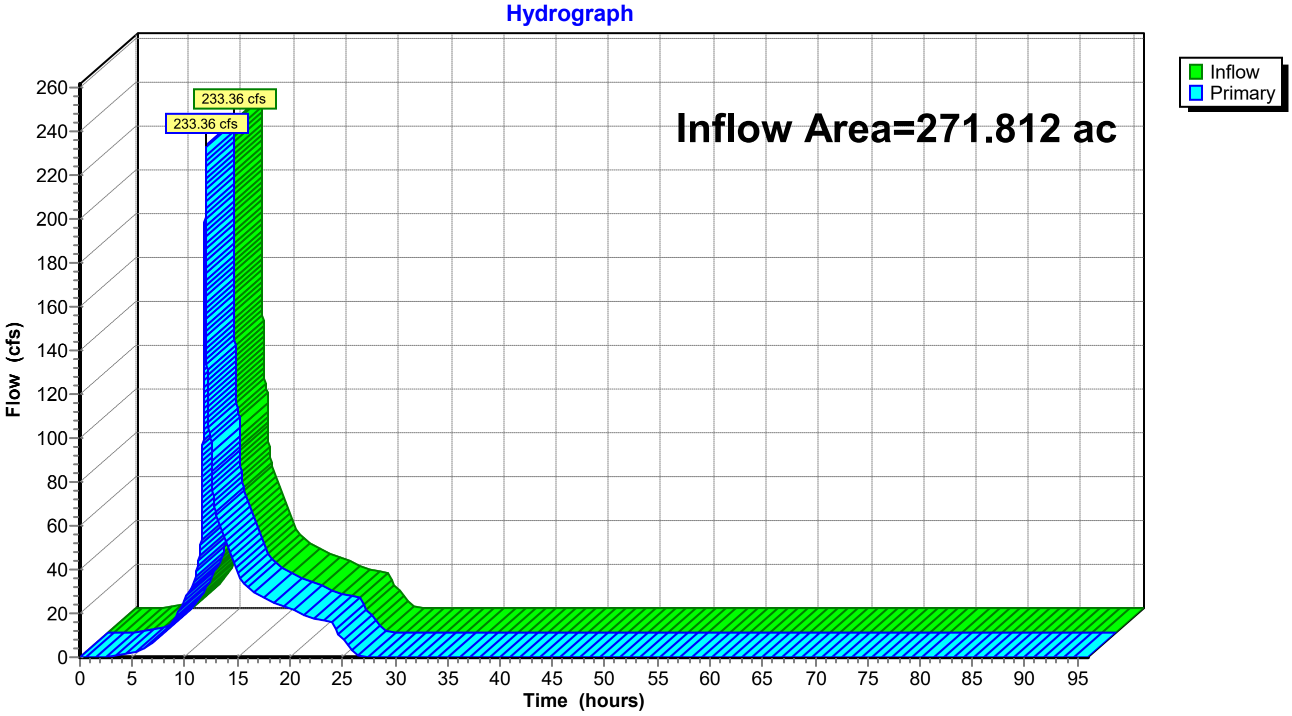
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

```
Inflow Area =      271.812 ac,  55.38% Impervious,  Inflow Depth =   2.20"    for  100-yr event
Inflow      =      233.36 cfs @   11.97 hrs,  Volume=          49.820 af
Primary     =      233.36 cfs @   11.97 hrs,  Volume=          49.820 af,  Atten= 0%,  Lag= 0.0 min
```

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-yr	Type II 24-hr		Default	24.00	1	2.50	2
2	1.25-inch	Type II 24-hr		Default	24.00	1	1.25	2
3	2-yr Atlas 14	Type II 24-hr		Default	24.00	1	2.86	2
4	10-yr	Type II 24-hr		Default	24.00	1	4.30	2
5	100-yr	Type II 24-hr		Default	24.00	1	5.90	2

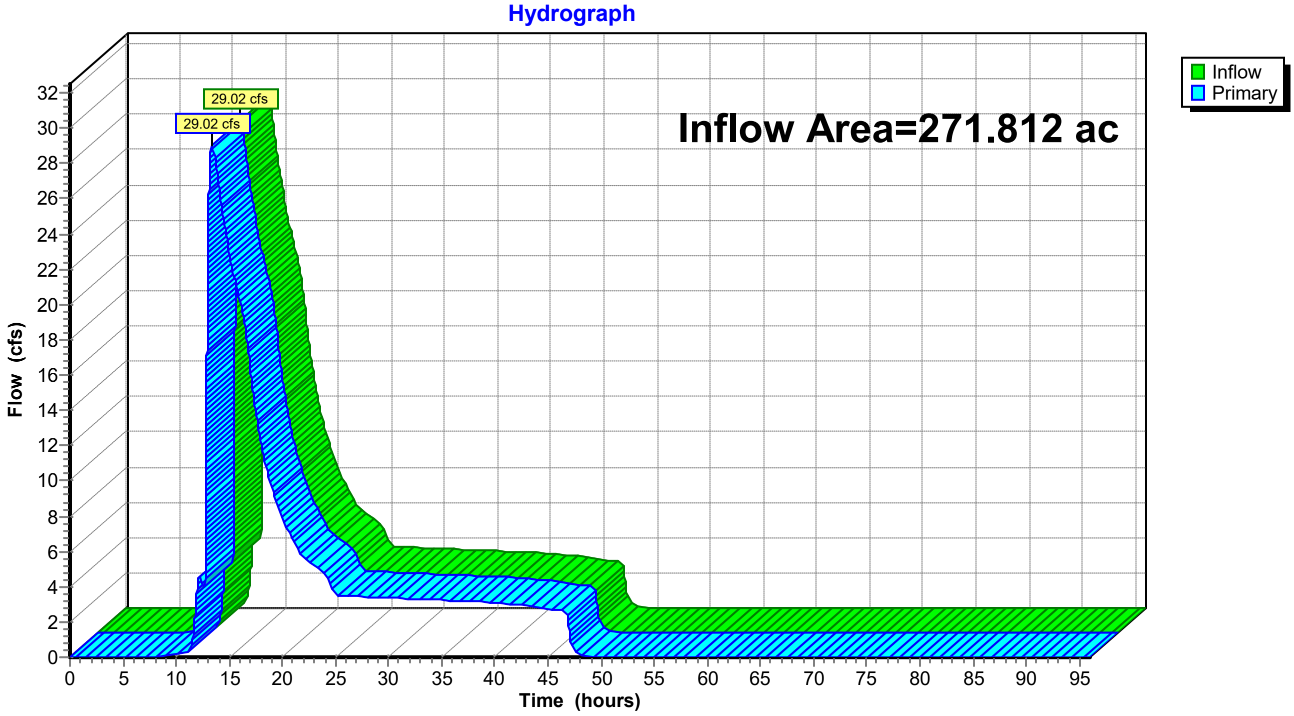
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 54.99% Impervious, Inflow Depth = 0.85" for 1-yr event
Inflow = 29.02 cfs @ 13.38 hrs, Volume= 19.254 af
Primary = 29.02 cfs @ 13.38 hrs, Volume= 19.254 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



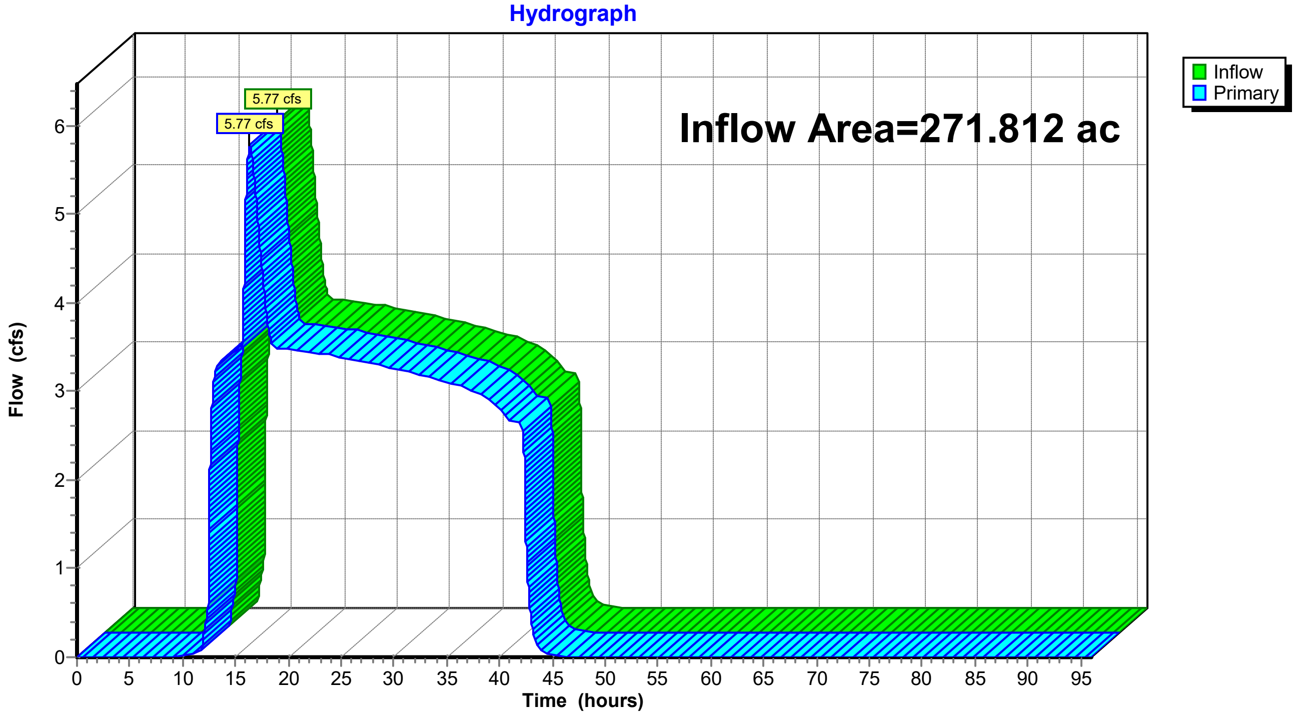
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 54.99% Impervious, Inflow Depth = 0.37" for 1.25-inch event
Inflow = 5.77 cfs @ 16.35 hrs, Volume= 8.343 af
Primary = 5.77 cfs @ 16.35 hrs, Volume= 8.343 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek

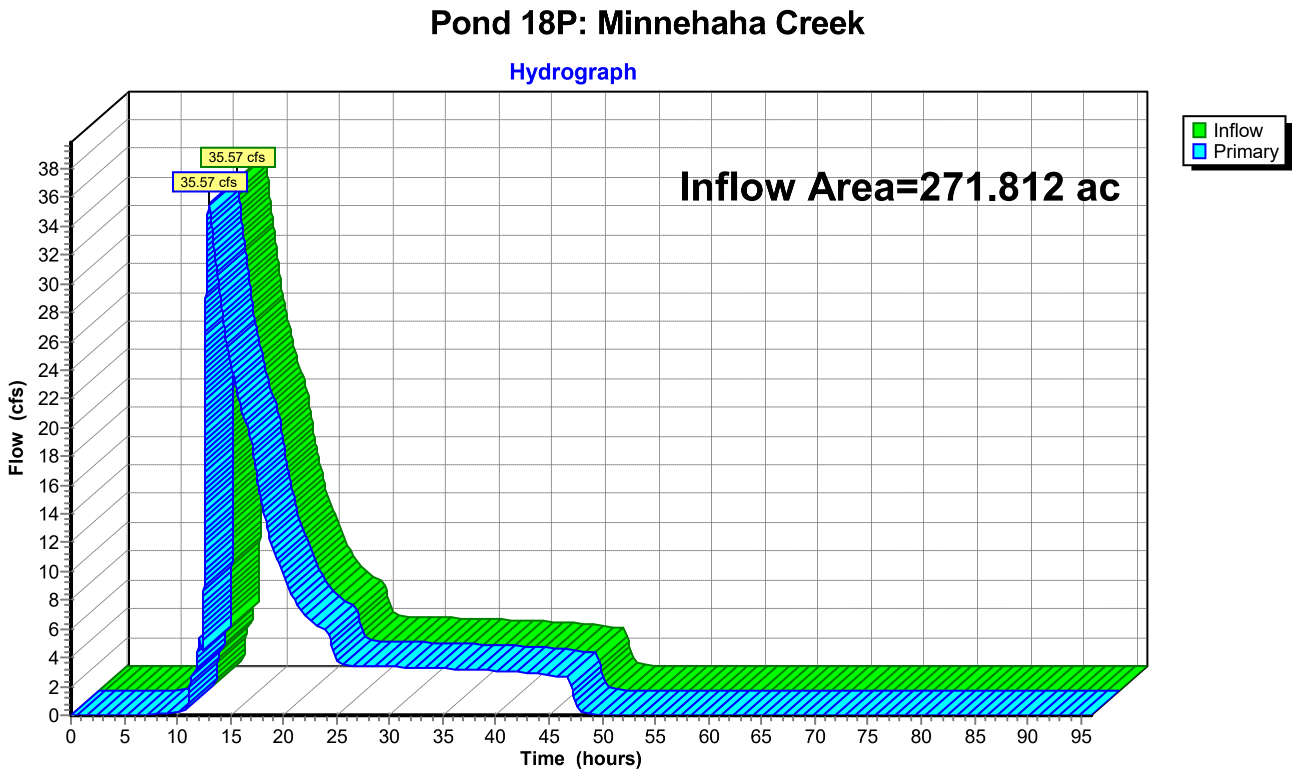


Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 54.99% Impervious, Inflow Depth = 0.98" for 2-yr Atlas 14 event
Inflow = 35.57 cfs @ 12.99 hrs, Volume= 22.124 af
Primary = 35.57 cfs @ 12.99 hrs, Volume= 22.124 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs



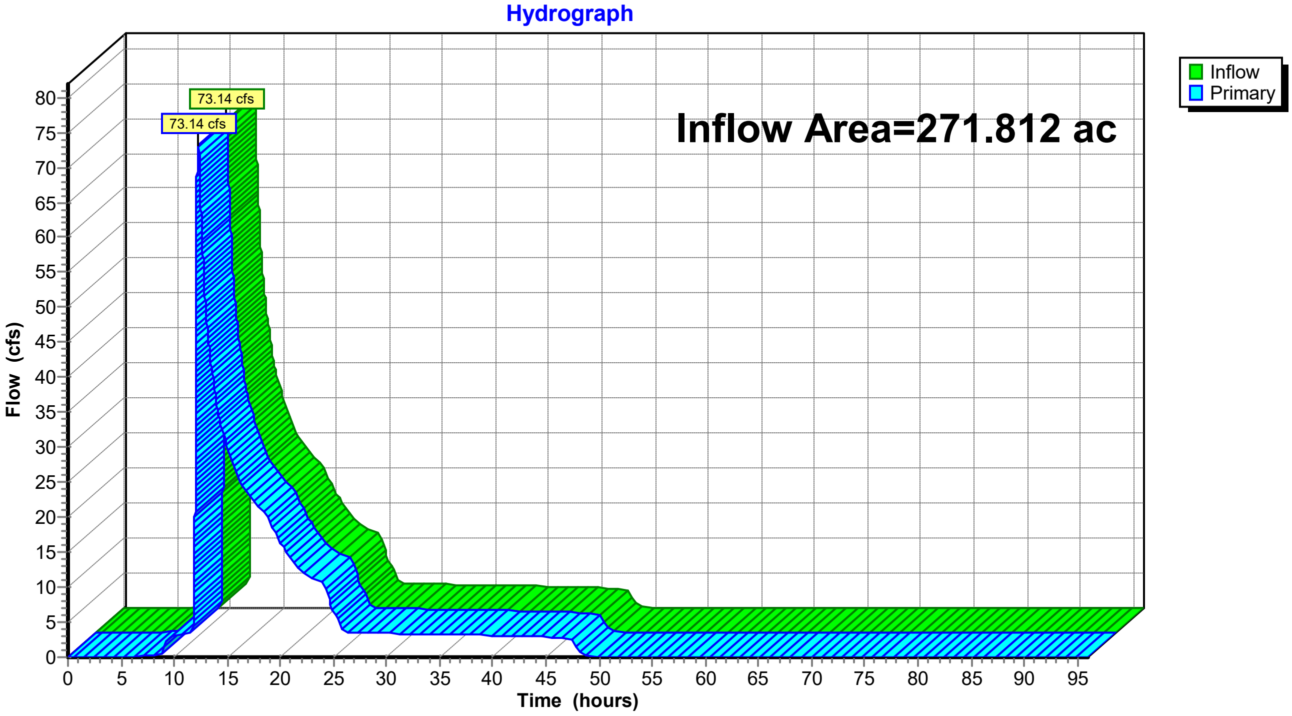
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 271.812 ac, 54.99% Impervious, Inflow Depth = 1.44" for 10-yr event
Inflow = 73.14 cfs @ 12.27 hrs, Volume= 32.652 af
Primary = 73.14 cfs @ 12.27 hrs, Volume= 32.652 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



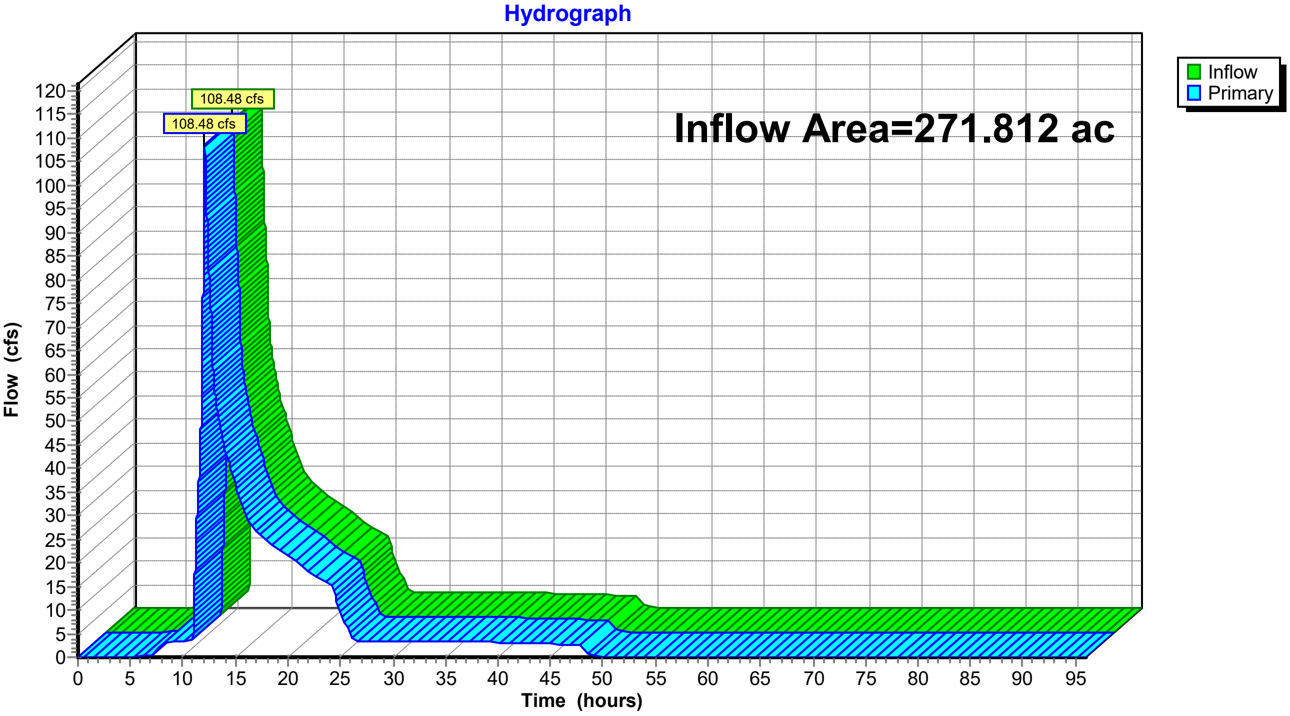
Summary for Pond 18P: Minnehaha Creek

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	271.812 ac,	54.99% Impervious,	Inflow Depth = 1.90"	for 100-yr event	
Inflow =	108.48 cfs @	12.07 hrs,	Volume=	43.137 af	
Primary =	108.48 cfs @	12.07 hrs,	Volume=	43.137 af,	Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.0005 hrs

Pond 18P: Minnehaha Creek



Appendix B

Hydraulic Model Technical Memorandum

December 12, 2022

Re: Floodplain Elevation Analysis for 325 Blake Road Regional Stormwater and Greenway Project

To Whom it May Concern,

This letter is to certify that I am a duly qualified registered professional engineer licensed to practice in the State of Minnesota.

It is further to certify that the technical data summarized in the Technical Memorandum entitled

“Floodplain Elevation Analysis for 325 Blake Road Regional Stormwater and Greenway Project (December 12, 2022),”

supports the conclusion that construction of the 325 Blake Road Regional Stormwater and Greenway Project documented in design materials provided to Inter-Fluve by HDR in September and October of 2022 will not raise by more than 0.00 feet on the Minnehaha Creek at published sections in the Flood Insurance Study Number 27053CV001B for Hennepin County dated November 4, 2016.

Attached is the following document that support these findings:

- Floodplain Elevation Analysis for 325 Blake Road Regional Stormwater and Greenway Project (December 12, 2022)

Regards,

Patton

Briana Patton, PE
Water Resources Engineer
m: (218) 600-6051
bpatton@interfluve.com

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Signature: Patton
Typed or Printed Name: Briana Irene Drake Patton
Date: 12/12/22 License Number: 56620

Offices Nationwide
1539 Grand Ave, Floor 2, St. Paul, MN 55105
www.interfluve.com

TECHNICAL MEMORANDUM

To:	Andrew Judd (HDR)
From:	Briana Patton, PE and Maren Hansell, PE (Inter-Fluve)
Date:	December 12, 2022
Re:	Floodplain Elevation Analysis for 325 Blake Road Regional Stormwater and Greenway Project

This memorandum summarizes the floodplain elevation analysis (no-rise analysis) conducted for 325 Blake Road Regional Stormwater and Greenway Project in the City of Hopkins, Minnesota. The results of this analysis support the conclusion that the proposed project will not result in an increase to the regulatory Regional Flood Elevations. The hydraulic model output files that support the floodplain elevation analysis are attached to this memorandum.

PROJECT BACKGROUND

A development project is being planned on the former industrial storage site located southeast of the corner of Blake Road and Lake Street NE, adjacent to a segment of the Minnehaha Creek. The Minnehaha Creek Watershed District (MCWD) is leading the site development project that will address regional stormwater management and recreational improvements. The design for this project is led by HDR, to which Inter-Fluve is a consultant. Within the regulatory floodplain, project will include a new pedestrian bridge crossing Minnehaha Creek just downstream of the Lake Street NE bridge, landscaping and trail features, and a new stormwater outfall structure.

A Flood Insurance Study (FIS) for Hennepin County was completed by the Federal Emergency Management Agency (FEMA) with an initial effective date of September 2, 2004 and revised as of November 4, 2016 (FEMA, 2016). The City of Hopkins is Community Number 270166. The project area is located within a designated Zone AE on the effective Flood Insurance Rate Maps (FIRM) for Hennepin County (FEMA, 2016). The project area is included in Map 27053C0342F, Panel 0342 (included in Appendix A).

Per Minnehaha Creek floodplain requirements, the project may cause no increase in the regional flood height.

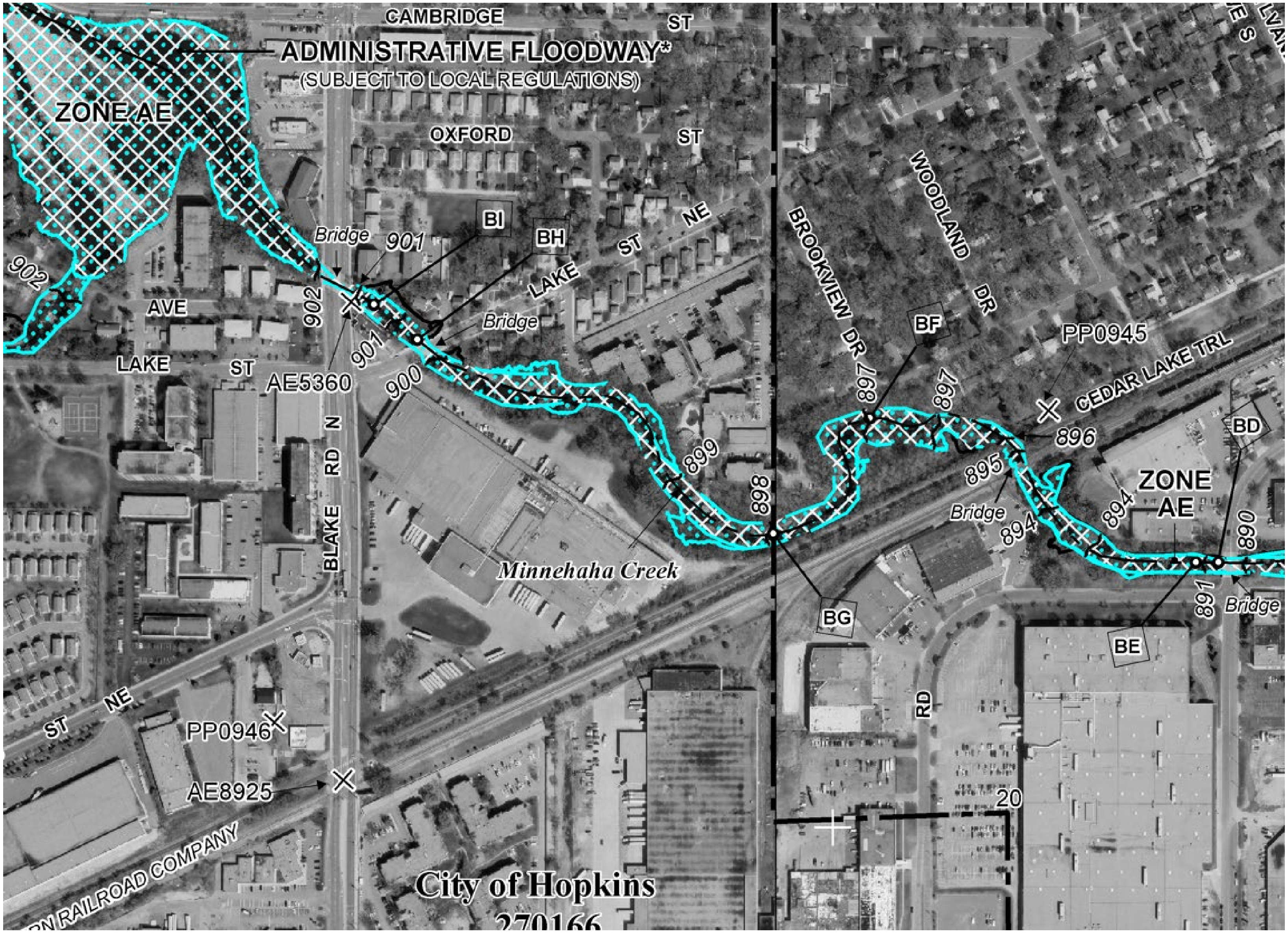


Figure 1. Overview map of the project area. Figure clipped from FEMA FIRM Map 27053C0342F, Panel 0342

HYDRAULIC ANALYSIS

Model Setup

The hydraulic characteristics of Minnehaha Creek under existing and post-project conditions were analyzed using one-dimensional, steady-state HEC-RAS models developed for the project (Version 6.3.1, USACE, 2022). Inter-Fluve understands that the regulatory effective model for Minnehaha Creek is an XP-SWMM model that is maintained by MCWD.

Existing Conditions Model

A HEC-RAS model for the reach of the Minnehaha Creek downstream of Meadowbrook Road to downstream of Excelsior Boulevard was built by Inter-Fluve in 2012. In order to extent the model upstream, through the proposed project area, Inter-Fluve collected topographic and bathymetric survey data in the creek on December 8 and 15, 2021 A combined surface of the project area was built using the Inter-Fluve creek survey data, upland topographic survey data that was collected by Stantec, and LiDAR data in the overbank areas on the north side of the Creek.

The existing conditions model was built using cross section geometry extracted from surveyed points in AutoCAD Civil3D for areas within the wetted channel and overbanks are based on the combined surface. Existing bridges were incorporated into the model based on survey data collected by Inter-Fluve.

Roughness values (Manning's n values) and ineffective flow areas for added sections were assigned to be consistent with existing model sections upstream and downstream of the project and based on observed sediment and vegetation conditions using the methods of Arcement and Schneider (1989) along with professional judgement (Table 1). The HEC-RAS model had a normal depth assigned for the downstream boundary conditions for each flow based on the creek bed slope.

Table 1. Manning's n values used for hydraulic analysis.

Location	Manning's n value	Typical Descriptions	Notes
Channel	0.035	Channel with sand/gravel substrates and little woody debris.	Used throughout the reach
Constructed Beach (see below)	0.040	Small gravel with sand.	Used to represent the beach material in post-project conditions.
Channel	0.050	Channel with gravel/cobble substrate and some woody debris.	Used for areas with log jams or significant woody debris
Overbank	0.050	Turf, scattered brush and heavy weeds	Lawn type overbank.
Overbank	0.080	Medium to dense brush, in winter (i.e., without foliage)	Shrub type overbank.
Overbank	0.100	Dense brush	Forest type overbank.

Post-Project Conditions Model

Post-project conditions were modeled by modifying the existing conditions surface in AutoCAD Civil 3D and updating cross sections to match the proposed geometry. Cross sections 9648 through 8843 were updated with the proposed design geometry (as defined by the 90% complete design documents provided by HDR) as summarized in Table 2. Post-project roughness values in areas receiving bank treatments were estimated using the same methodology as existing conditions, considering vegetation in full foliage to produce conservative estimates of water surface elevations. Other roughness values, ineffective flow areas, and computational parameters were not changed between existing and post-project conditions.

Table 2. HEC-RAS changes for post-project conditions

HEC-RAS River Station	Description of Change based on Proposed Design
9637	New pedestrian bridge added based on design drawings
9180	Manning's n value on right bank modified to account for material change for beach landing. Post-project grade will match existing grade.
8927	Geometry modified on right bank to account for channel widening at stormwater pond outlet. Since this change is highly localized, ineffective flow areas were added to this region.
9554 through 8927	Grading for the stormwater pond was included as it was within the extent of the existing cross sections, but this area was added as an obstruction. Flood elevations do not raise to an elevation high enough to enter the pond.

Hydrology

Flows in Minnehaha Creek are controlled by releases at Gray's Bay Dam at the outlet of Lake Minnetonka, impacting creek hydrology. Peak flow magnitudes in the vicinity of the project site from the FEMA FIS and the regulatory effective XP-SWMM model are shown in Table 3. Results for both flow magnitudes are presented for the analysis. Model results reported herein correspond to the 1% annual exceedance probability/100-year recurrence interval regulatory regional flood included in the provided HEC-RAS model.

Table 3. 100-Year flow profiles and discharges from the FEMA FIS (FEMA, 2016) and regulatory effective XP-SWMM model used for the analysis.

Annual Exceedance Probability (%)	Average Recurrence Interval (years)	FEMA FIS Discharge at Project Area (cfs)	Regulatory Effective XP-SWMM Model at Project Area (cfs)[1]
1	100	641	684

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[1] Received via email from Stantec dated February 8, 2022.

MODEL RESULTS

Appendix B contains model outputs for both of the 100-year recurrence interval flows from approximately 650 feet upstream of the project area to 1,050 feet downstream of the project area within Minnehaha Creek starting upstream of the Blake Road bridge (RS 10317) and extending downstream to downstream of the existing utility pipeline crossing (RS 7879).

Existing Conditions vs FEMA FIS Elevations

The simulated Existing Conditions model water surface elevations were compared to those reported in the FEMA FIS and those from the regulatory effective XP-SWMM model. A comparison between FEMA Cross Sections BG, BH, and BI is provided in Table 4. The results demonstrate that the Existing Conditions model simulated a regional flood water surface profile 0.28 to 0.97 feet lower than the regional flood profile reported in the FEMA FIS at these FEMA Cross Sections. Model results were converted from the model vertical datum of NAVD88 to the vertical datum used in the FEMA FIS, NGVD29, based on the conversion from The National Geodetic Survey's Coordinate Conversion and Transformation Tool (NOAA, 2022).

Table 4. FEMA cross section elevation comparison

HEC-RAS River Station	**Approximate FEMA Cross Section Letter**	**FEMA Regulatory Flood Elevation** *(ft, NGVD29)*	**Existing Conditions Model WSE** *(ft, NGVD29)*	**WSE Difference (FEMA Flood Elev. - Ex. Cond.)** *(ft)*
10055	BI	901.0	900.35	0.65
9979	BH	900.6	900.32	0.28
8611	BG	898.2	897.23	0.97

Floodplain Elevation Analysis

Comparison of the regional flood profiles simulated by the Existing Conditions and Post-Project models demonstrates that the proposed project will not result in an increase to the regional flood profile. Table 5 and Table 6 contain a subset of the analysis between FEMA sections BG and BH (see Appendix B for a comprehensive summary of hydraulic model results used for the analysis for the 100-year FEMA FIS flow of 641 cfs and the effective regulatory XP-SWMM model 100-year flow of 684 cfs.

Table 5. Results of hydraulic modeling comparing Existing Conditions, and Post-Project model water surface elevation (WSE) results for the 100-year FEMA FIS flood event.

HEC-RAS River Station	Approximate FEMA Cross Section Letter	Existing Conditions Model WSE	Post-Project Model WSE	WSE Change (Post Project minus Ex. Cond.)
		(ft, NGVD29)	*(ft, NGVD29)*	*(ft)*
9979	BH	900.32	900.31	0.00
9952	-	900.23	900.22	0.00
9915	-	900.09	900.09	0.00
		Lake Street NE Bridge		
9830	-	899.73	899.73	0.00
9804	-	899.65	899.65	0.00
9756	-	899.37	899.36	0.00
9688	-	899.16	899.16	0.00
9648	-	899.21	899.21	0.00
		Location of new pedestrian bridge		
9629	-	899.19	899.19	-0.01
9554	-	899.18	899.17	-0.01
9450	-	899.14	899.14	-0.01
9340	-	898.92	898.91	-0.01
9276	-	898.85	898.85	-0.01
9180	-	898.70	898.70	0.00
9126	-	898.56	898.56	0.00
9057	-	898.41	898.41	0.00
9009	-	898.19	898.19	0.00
8970	-	898.16	898.16	0.00
8927	-	898.09	898.09	0.00
8843	-	897.96	897.96	0.00
8765	-	897.85	897.85	0.00
8611	BG	897.23	897.23	0.00

Table 6. Results of hydraulic modeling comparing Existing Conditions, and Post-Project model water surface elevation (WSE) results for the 100-year flood event from the regulatory effective XP-SWMM model.

HEC-RAS River Station	Approximate FEMA Cross Section Letter	Existing Conditions Model WSE	Post-Project Model WSE	WSE Change (Post Project minus Ex. Cond.)
		(ft, NGVD29)	*(ft, NGVD29)*	*(ft)*
9979	BH	900.45	900.45	0.00
9952	-	900.36	900.36	0.00
9915	-	900.22	900.22	0.00
		Lake Street NE Bridge		
9830	-	899.84	899.84	0.00
9804	-	899.76	899.76	0.00
9756	-	899.48	899.48	0.00
9688	-	899.28	899.27	0.00
9648	-	899.33	899.32	0.00
		Location of new pedestrian bridge		
9629	-	899.31	899.30	-0.01
9554	-	899.30	899.29	-0.01
9450	-	899.26	899.26	-0.01
9340	-	899.03	899.02	-0.01
9276	-	898.96	898.96	0.00
9180	-	898.81	898.81	0.00
9126	-	898.66	898.66	0.00
9057	-	898.52	898.52	0.00
9009	-	898.30	898.30	0.00
8970	-	898.27	898.27	0.00
8927	-	898.20	898.20	0.00
8843	-	898.08	898.08	0.00
8765	-	897.96	897.96	0.00
8611	BG	897.35	897.35	0.00

SUMMARY

This report summarizes the hydraulic analysis for the proposed 325 Blake Road Regional Stormwater and Greenway Project and the potential impacts to Regulatory Regional Flood Elevations in the vicinity of the project. Project work within the regulatory floodway consists of construction of a stormwater pond outlet. The model results demonstrate that the project will not cause a rise in the water surface elevations between the existing and post-project conditions for the Regulatory Regional Flood.

REFERENCES

Arcement, G.J., and V.R. Schneider. 1989. Guide for selecting Manning's roughness coefficients for natural channels and flood plains. USGS Water-Supply Paper 2239.

Federal Emergency Management Agency (FEMA), 2016. Flood Insurance Study for Hennepin County, Minnesota (All Jurisdictions). Volume 1 of 2. Revised November 4, 2016. Federal Emergency Management Agency. Flood Insurance Study Number 27053CV001B.

National Oceanic and Atmospheric Administration (NOAA). (2022). NGS coordinate conversion and transformation tool (NCAT). Retrieved November 15, 2022, from https://www.ngs.noaa.gov/NCAT/

Appendix A: FEMA FIRM

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' National Geodetic Vertical Datum of 1929 (NGVD 29). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 15. The **horizontal datum** was NAD 27, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in mapfeatures across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the National Geodetic Vertical Datum of 1929. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by the Minnesota Department of Natural Resources. This information was photogrammetrically compiled at a scale of 1:12,000 from aerial photography dated 2010 or later.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

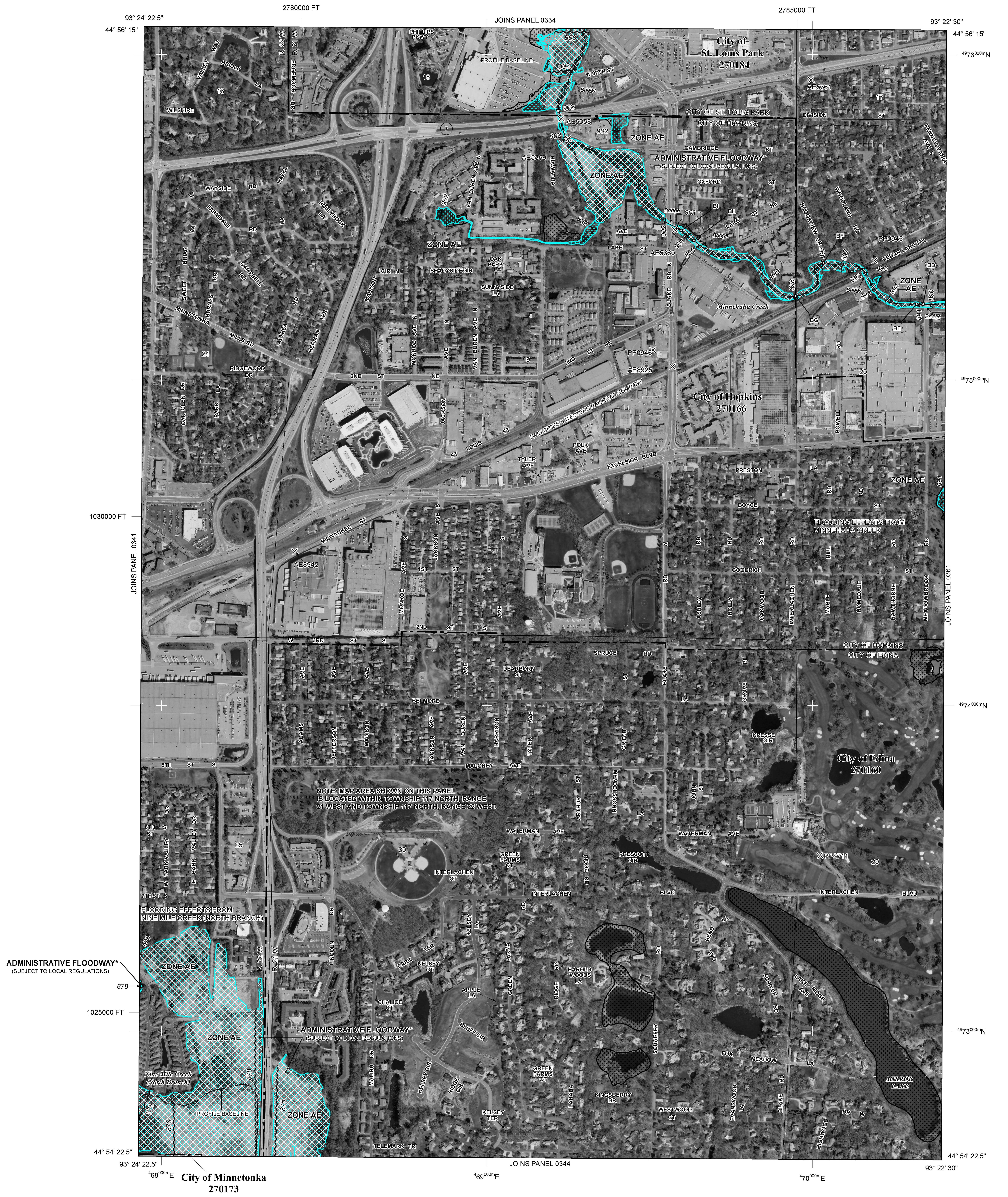
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

▨ ADMINISTRATIVE FLOODWAY

* Administrative floodway designated in accordance with local regulations for management of these areas

—◇A MODELED NODE LABEL



LEGEND

▨ SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

▨ FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

▨ OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

☐ OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

▨ COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

▨ OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

———	1% Annual Chance Floodplain Boundary
———	0.2% Annual Chance Floodplain Boundary
— —	Floodway boundary
— — —	Zone D boundary
• • • • • •	CBRS and OPA boundary
▨ ←	Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
~~ 513 ~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the National Geodetical Vertical Datum of 1929

(A)———(A)	Cross section line
(23) - - - - - - (23)	Transect line
45° 02' 08", 93° 02' 12"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
3100000 FT	5000-foot ticks: Minnesota State Plane coordinate system, South Zone (FIPSZONE 2203), Lambert Conformal Conic projection
4989000m N	1000-meter Universal Transverse Mercator grid values, zone 15
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
● M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
September 2, 2004

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

November 4, 2016 - to add Special Flood Hazard Areas, to change Base Flood Elevations, to change floodway, to change Special Flood Hazard Areas, to decrease Base Flood Elevations, to incorporate previously issued Letters of Map Revisions, to increase Base Flood Elevations, to reflect updated topographic information, to update corporate limits, to update map format

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

N

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0342F

FIRM

FLOOD INSURANCE RATE MAP

HENNEPIN COUNTY, MINNESOTA
(ALL JURISDICTIONS)

PANEL 342 OF 500
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
EDINA, CITY OF	270160	0342	F
HOPKINS, CITY OF	270166	0342	F
MINNETONKA, CITY OF	270173	0342	F
ST. LOUIS PARK, CITY OF	270184	0342	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
27053C0342F

MAP REVISED
NOVEMBER 4, 2016

Federal Emergency Management Agency

Appendix B: Detailed Hydraulic Model Result Table

HEC-RAS Results for 325 Blake Road Regional Stormwater and Greenway Project

Minnehaha Creek; 100-year FEMA FIS Flow of 641 cfs

River Station	Plan	Q Total	Water Surface Elevation	E.G. Slope	Velocity, Channel	Flow Area	Top Width
		(cfs)	*(ft, NAVD88)*	*(ft/ft)*	*(ft/s)*	*(sq ft)*	*(ft)*
10317	Existing	641	901.81	0.000334	2.06	317.26	78.22
10317	Post-Project	641	901.81	0.000334	2.06	317.26	78.22
10280	Existing	641	901.72	0.000743	2.91	233.88	72.05
10280	Post-Project	641	901.72	0.000743	2.91	233.87	72.05
10247	Existing	641	901.66	0.000936	3.19	213.57	65.53
10247	Post-Project	641	901.66	0.000936	3.19	213.57	65.53
10197 Blake Road N Bridge							
10135	Existing	641	900.48	0.003836	5.73	130.52	55.95
10135	Post-Project	641	900.48	0.00384	5.73	130.47	55.94
10114	Existing	641	900.57	0.001607	3.91	182.84	55.88
10114	Post-Project	641	900.57	0.001608	3.91	182.8	55.88
10055	Existing	641	900.53	0.001143	3.28	200.68	65.99
10055	Post-Project	641	900.53	0.001144	3.28	200.63	65.97
9979	Existing	641	900.49	0.00071	2.77	235.13	66.02
9979	Post-Project	641	900.49	0.000711	2.77	235.08	66.02
9952	Existing	641	900.40	0.001199	3.32	194.75	60.16
9952	Post-Project	641	900.40	0.0012	3.32	194.69	60.16
9915	Existing	641	900.27	0.001974	3.92	163.69	53.38
9915	Post-Project	641	900.27	0.001976	3.92	163.63	53.37
9859 Lake Street NE Bridge							
9830	Existing	641	899.91	0.00282	4.87	134.26	44.29
9830	Post-Project	641	899.91	0.002824	4.87	134.19	44.29
9804	Existing	641	899.83	0.00677	4.77	134.52	47.61
9804	Post-Project	641	899.83	0.006783	4.77	134.44	47.6
9756	Existing	641	899.54	0.00415	4.89	131.23	50.02
9756	Post-Project	641	899.54	0.004165	4.89	131.08	50.01

(*continued*)

River Station	Plan	Q Total	Water Surface Elevation	E.G. Slope	Velocity, Channel	Flow Area	Top Width
		(cfs)	*(ft, NAVD88)*	*(ft/ft)*	*(ft/s)*	*(sq ft)*	*(ft)*
9688	Existing	641	899.34	0.002924	4.49	146.85	59.66
9688	Post-Project	641	899.33	0.002939	4.49	146.59	59.63
9648	Existing	641	899.39	0.00105	3.16	214.84	74.24
9648	Post-Project	641	899.38	0.001054	3.16	214.53	74.21
9637 New Pedestrian Bridge in Post-Project Model							
9629	Existing	641	899.37	0.001059	3.2	219.8	79.18
9629	Post-Project	641	899.36	0.001065	3.2	219.4	79.16
9554	Existing	641	899.36	0.000562	2.37	322.39	123.78
9554	Post-Project	641	899.35	0.000565	2.37	321.73	123.64
9450	Existing	641	899.32	0.000659	1.66	388.26	115.62
9450	Post-Project	641	899.32	0.000662	1.67	387.84	116.43
9340	Existing	641	899.09	0.001384	3.18	201.34	70.28
9340	Post-Project	641	899.09	0.001416	3.19	200.81	70.11
9276	Existing	641	899.03	0.000988	3.06	216.71	73.43
9276	Post-Project	641	899.02	0.000977	3.04	220.83	78.4
9180	Existing	641	898.88	0.001634	3.34	195.09	79.98
9180	Post-Project	641	898.87	0.001523	3.34	194.77	79.95
9126	Existing	641	898.73	0.002087	3.72	175.6	72.89
9126	Post-Project	641	898.73	0.002088	3.72	175.59	72.89
9057	Existing	641	898.59	0.002206	3.69	173.85	68.16
9057	Post-Project	641	898.59	0.002206	3.69	173.85	68.16
9009	Existing	641	898.37	0.003664	4.31	148.69	67.91
9009	Post-Project	641	898.37	0.003665	4.31	148.68	67.91
8970	Existing	641	898.34	0.001672	3.58	182.61	67.63
8970	Post-Project	641	898.34	0.001672	3.58	182.6	67.62
8927	Existing	641	898.26	0.001851	3.57	182.85	73.35
8927	Post-Project	641	898.26	0.001842	3.56	182.47	105.63
8843	Existing	641	898.14	0.001535	3.5	216.92	121.88
8843	Post-Project	641	898.14	0.001535	3.5	216.92	121.88

(*continued*)

River Station	Plan	Q Total	Water Surface Elevation	E.G. Slope	Velocity, Channel	Flow Area	Top Width
		(cfs)	*(ft, NAVD88)*	*(ft/ft)*	*(ft/s)*	*(sq ft)*	*(ft)*
8765	Existing	641	898.02	0.001556	3.24	198.72	76.27
8765	Post-Project	641	898.02	0.001556	3.24	198.72	76.27
8611	Existing	641	897.40	0.007451	4.51	143.84	64.75
8611	Post-Project	641	897.40	0.007451	4.51	143.84	64.75
8442	Existing	641	897.10	0.001236	3.11	213.26	75.31
8442	Post-Project	641	897.10	0.001236	3.11	213.26	75.31
8325	Existing	641	896.57	0.003568	5.27	136.6	60.28
8325	Post-Project	641	896.57	0.003568	5.27	136.6	60.28
8238	Existing	641	896.74	0.000388	2.11	334.59	126.46
8238	Post-Project	641	896.74	0.000388	2.11	334.59	126.46
8139	Existing	641	896.53	0.002255	3.49	183.74	89.73
8139	Post-Project	641	896.53	0.002255	3.49	183.74	89.73
8016	Existing	641	896.36	0.001295	3.09	214.68	86.36
8016	Post-Project	641	896.36	0.001295	3.09	214.68	86.36
7972	Existing	641	896.34	0.000867	2.64	249.95	92.76
7972	Post-Project	641	896.34	0.000867	2.64	249.95	92.76
7926	Existing	641	895.74	0.004395	6.2	120.68	64.84
7926	Post-Project	641	895.74	0.004395	6.2	120.68	64.84
7892	Existing	641	895.65	0.003513	5.61	117.78	39.29
7892	Post-Project	641	895.65	0.003513	5.61	117.78	39.29
7885 Pipeline Utility Crossing							
7879	Existing	641	895.69	0.002675	4.91	131.04	38.01
7879	Post-Project	641	895.69	0.002675	4.91	131.04	38.01

(*continued*)

HEC-RAS Results for 325 Blake Road Regional Stormwater and Greenway Project

Minnehaha Creek; 100-year XP-SWMM Flow of 684 cfs

River Station	Plan	Q Total	Water Surface Elevation	E.G. Slope	Velocity, Channel	Flow Area	Top Width
		(cfs)	*(ft, NAVD88)*	*(ft/ft)*	*(ft/s)*	*(sq ft)*	*(ft)*
10317	Existing	684	901.989	0.000331	2.11	331.62	78.83
10317	Post-Project	684	901.9888	0.000331	2.11	331.6	78.83
10280	Existing	684	901.8985	0.000728	2.97	247.08	73.46
10280	Post-Project	684	901.8983	0.000728	2.97	247.07	73.46
10247	Existing	684	901.8428	0.000913	3.24	225.57	66.69
10247	Post-Project	684	901.8425	0.000913	3.24	225.55	66.69
10197 Blake Road N Bridge							
10135	Existing	684	900.6127	0.003788	5.85	137.87	56.38
10135	Post-Project	684	900.6113	0.003794	5.85	137.79	56.37
10114	Existing	684	900.6993	0.001629	4.02	190.34	56.66
10114	Post-Project	684	900.698	0.001631	4.02	190.27	56.66
10055	Existing	684	900.6658	0.001144	3.35	209.84	68.12
10055	Post-Project	684	900.6643	0.001146	3.35	209.74	68.1
9979	Existing	684	900.629	0.000719	2.86	244.15	66.61
9979	Post-Project	684	900.6275	0.00072	2.86	244.05	66.6
9952	Existing	684	900.5363	0.001203	3.41	202.83	61.23
9952	Post-Project	684	900.5348	0.001205	3.41	202.73	61.21
9915	Existing	684	900.4001	0.001986	4.01	170.72	53.99
9915	Post-Project	684	900.3983	0.001989	4.01	170.62	53.98
9859 Lake Street NE Bridge							
9830	Existing	684	900.0213	0.002878	5.02	139.12	44.71
9830	Post-Project	684	900.0188	0.002885	5.03	139.01	44.71
9804	Existing	684	899.9371	0.006797	4.9	139.79	48.12
9804	Post-Project	684	899.9351	0.006813	4.9	139.69	48.11
9756	Existing	684	899.6567	0.004145	5	136.85	50.42
9756	Post-Project	684	899.6533	0.004162	5.01	136.68	50.4

(*continued*)

River Station	Plan	Q Total	Water Surface Elevation	E.G. Slope	Velocity, Channel	Flow Area	Top Width
		(cfs)	*(ft, NAVD88)*	*(ft/ft)*	*(ft/s)*	*(sq ft)*	*(ft)*
9688	Existing	684	899.4533	0.002904	4.59	153.75	60.27
9688	Post-Project	684	899.4487	0.00292	4.6	153.47	60.24
9648	Existing	684	899.5068	0.001068	3.26	223.67	75.1
9648	Post-Project	684	899.5023	0.001072	3.26	223.33	75.07
9629	Existing	684	899.4864	0.001076	3.29	229.19	79.73
9629	Post-Project	684	899.4811	0.001082	3.3	228.77	79.71
9637 New Pedestrian Bridge in Post-Project Model							
9554	Existing	684	899.4772	0.00057	2.43	337.46	126.71
9554	Post-Project	684	899.4717	0.000573	2.44	336.77	126.66
9450	Existing	684	899.4426	0.000671	1.72	402.38	118.52
9450	Post-Project	684	899.4368	0.000675	1.72	402.04	119.49
9340	Existing	684	899.2076	0.001394	3.27	209.42	72.19
9340	Post-Project	684	899.1997	0.001425	3.28	208.85	72.07
9276	Existing	684	899.1415	0.00101	3.16	224.97	74.81
9276	Post-Project	684	899.1368	0.000995	3.14	229.7	79.92
9180	Existing	684	898.9898	0.001626	3.42	204.05	81.47
9180	Post-Project	684	898.9857	0.001527	3.42	203.71	81.4
9126	Existing	684	898.8417	0.00208	3.81	183.57	74.34
9126	Post-Project	684	898.8417	0.00208	3.81	183.57	74.34
9057	Existing	684	898.6976	0.002219	3.77	181.29	69.07
9057	Post-Project	684	898.6975	0.002219	3.77	181.29	69.07
9009	Existing	684	898.478	0.003605	4.38	156.21	68.83
9009	Post-Project	684	898.4779	0.003605	4.38	156.2	68.83
8970	Existing	684	898.4473	0.001688	3.68	189.99	68.52
8970	Post-Project	684	898.4472	0.001688	3.68	189.98	68.52
8927	Existing	684	898.3737	0.001848	3.66	190.91	74.35
8927	Post-Project	684	898.3737	0.00184	3.65	190.18	106.34
8843	Existing	684	898.2549	0.001499	3.54	231.5	127.05
8843	Post-Project	684	898.2549	0.001499	3.54	231.5	127.05

(*continued*)

River Station	Plan	Q Total	Water Surface Elevation	E.G. Slope	Velocity, Channel	Flow Area	Top Width
		(cfs)	*(ft, NAVD88)*	*(ft/ft)*	*(ft/s)*	*(sq ft)*	*(ft)*
8765	Existing	684	898.1375	0.001544	3.31	207.48	77.24
8765	Post-Project	684	898.1375	0.001544	3.31	207.48	77.24
8611	Existing	684	897.5258	0.007163	4.57	151.72	65.34
8611	Post-Project	684	897.5258	0.007163	4.57	151.72	65.34
8442	Existing	684	897.2302	0.001219	3.18	223.19	75.74
8442	Post-Project	684	897.2302	0.001219	3.18	223.19	75.74
8325	Existing	684	896.6978	0.003529	5.38	144.11	60.81
8325	Post-Project	684	896.6978	0.003529	5.38	144.11	60.81
8238	Existing	684	896.876	0.000394	2.17	351.68	132.51
8238	Post-Project	684	896.876	0.000394	2.17	351.68	132.51
8139	Existing	684	896.6661	0.002139	3.52	195.87	93.28
8139	Post-Project	684	896.6661	0.002139	3.52	195.87	93.28
8016	Existing	684	896.4976	0.001257	3.14	226.89	88.21
8016	Post-Project	684	896.4976	0.001257	3.14	226.89	88.21
7972	Existing	684	896.4805	0.000849	2.69	263.21	94.64
7972	Post-Project	684	896.4805	0.000849	2.69	263.21	94.64
7926	Existing	684	895.8525	0.004426	6.37	128.34	67.85
7926	Post-Project	684	895.8525	0.004426	6.37	128.34	67.85
7892	Existing	684	895.7644	0.003589	5.8	122.2	39.54
7892	Post-Project	684	895.7644	0.003589	5.8	122.2	39.54
7885 Pipeline Utility Crossing							
7879	Existing	684	895.8001	0.002742	5.07	135.42	38.29
7879	Post-Project	684	895.8001	0.002742	5.07	135.42	38.29

Appendix C

Site Water Quality Model Outputs

Project Information

Calculator Version:	Version 4: July 2020
Project Name:	325 Blake Rd Regional Stormwater and Greenway
User Name / Company Name:	HDR Engineering, Inc.
Date:	9/20/2022
Project Description:	Regional stormwater management, recreational facilities, and mixed-use development.
Construction Permit?:	No

Site Information

Retention Requirement (inches):	1.1
Site's Zip Code:	55343
Annual Rainfall (inches):	30.6
Phosphorus EMC (mg/l):	0.3
TSS EMC (mg/l):	54.5

Total Site Area

Land Cover	A Soils (acres)	B Soils (acres)	C Soils (acres)	D Soils (acres)	Total (acres)
Forest/Open Space - Undisturbed, protected forest/open space or reforested land			8.8		8.8
Managed Turf - disturbed, graded for yards or other turf to be mowed/managed		4.5	43.8		48.3
			Impervious Area (acres)		121.5
			Total Area (acres)		178.6

Site Areas Routed to BMPs

Land Cover	A Soils (acres)	B Soils (acres)	C Soils (acres)	D Soils (acres)	Total (acres)
Forest/Open Space - Undisturbed, protected forest/open space or reforested land			8.8		8.8
Managed Turf - disturbed, graded for yards or other turf to be mowed/managed		4.5	43.8		48.3
			Impervious Area (acres)		121.5
			Total Area (acres)		178.6

Summary Information

Performance Goal Requirement

Performance goal volume retention requirement:	485148	ft3
Volume removed by BMPs towards performance goal:	413	ft^3
Percent volume removed towards performance goal	**0**	**%**

Annual Volume and Pollutant Load Reductions

Post development annual runoff volume	289.8883	acre-ft
Annual runoff volume removed by BMPs:	0.0637	acre-ft
Percent annual runoff volume removed:	**0**	**%**

Post development annual particulate P load:	130.1019	lbs
Annual particulate P removed by BMPs:	128.71	lbs
Post development annual dissolved P load:	106.447	lbs
Annual dissolved P removed by BMPs:	46.5	lbs
Total P removed by BMPs	175.21	lbs
Percent annual total phosphorus removed:	**74**	**%**

Post development annual TSS load:	42973	lbs
Annual TSS removed by BMPs:	42928.3	lbs
Percent annual TSS removed:	**100**	**%**

BMP Summary

Performance Goal Summary

BMP Name	BMP Volume Capacity (ft3)	Volume Recieved (ft3)	Volume Retained (ft3)	Volume Outflow (ft3)	Percent Retained (%)
Tree Trench System	413	485148	413	484735	0
South Pond	0	331817	0	331817	0
North Pond	0	484748	0	484748	0
South NSBB	0	328623	0	328623	0
North NSBB	0	116595	0	116595	0
Jellyfish Filter	0	484748	0	484748	0
Phosphosorb Media	0	484748	0	484748	0

Annual Volume Summary

BMP Name	Volume From Direct Watershed (acre-ft)	Volume From Upstream BMPs (acre-ft)	Volume Retained (acre-ft)	Volume outflow (acre-ft)	Percent Retained (%)
Tree Trench System	0.2915	23.5765	0.0637	23.8043	0
South Pond	2.4052	0	0	2.4052	0
North Pond	21.1714	2.4052	0	23.5766	0
South NSBB	201.8016	0	0	201.8016	0
North NSBB	64.2187	0	0	64.2187	0
Jellyfish Filter	0	23.5765	0	23.5765	0
Phosphosorb Media	0	23.5765	0	23.5765	0

Particulate Phosphorus Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
Tree Trench System	0.1308	6.8477	5.5865	1.392	80
South Pond	1.0794	81.5117	49.5547	33.0364	60
North Pond	9.5017	58.9756	41.0864	27.3909	60
South NSBB	90.5686	0	9.0569	81.5117	10
North NSBB	28.8213	0	2.8821	25.9392	10
Jellyfish Filter	0	27.3909	13.6955	13.6954	50
Phosphosorb Media	0	13.6954	6.8477	6.8477	50

Dissolved Phosphorus Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
Tree Trench System	0.107	72.3112	12.4716	59.9466	17
South Pond	0.8832	74.1016	0	74.9848	0
North Pond	7.7741	98.5659	0	106.34	0
South NSBB	74.1016	0	0	74.1016	0
North NSBB	23.5811	0	0	23.5811	0
Jellyfish Filter	0	106.34	0	106.34	0
Phosphosorb Media	0	106.34	34.0288	72.3112	32

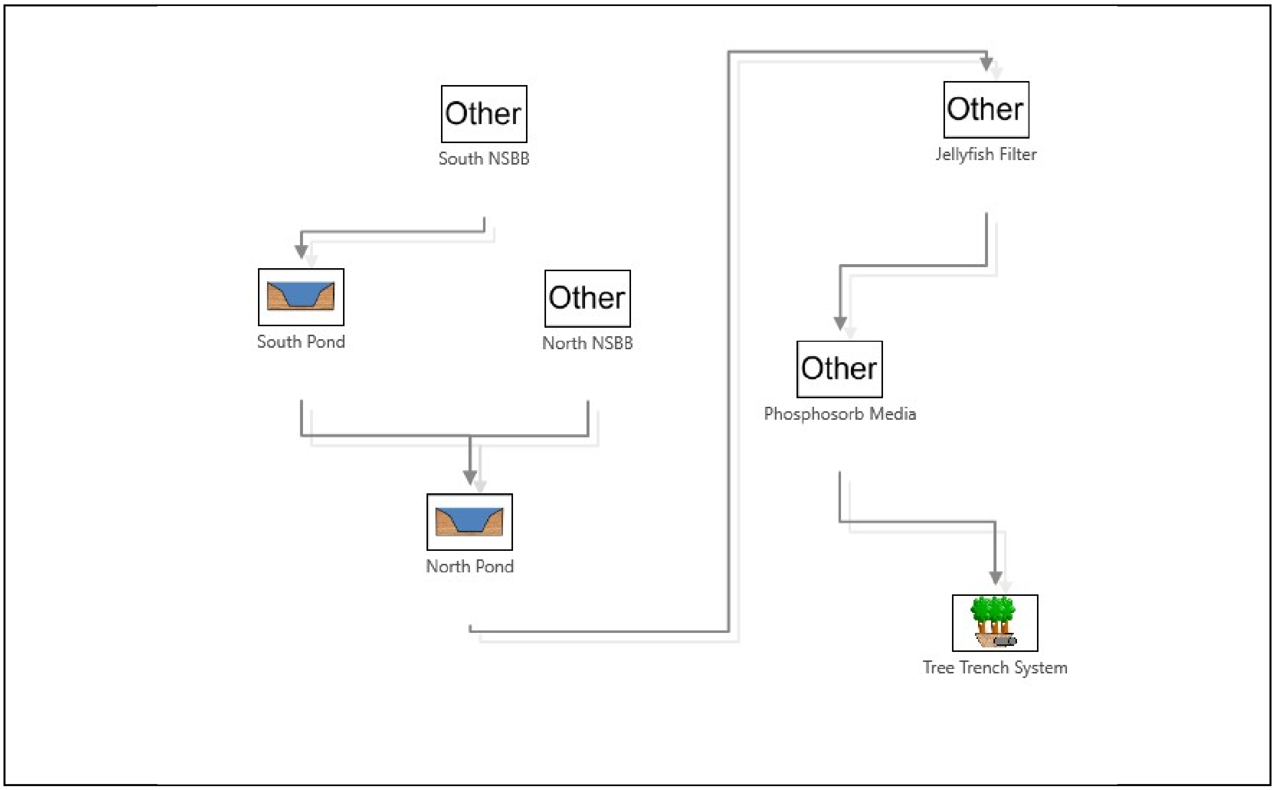
Total Phosphorus Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
Tree Trench System	0.2378	79.1589	18.0581	61.3386	48
South Pond	1.9626	155.6133	49.5547	108.0212	30
North Pond	17.2758	157.5415	41.0864	133.7309	30
South NSBB	164.6702	0	9.0569	155.6133	5
North NSBB	52.4024	0	2.8821	49.5203	5
Jellyfish Filter	0	133.7309	13.6955	120.0354	25
Phosphosorb Media	0	120.0354	40.8765	79.1589	41

TSS Summary

BMP Name	Load From Direct Watershed (lbs)	Load From Upstream BMPs (lbs)	Load Retained (lbs)	Outflow Load (lbs)	Percent Retained (%)
Tree Trench System	43.21	181.18000000	179.63	44.760000000	80
South Pond	356.54	16453.29	10085.9	6723.93	60
North Pond	3138.44	11959.81	9058.95	6039.3	60
South NSBB	29915.08	0	13461.79	16453.29	45
North NSBB	9519.78	0	4283.9	5235.88	45
Jellyfish Filter	0	6039.3	4831.44	1207.86	80
Phosphosorb Media	0	1207.86	1026.68	181.18000000	85

BMP Schematic



Appendix D

Geotechnical Findings Technical Memorandum

Technical Memorandum

Date:	Thursday, September 29, 2022
Project:	325 Blake Road Regional Stormwater and Greenway/Cottageville Park Phase II Riparian Restoration Project, Hopkins, MN Project No. 10268112
To:	File
From:	Kerrie Berg, PE, HDR Engineering Inc. Greta Backman, PE, HDR Engineering Inc. Erica Bley, EIT, HDR Engineering Inc.
Subject:	Geotechnical Findings

Introduction

This technical memorandum presents the results of the geotechnical analyses and engineering evaluation of the proposed regional stormwater treatment pond to be located at 325 Blake Road in Hopkins, Minnesota. This parcel was purchased by Minnehaha Creek Watershed District (MCWD) in 2011 with the intent to create a transformative, water-centric development on this site adjacent to Minnehaha Creek premised on its vision of Balanced Urban Ecology (HDR 2021) [1].

This memorandum presents findings, conclusions, and recommendations regarding:

- Evaluation of pond embankment exit gradients
- Evaluation of the slope stability of the pond embankment and foundation soils
- Evaluation of the foundation conditions at the pedestrian bridge, weir wall, and outlet structure.

Project Description

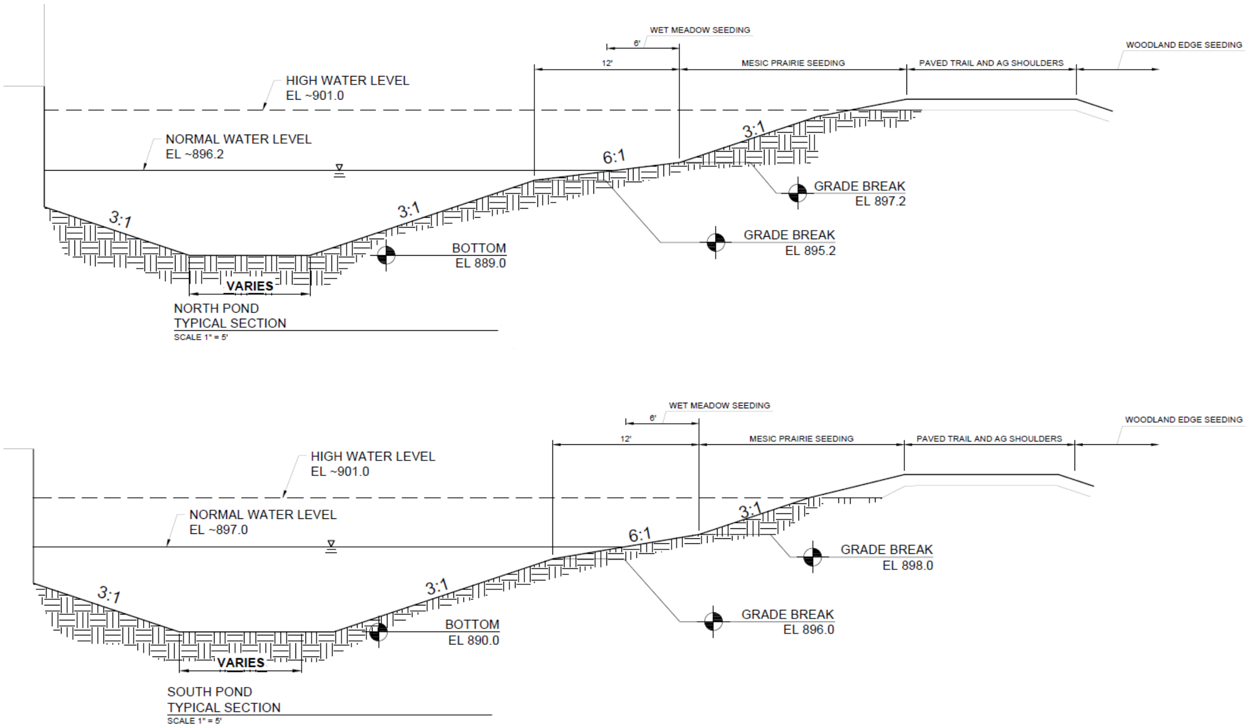
Figure 1 shows the location of the proposed two-pond concept stormwater design, which is located to the west of Minnehaha Creek. The proposed normal water surface of the north pond is elevation 896 feet, and the south pond is elevation 897 feet. The proposed emergency overflow elevation is 901.25 feet. The pond will be excavated into existing ground.

The proposed footprint is approximately 1.7 acres. There is approximately 8 acre-feet of temporary storage between the ponds normal water surface elevations and peak storage elevation. The top of the pond embankment would be at an elevation of 901.25 feet, or higher depending on surrounding ground surface elevations. The bottom elevation of the south pond will be excavated to an elevation of 890 feet and the north pond to 889 feet. This results in a maximum pond slope height of approximately 20 feet based on the maximum ground elevation at the pond footprint of approximately 910 feet.

Sections SL-2 (STA 103+50, typical cross section of the north pond) and SL-3 (STA 105+00, typical cross section of the south pond) from Figure 1 are shown in Figure 2. These embankment cross sections have interior side slopes ranging from 3H:1V to 10H:1V.

Figure 1. Plan View, Proposed Stormwater Basin

Figure 2. Typical North and South Pond Cross Sections (Sections SL-2 and SL-3 respectively, shown in Figure 1)



Geotechnical Site Investigation

A geotechnical site investigation was completed at the project site on January 17, 18, 20 and 26, 2022 by American Engineering Testing (AET) located in Saint Paul, MN (see Attachment A for report).

The objectives of this investigation were to:

- Determine soil and rock stratigraphy across the project site as well as the characteristics of the typical soils encountered.
- Determine a better knowledge of groundwater conditions.
- Determine soil material parameters based on field and laboratory testing for use in final design.
- Assess the degree of variability of the encountered soils based on field and laboratory testing.

The investigation consisted of 5 borings to depths ranging from 35 to 80 feet. Details of the geotechnical investigation included:

- B-1 and B-2: SPT borings drilled to bedrock (approximately 80 feet) near the proposed bridge abutments.
- B-3 and B-4: SPT borings at the proposed edge of the ponds drilled to 50 feet BGS.
- B-5: Standard penetration test (SPT) boring drilled to a depth of 35 feet below ground surface (BGS)
    - Installation of a two-inch diameter PVC cased well with 5-foot screen, located at the depth interval from 30 to 35 feet BGS
    - Development of the well
    - Slug test completed within the well

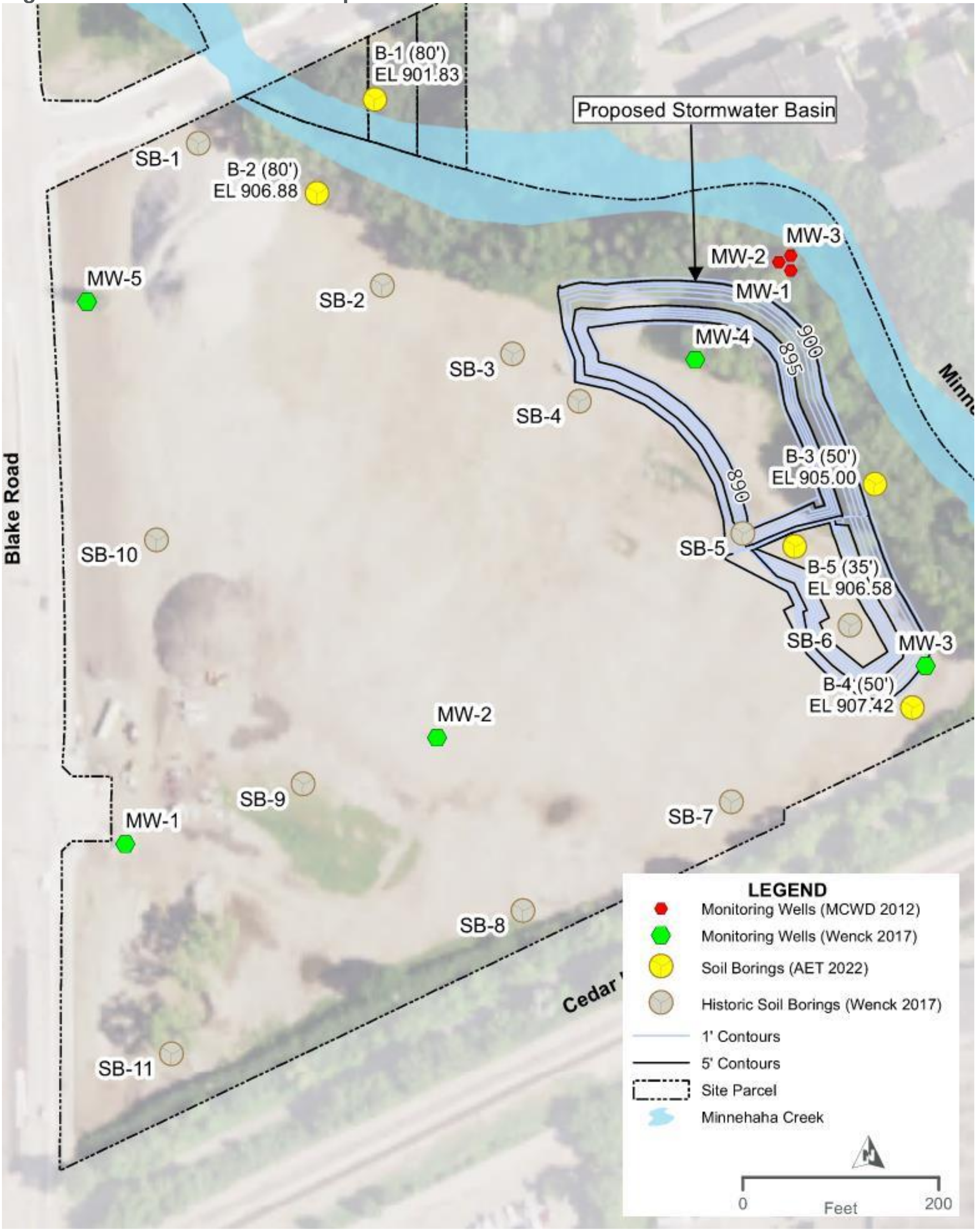
The SPT sampling provides an insight of the in-situ ground conditions, specifically the relative strength of the soil. The piezometer installed is used to complete in-situ hydraulic (slug) testing; measurements from this test were used in subsequent seepage analysis. Finally, representative soil samples were collected, and lab test results were used to characterize soil and determine the soil parameters for final design. Figure 3 shows the location of historic borings and wells and the 2022 borings mentioned above.

AET performed laboratory testing on the soil samples including:

- Water content (ASTM D2216)
- Grain size distribution (ASTM D422)
- Hydrometer (ASTM D7928 - 17)

Detailed geotechnical information on the borehole logs and laboratory test results can be found in Appendix A.

Figure 3. Borehole Location Map



Subsurface Stratigraphy and Soil Parameters

Subsurface stratigraphy at the site was determined based on the field and laboratory testing data, the available regional geological data, and soil descriptions from historic geologic reports for the site:

- Surficial Geology of Minnesota [2]
- Wenck 2017 Borehole Logs [3]
- Wenck 2017 Monitoring Well Logs [3]
- Piezometer information from *Baseflow Restoration in Minnehaha Creek Watershed with Stormwater Infiltration* report (University of Minnesota 2013) [4]

Based on the available data, the following soils are found at the site, listed from the ground surface downward:

- Fill (SM/SC) – Previous boring and well logs describe a fill material typically 2 to 5 ft thick overlying native sand deposits. The fill is classified as a gravelly, silty to clayey sand (SM/SC).
- Glacial Outwash (SP)-The native sand deposit located below the fill are described a as gravelly to silty sand based on previous boring and well logs. The fill is classified as a gravelly sand (SP). Regional geological maps show that the predominant native surficial material at the site is a glacial outwash deposit. This material is described as gravelly sand Outwash.

Results from the 2022 investigation confirm the general stratigraphy trends described above.

Groundwater Conditions

Error! Reference source not found. provides a summary of groundwater conditions during drilling with elevations ranging from 893.8 to 897.0 feet or 8.4 to 11.5 feet below ground surface. Mud rotary drilling (a method used in this investigation) can affect water elevations, however mud was added after it was encountered while drilling. The elevation of the start of mud rotary is noted.

Table 1. Drilling Groundwater Data

Boring Number	B-1	B-2	B-3	B-4	B-5
Ground Surface elevation (ft)	902.2	906.9	905.5	907.8	907.3
Water depth below ground surface during drilling (ft) – 1/26/22	8.4	9.9	10.6	11.5	10.6
Water elevation during drilling (ft)	893.8	897.0	894.9	896.3	896.7
Water elevation prior to slug testing (ft) - 2/9/2022	NA[1]				896.6
Elevation mud rotary was started (ft)	891.2	892.4	886.0	893.3	893.3

[1] Boring backfilled after drilling

[2] Elevations are reported in NAVD88 vertical datum

The groundwater readings represent conditions at the time the borings were drilled and except for boring B-5, all borings were backfilled immediately after drilling. It should be noted that groundwater levels will fluctuate seasonally and in response to climatic conditions. Very little fluctuation was observed between readings in the piezometer at B-5.

Groundwater had also been studied as part of University of Minnesota's Baseflow report (University of Minnesota, 2013). Three shallow wells within the project area were installed as part of this study. Well and stream elevations were recorded for the study period (35 daily measurements), although the elevations reported for this study used a project specific datum. Although the elevation data could not be translated back to NAVD88, the relationship between the groundwater and stream elevation was analyzed.

A linear regression model was created to relate the stream elevation to well elevation for all three wells. The results found a significant relationship ($p<0.001$) between all three well elevations and the stream elevation ($R^2=0.96$ to 0.98, depending on the well) with a 1-foot increase in well elevation for every 1-foot increase in stream elevation. From this, we conclude that groundwater and stream elevation are very closely related and that it is expected that fluctuations in the stream elevation will influence groundwater elevation in the project site. Additionally, given the coarse nature and relatively high permeability of the native soils (discussed in the next sections in greater detail), the time it takes for groundwater conditions to equilibrate to changes in stream conditions is assumed to be small.

Soil Strength Design Parameters

Analyses were performed to assess the factor of safety for slope stability at critical cross-sections through the ponds. Pond slope stability modeling requires strength parameter inputs. The strength parameters selected for the materials encountered within the pond slopes are presented in Table 2. These parameters include the material unit weight and the drained shear strength for the soil. Soil strength parameters were selected based on values presented in literature [5, 6, 7] as well as SPT N-value correlations [8].

Table 2. Soil Parameters

Soil Type	Moist Unit Weight γ (lbs/ft^3)	Shear Strength Parameters		Horizontal Saturated Permeability, [k_h] (ft/sec)	Anisotropy k_v/k_h (1)	Coefficient of Volume Compressibility (M_v) /psf(2)	Saturated Volumetric Water Content, Θs (ft^3/ft^3)(3)	Residual Volumetric Water Content, Θr (4)	GeoStudio SWCC Function
		Effective Stress Envelope (Drained Strength)							
		c' (psf)	ϕ'						
Fill (gravelly, silty to clayey sand)	125	0	30	1.64E-05(1)	0.5	5.00E-06	0.32	0.032	Grainsize Data
Glacial Outwash (gravelly sand with varying amounts of silt)	123	0	30	1.64E-04(5)	0.5	2.00E-06	0.33	0.033	Grainsize Data
Sheetpile	N/A	N/A	N/A	3.28E-08(6)	1	N/A	N/A	N/A	N/A
Coarse Filter Aggregate	N/A	0	37	2.13E-02(7)	0.5	5.56E-07	0.33	0.033	Gravel

Notes:

(1) USBR (United States Bureau of Reclamation) DS13-8 Seepage 2014 [8]
(2) Calculated from Young's modulus values from AASHTO 2014 [10].
(3) Calculated from void ratio estimate from Fredlund and Rahardjo 1993 [11].
(4) Leij et al, 1996 [12].
(5) Slug test result
(6) Baxter 2000 [13]
(7) NAVFAC 7.02- Table 1 [6], Das 2005 [7]

Seepage Parameters

The primary input parameter in seepage analyses is hydraulic conductivity (or “permeability”) of the materials at the site. The permeability, as well as the other hydraulic input parameters, were selected based on values published from literature [9, 10, 11, 12] and by correlation from hydrometer lab data. For the Glacial Outwash layer, permeability results from the slug test were considered and were similar to the published and correlated values (Table 3). The hydraulic conductivity result from the slug test was selected for model input for the Glacial Outwash layer.

Table 3. Glacial Outwash Permeability Assessment

Glacial Outwash Layer	Hydraulic Conductivity (ft/sec)
Hazen's (geometric mean)	1.15E-04
Slug test result	3.53E-04
Selected from USBR DS13-8 [8]	1.64E-04

Seepage Analysis and Slope Stability

Seepage analysis and slope stability were evaluated using SEEP/W and SLOPE/W in GeoStudio 2021 R2 software [14]. SEEP/W uses the finite-element analysis technique to model water movement and porewater pressure distribution within porous materials, such as soil and rock. This program can analyze both simple and highly complex seepage problems, including saturated and unsaturated flow, steady-state and transient conditions, and various boundary conditions.

SLOPE/W module uses limit equilibrium theory to compute the factor of safety of earth and rock slopes. Like SEEP/W, SLOPE/W has an established track record for analyzing critical infrastructure within the geotechnical profession. In the limit equilibrium approach, the geologic material is assumed to be at the state of limiting equilibrium and a factor of safety is computed. SLOPE/W can use a variety of methods to compute the factor of safety of a slope while analyzing complex geometry, stratigraphy, and loading conditions.

The loading cases modeled in the seepage analyses were also analyzed for slope stability. GeoStudio allows for integration of SEEP/W and SLOPE/W, such that the porewater pressures and phreatic surface computed in SEEP/W can be automatically imported and used in the SLOPE/W analysis. This allows for a more realistic stability analysis than can be obtained by drawing in a phreatic surface. For any node on the ground surface line where the pore water pressure is positive (i.e., surface ponding condition), SLOPE/W automatically computes the equivalent weight of the water above the ground surface. A minimum slip surface depth of 3 feet was set. Slip surfaces less than 3 feet were assumed to be considered a maintenance issue.

Cross Section Geometry and Subsurface Stratigraphy

Two critical embankment cross sections were selected to evaluate seepage and stability for the proposed stormwater pond embankment based on preliminary embankment geometry and the encountered subsurface conditions at the site. Existing survey data, the Minnesota Department of Natural Resources MNTOPO website [15], existing piezometer data, and the Schematic Design Memorandum [1] were used to determine the ground surface topography beyond the proposed pond dimensions and to estimate the bathymetry of the Minnehaha Creek. Locations of the two cross sections (labeled North-South and East-West) are shown in Figure 4 and were deemed critical based on ground surface elevations and proximity to Minnehaha Creek. Figure 5 shows the East-West cross section and slope stability results for the High Pond, Low Creek case modeled in SLOPE/W. Figure 6 shows the North-South cross section and seepage output for the Empty Pond, High Creek case modeled.

Figure 4. Location of modeled cross sections

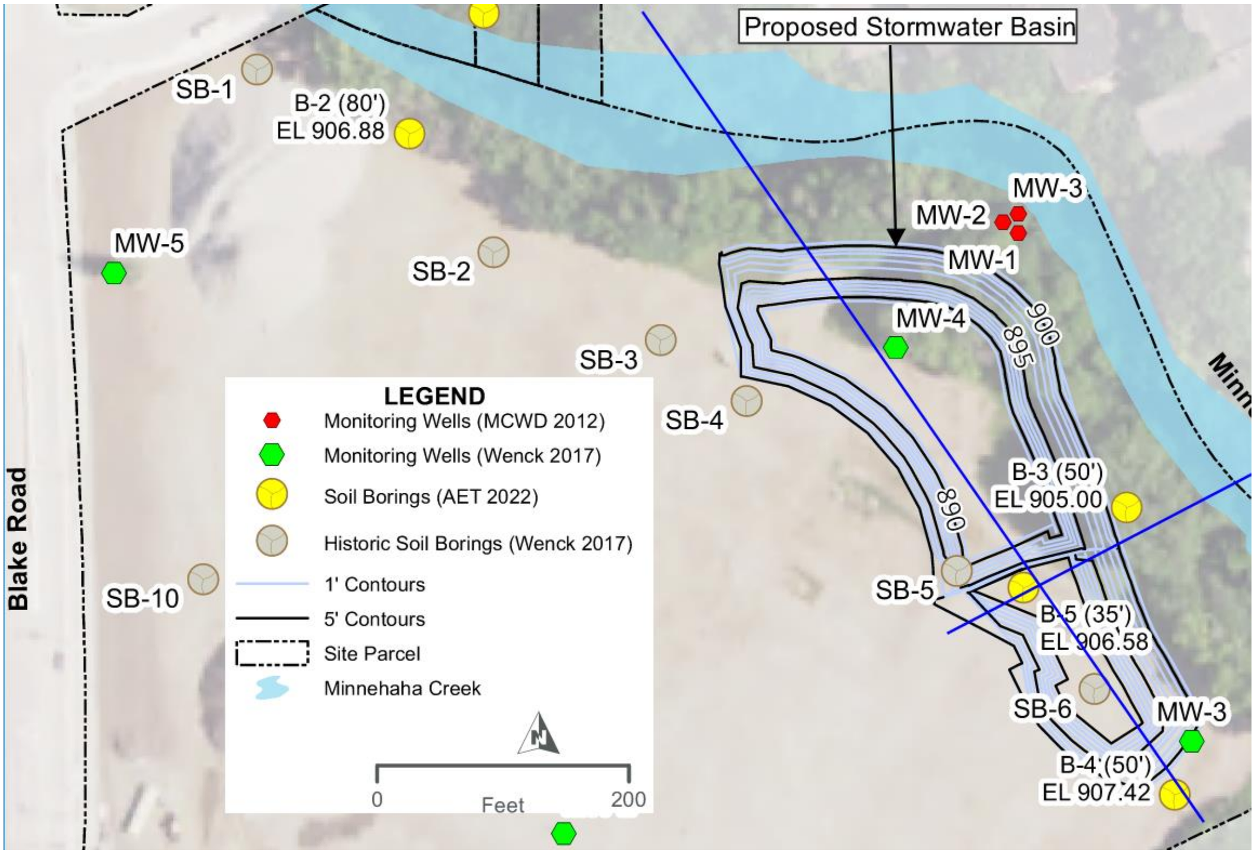
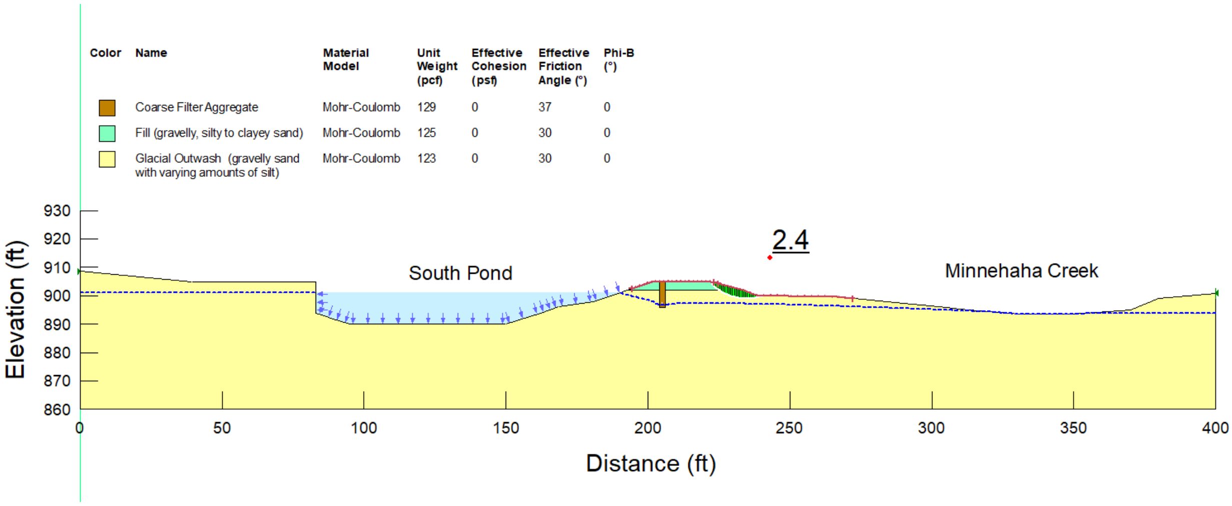
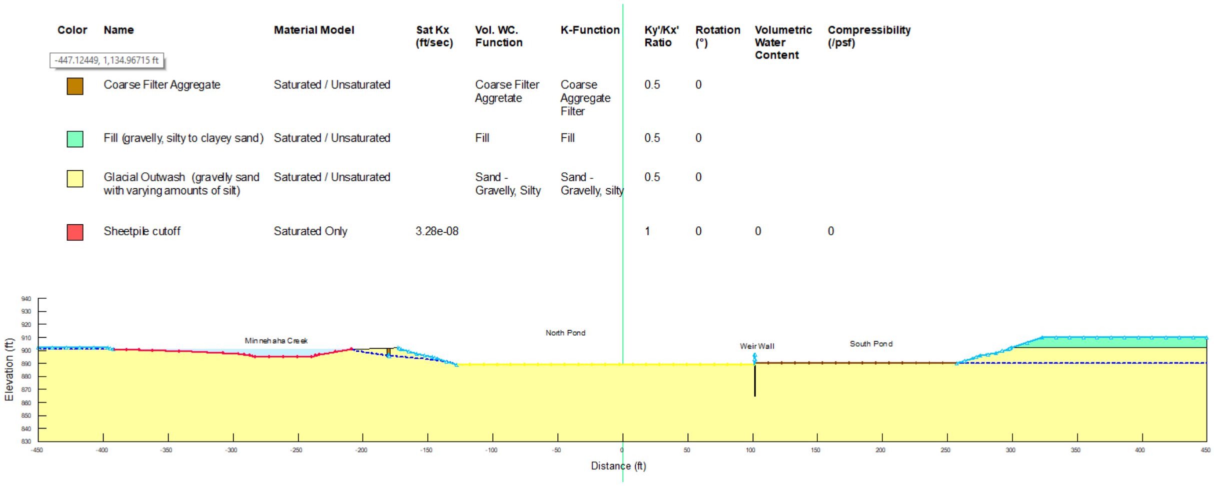


Figure 5. East-West cross section showing slope stability results for Case 2: High Pond, Low Creek



Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
🟫	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37	0
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30	0
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30	0

Figure 6. North-South cross section showing seepage output for Case 1: Empty Pond, High Creek



Color	Name	Material Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
🟧	Coarse Filter Aggregate	Saturated / Unsaturated		Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0		
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated		Fill	Fill	0.5	0		
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated		Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0		
🟥	Sheetpile cutoff	Saturated Only	3.28e-08			1	0	0	0

Loading Conditions

The hydraulic boundary conditions for the seepage models are provided in Table 4.

Table 4. Hydraulic Boundary Conditions for Loading Cases

Cross Section	Loading Case	Analysis Type	Slope analyzed	Pond Water Elevation [feet]	Far field Creek Conditions
East-West	Case 1: Empty Pond, High Creek	Steady-State	Interior Slope	890	Minnehaha Creek Elev. 901 feet
	Case 1a: 894-foot Elev. Pond, High Creek	Steady-State	Interior Slope	894	Minnehaha Creek Elev. 901 feet
	Case 2: High Pond, Low Creek	Steady-State	Exterior Slope	901.25	Minnehaha Creek Elev. 893.5 feet
North-South	Case 1: Empty Pond, High Creek	Steady-State	Interior Slope – North Pond	889	Minnehaha Creek Elev. 901 feet
	Case 1a: 894-foot Elev. Pond, High Creek	Steady-State	Interior Slope - North Pond	894	Minnehaha Creek Elev. 901 feet
	Case 2: High Pond, Low Creek	Steady-State	Exterior Slope – North Pond	901.25	Minnehaha Creek Elev. 895 feet
	Case 1: Empty Pond, High Creek	Steady-State	Interior Slope – South Pond	890	Minnehaha Creek Elev. 901 feet

Currently, there is limited surface water elevation data of the Minnehaha Creek at the Blake Road site. In addition, well data at the site is limited. Groundwater monitoring from the Wenck 2017 report [3] (included in Attachment B) provides a limited history for the groundwater conditions. The lowest reading from Monitoring Wells 3 and 4 (the Wenck 2017 wells that are closest to the proposed stormwater basin, see Figure 1) is 896.73 feet. This correlates well with the groundwater elevations encountered during the 2022 AET drilling. Unfortunately, readings from the three monitoring wells described in the University of Minnesota 2013 report [4] are based on a local benchmark that was assigned an elevation of 100 feet and the readings are not useable at this time. Considering the limited data available, conservative water elevations were selected and are described below:

- The maximum creek elevation is based on the Wenck 2017 Monitoring Well 3 water level reading at time of install (rounded to the nearest foot to obtain an elevation of 901 feet, which coincides with the high-water level of the pond; see Attachment B).
- The low creek elevation was selected as 893.5 feet for the East-West cross section, and 895 feet for the North-South cross section. These elevations are from survey data of the bottom of creek. During 2021 drought conditions the stream was nearly dry, therefor a dry creek was conservatively selected for model input.
- The high-water level elevation in both the North and South pond is 901.25 feet as this is the emergency overflow elevation.

No additional external loading was applied to the models, such as surcharge loads associated with vehicle traffic or stockpiles. Using the seepage conditions modeled based on the hydraulic loading conditions in Table 4, the slope stability modeling cases were analyzed for the interior and exterior pond slopes. For this analysis, only steady-state seepage conditions were analyzed, and only drained strengths were applied for the soil strength parameters.

Seepage and Stability Results

Seepage Analysis Results

The pond cross sections for the proposed stormwater pond were evaluated with respect to excessive vertical (or upward) exit gradients. Guidance for *High Exit Gradients in a Cohesionless Soil* from USBR Design Standards No.13 Chapter 8: Seepage (2014) was used to evaluate seepage concerns [9].

Excessive vertical exit gradients in cohesionless soil can lead to a “quick” ground condition at the location of seepage, which could lead to the presence of sand boils [9] and could possibly develop into progressive backward erosion and pond breach. To evaluate for the potential of excessive gradient (aka heave) in the seepage model, the vertical exit gradient (I_e) in the Glacial Outwash where the piezometric line exited the slope (the area of maximum vertical gradient) was evaluated with respect to the critical gradient, I_c, of the Glacial Outwash. The I_c is defined as the ratio of the soils’ buoyant unit weight to the unit weight of water. The FOS with respect to the vertical exit gradient is the ratio of the critical gradient to the exit gradient. For new dams, USBR recommends a FOS (factor of safety) of 4.0 to evaluate heave. The seepage results for all cross sections demonstrate a FOS greater than 4.0 (Table 4).

In addition, seepage analysis was evaluated per USACE EM 1110-2-1913, “Design and Construction of Levees” manual guidelines [17], which states that the vertical exit hydraulic gradient does not exceed 0.5 at the toe of the pond embankment. Seepage results for all cross sections demonstrate the vertical exit gradient is less than the maximum allowable value of 0.5 at the toe of the pond embankment for both interior and exterior slopes, indicating seepage design requirements are satisfied (Table 4).

Review of the borings from the 2022 investigation did not indicate thin lenses of either granular or cohesive materials interbedded within the soil layers. Soil lenses that vary from the material layer may provide a path for seepage allowing water to exit the slope face. However, the horizontal gradient (X-gradient) was assessed for internal erosion. Guidance from Document D-6, Internal Erosion Risks for Embankments and Foundations (USBR/USACE) [18] was used to assess the horizontal gradient. D-6 states that "highly erodible soils such as silts, silty sands, or dispersive clays may be likely to erode at a crack width of 0.25 to 0.5-inch under a hydraulic gradient as low as 0.1". Table 4 reports the horizontal gradients from the face of the slope where water is exiting (the location of maximum horizontal gradient). In many cases, the horizontal gradient is greater than 0.1 (Table 4). Because of this, slope treatment of the pond interior slopes to prevent internal erosion is recommended.

Table 5 shows the seepage analysis results. See Attachment C for figures of the SEEP/W seepage analysis results.

Table 5. Seepage Analysis Results

Cross Section	Piezometric Conditions	Slope analyzed	Exit Gradient (Y Gradient) – USACE[1] Recommended < 0.5	Factor of Safety- Heave Recommended USBR[2] Minimum- 4.0	Exit Gradient (X Gradient) – USBR[2] Recommended < 0.1
East-West	Case 1: Empty Pond, High Creek	Interior Slope, South Pond	0.20	6.3	0.20
	Case 1a: 894-foot Elev. Pond, High Creek	Interior Slope, South Pond	0.00	>>4.0	0.10
	Case 2: High Pond, Low Creek	Exterior Slope, South Pond	0.00	>>4.0	0.05
North-South	Case 1: Empty Pond, High Creek,	Interior Slope, North Pond	0.20	6.3	0.20
	Case 1a: 894-foot Elev. Pond, High Creek	Interior Slope, North Pond	0.10	12.6	0.10
	Case 2: High Pond, Low Creek	Exterior Slope, North Pond	0.00	>>4.0	0.10
	Case 1: Empty Pond, High Creek	Interior Slope, South Pond	0.00	>>4.0	0.00

[1] USACE = United States Army Corps of Engineers
[2] USBR = United States Bureau of Reclamation

Slope Stability Analysis Results

Slope stability criteria and guidance as defined in EM 1110-2-1913 and EM 1110-2-1902 [17,19], was used to evaluate the stormwater pond embankment stability. This was deemed the most appropriate guidance for this project.

LONG TERM - STEADY STATE SEEPAGE

For the steady state condition, the water surfaces as described in Table 4 were first used to estimate the pore water pressures in the embankment based on a seepage analysis. The pore water pressures from the seepage analysis were used in the stability analysis. Drained soil strengths are used for this analysis.

Results

The cross sections were evaluated using established FOS typically used by USACE as defined in EM 1110-2-1913 and EM 1110-2-1902 [17,19]. For the long-term stability condition, a factor of safety of 1.4 was selected. The minimum factors of safety calculated for each section under the various loading conditions are shown in Table 6. All factors of safety determined for the embankment were above minimum requirements except for the East-West (south pond) and North-South (north pond) cross sections under the empty pond, high creek condition. By increasing the pond water level to an elevation of 894 feet, a factor of safety of 1.4 is achieved. Attachment D includes figures of the SLOPE/W slope stability analysis results.

Table 6. Slope Stability Results

Case		Slope Analyzed	USACE Recommended Minimum Factor of Safety (EM 1110-2-1913)	East-West Cross Section (South Pond)	North-South Cross Section (North Pond)	North-South Cross Section (South Pond)
Steady State Seepage-Drained (Long-term) Loading	**Case 1: Empty Pond, High Creek**	Interior Slope	1.4	1.3	1.2	1.9
	Case 1a: 894’ Elev. Pond, High Creek	Interior Slope		1.4	1.5	N/A
	Case 2: High Pond, Low Creek	Exterior Slope		2.4	2.0	N/A

Slope Stability and Seepage Findings

Preliminary engineering evaluations demonstrate that design requirements are satisfied for the proposed Blake Road Stormwater Pond except for Case 1 of the East-West (south pond) and North-South (north pond) cross sections (under the empty pond, high creek condition). While these two cases are below the recommended FOS values, they do still have a FOS greater than 1.0. All analysis were completed under steady state seepage conditions, which is conservative. If the pond is raised to elevation 894’ FOS requirements are met.

In addition, the case of an empty pond and a high river is not likely. However, the pond may be emptied for maintenance purposes if it’s drawn down for weir wall or outlet structure maintenance. These slope stability results can be used to inform maintenance recommendations (e.g., avoid draining the pond when the creek is high).

Due to high horizontal gradients, interior pond slopes should be treated. A trench drain design is recommended to prevent nuisance slope erosion during normal pond operation levels. The trench drain will include a trench excavated at the top of the slope on the east side of the pond (between the creek and the pond). The trench will be excavated to approximately 1 foot above the pond normal water level with a six-inch perforated collector pipe located at the bottom of the trench. Surrounding the pipe and filling the trench will be second stage filter material (same specification as the second stage filter material described in the *Filter Analysis* section below). At least two outlets should be placed down the pond slope with cleanouts located at the top of the slope at the connection of the downslope outlet and the trench drain.

Filter Analysis

The purpose of the filter analysis was to:

- Determine if on-site granular material would meet Stage 1 filter gradational requirements at the outlet structure.
- Determine the required Stage 2 filter gradation required between the Stage 1 filter and the riprap at the outlet.

The first step in filter design was to determine the necessary gradation for these filters. The process to determine the necessary filter requirements followed the procedure outlined in Chapter 5 of FEMA’s Filters for Embankment Dams manual (October 2011) [19]. This procedure is based on historic research and guidance provided by the Natural Resource Conversation Service (NRCS), USACE, and Bureau of Reclamation (Reclamation). This procedure includes the filter requirements presented in EM-1110-2-1901 [20]. The first stage filter requirements are based on the gradation of the base material (specifically the finest sample of the foundation material evaluated), controls the design of the necessary sand filter. The second stage filter requirements are based on the gradation of the first stage filter.

First Stage Filter for Outlet Material

A sieve-hydrometer test for a sample from B-3 at 7-8.5 feet below ground surface was selected to represent the Glacial Outwash material at the outlet (Figure 7). This boring is located nearest the outlet location and the highest fines content. The first stage filter requirements are based on the gradation of the base material (specifically the finest sample of the foundation material evaluated) and controls the design of the necessary sand filter. The material of the sample was classified as a clayey sand (SC). The minimum and maximum first stage filter requirements are presented in Figure 8 along with seven representative samples of onsite Granular Outwash material located in the project site. All samples except for two (B-3 at 12 to 13.5 feet below ground surface B-5 at 9.5 to 11 feet below ground surface) fit with the minimum and maximum first stage filter requirements.

First Stage Filter Material Selection (Outlet Structure)

The gradational requirements for the foundation sand filter material are shown in Figure 8Figure 9. Excavated onsite Glacial Outwash material may be used for the first stage filter, however, it is recommended gradation analysis be completed on the material prior to placement. In addition, ASTM C33 concrete sand is plotted on Figure 8 at meets first stage filter requirements.

Second Stage Filter Material Selection (Riprap bedding)

The second stage filter was developed based on the gradation of the first stage filter (using ASTM C33 concrete sand). MNDOT Coarse Aggregate bedding (MNDOT Table 3149.2-7) was checked for suitability as a second stage filter for the first stage filter and, when slightly adjusted, meets the requirements for a second stage filter (Figure 9). The gradation requirements for the second stage filter are provided in Table 7.

Table 7: Second Stage Filter Requirements

Size (inches)	Size (mm)	Percent Passing	
		Upper Bound	Lower Bound
1 1/2	38.1	100	100
No. 10	2	10	0

Figure 7. Clayey sand gradation from sample B-3 at 7-8.5 feet below ground surface.

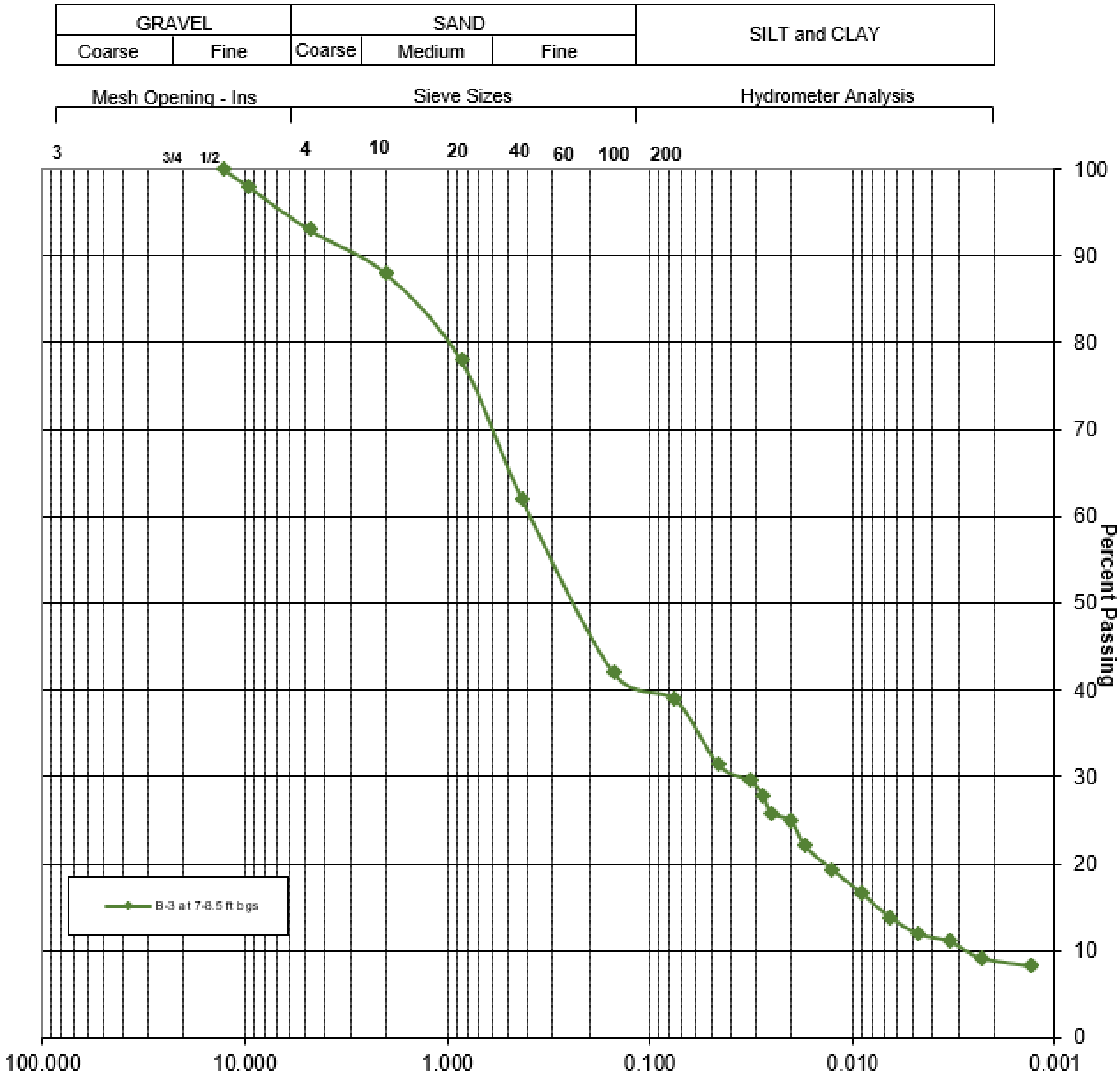


Figure 8. Stage 1 Filter specifications plotted with ASTM C33 concrete sand and samples of on-site Outwash Material

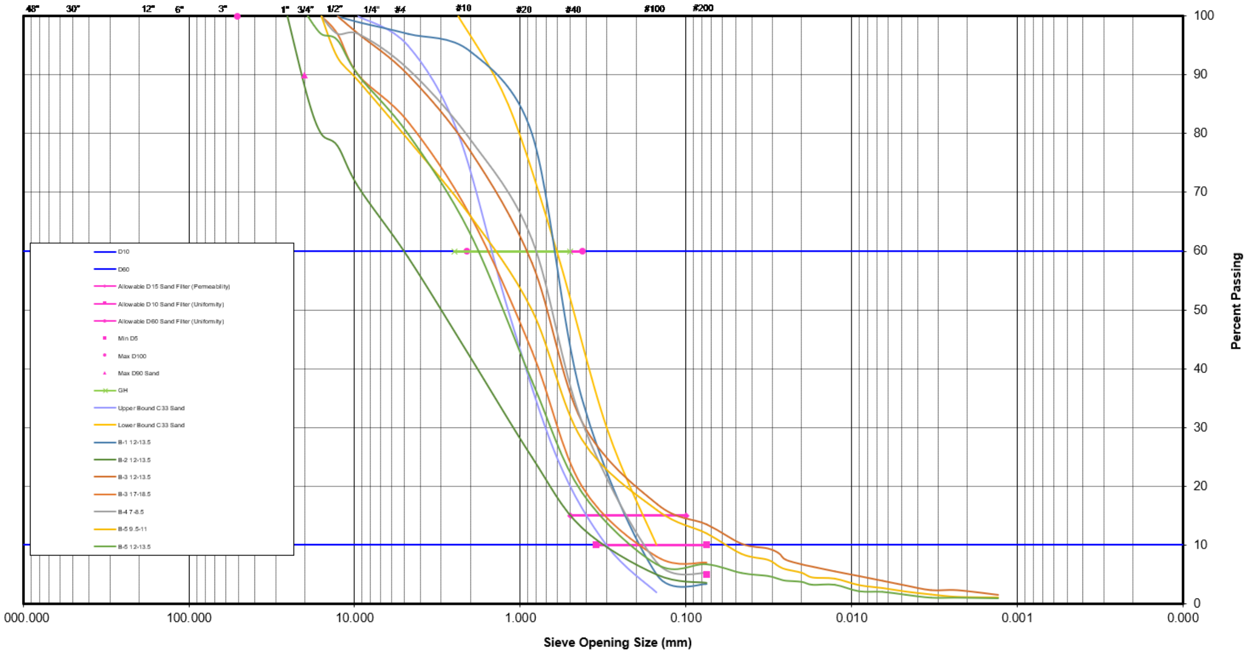
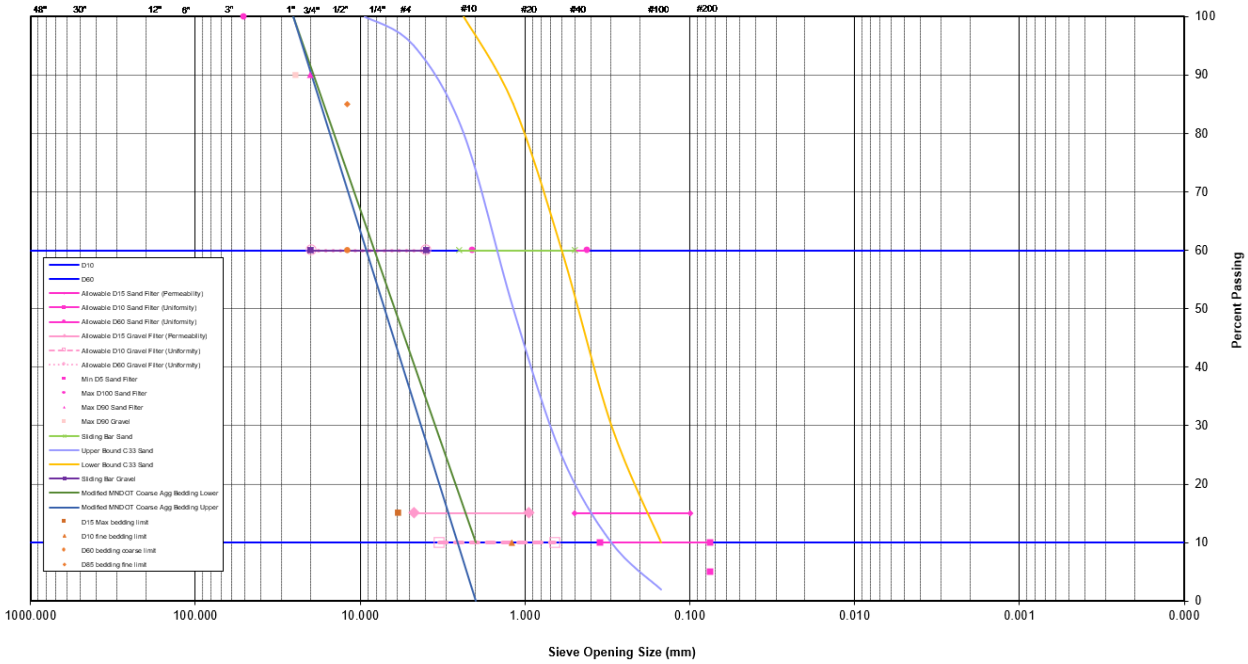


Figure 9. First and second stage filter specifications plotted with ASTM C33 concrete sand and modified MNDOT Coarse Aggregate Bedding



Trench Drain Pipe Sizing

The perforated six-inch trench drainpipe will be placed at the bottom of the toe trench drain within the second stage filter material. Based on FEMA filter guidance [20], the maximum pipe perforation dimension is based on the D50 of the second stage filter material which is 0.24 inches (6 mm). In addition, USBR 1987 [22] guidance was checked and recommends perforations in the pipe should be smaller than one-half of the surrounding D85 filter size, which is 0.24 inches (6 mm). Therefore, perforations must be less than 0.24 inches in width/diameter.

Pedestrian Bridge, Outlet Structure, and Weir Wall Evaluation

Pedestrian Bridge

The 2022 subsurface investigation included two SPT borings drilled to bedrock (highly weathered limestone, which transitions into more competent and less weathered limestone encountered at approximately 70 to 73 feet below ground surface) near the proposed bridge abutments (B-1 and B-2 on Figure 3).

It is anticipated the H-piles will be driven to “refusal” (typically defined as 10 blows per inch at termination of driving) into the weathered limestone. The allowable structural capacity should be limited to 33 percent of the pile yield stress for piles driven to refusal in rock.

A drivability analysis was performed using GRLWEAP Version 2014 with a Delmag D19-32 hammer. Based on the drivability runs, the selected HP12x53 can be driven to an ultimate capacity on the order of 450 kips. As a result, the allowable capacity of the H-piles driven to refusal in limestone is 150 kips which provides a factor of safety of 3. We recommend that the pile installation contractor perform pile drivability analyses (using GRLWEAP or approved equivalent) and should demonstrate that the pile driving setup will achieve design penetration and/or capacity and identify a refusal criteria without overstressing the pile. GRLWEAP output is provided in Attachment E.

Outlet Structure

The 2022 subsurface investigation included one SPT boring drilled to 50 feet below ground surface near the proposed weir wall (B-3 on Figure 3). Spread foundation design can be based on a net allowable soil bearing capacity of up to 1000 psf at elevation 890.5 feet or below. With this allowable bearing pressure, the factor of safety against bearing capacity failure is greater than the minimum required factor of safety of 3.0 for the outlet structure foundation and results in a settlement of less than 1-inch. Bearing capacity and settlement analysis are included in Attachment F.

Weir Wall

The 2022 subsurface investigation included one SPT boring drilled to 35 feet below ground surface near the proposed weir wall (B-5 on Figure 3). The weir wall will consist of concrete capped sheetpile extended to a depth of 20 feet below the bottom of the pond to about pile tip elevation at 870 feet. Pile analysis is provided in Attachment G.

Recommendations

The long-term slope stability FOS for the empty pond, high creek condition does not meet the selected factor of safety of 1.4. In the case that the pond requires draining (e.g., for maintenance concerns), it is recommended to avoid draining the pond when the creek is high.

Due to high horizontal gradients, interior pond slopes require treatment. A trench drain design is recommended to prevent nuisance slope erosion during normal pond operation levels. The design consists of a trench excavated at the top of the slope on the east side of the pond (between the creek and the pond) and includes a filter design and collector pipe as described in the *Slope Stability and Seepage Findings* and *Filter Analysis* sections above.

The pedestrian bridge foundation design includes HP12x53 piles driven to refusal on bedrock. We recommend that the pile installation contractor perform pile drivability analyses (using GRLWEAP or approved equivalent) and should demonstrate that the pile driving setup will achieve design penetration and/or capacity and identify a refusal criteria without overstressing the pile.

The weir wall will be driven or vibrated to a depth of 20 feet below the bottom of the pond to the tip elevation specified in the plans. We recommend the pile installation contractor to perform a pile drivability analyses (using GRLWEAP or approved equivalent) to demonstrate pile driving setup will achieve the design penetration without overstressing the sheetpile.

Given the hard driving conditions, and that we are driving into rock, driving shoes (also known as pile points) fabricated from cast steel conforming to the requirements of ASTM A27 shall be provided for all piles. The driving shoe shall not increase the tip bearing area of the H-Pile. The pile driving specifications will be updated to require the contractor to perform a pile drivability analysis and use driving shoes for H-Pile driving.

Abbreviations

AASHTO LRFD. American Association of State Highway and Transportation Officials Load-and-Resistance Factor Design.

EM. Engineering Manual.

FOS. Factor of Safety.

Ft. Feet.

I_c. Critical Gradient.

I_e. Exit Gradient.

MCWD. Minnehaha Creek Watershed District.

NAVFAC. Naval Facilities Engineering Command.

SWCC. Soil-Water Characteristic Curve.

USACE. United States Army Corps of Engineers.

USBR. United State Bureau of Reclamation.

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Attachments

Attachment A – 2022 AET Revised Report of Geotechnical Exploration

Attachment B – Existing Well Monitoring Data

Attachment C – SEEP/W Seepage Analysis Results

Attachment D – SLOPE/W Slope Stability Analysis Results

Attachment E – Pedestrian Bridge: GRLWEAP Output

Attachment F – Outlet Structure: Bearing Capacity and Settlement Analysis

Attachment G – Weir Wall: Pile Analysis

Attachment A

2022 AET Revised Report of Geotechnical Exploration

(Borehole Logs and Laboratory Test Results)

REVISED REPORT OF GEOTECHNICAL EXPLORATION

Stormwater and Greenway Project
325 Blake Road North
Hopkins, Minnesota

AET Project No. P-0006986

Date: March 9, 2022

Prepared for:
HDR Engineering, Inc.
701 Xenia Avenue South, Suite 600
Minneapolis, MN 55416

Geotechnical • Materials
Forensic • Environmental
Building Technology
Petrography/Chemistry

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AMERICAN
ENGINEERING TESTING

March 9, 2022

HDR Engineering, Inc.
701 Xenia Avenue South, Suite 600
Minneapolis, MN 55416

Attn: Greta Backman
Greta.Backman@HDRinc.com

RE: Revised Report of Geotechnical Exploration
Stormwater and Greenway Project
325 Blake Road North
Hopkins, Minnesota
AET Report No. P-0006986

Dear Greta Backman:

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for your project in Hopkins, Minnesota. These services were performed according to our proposal to you dated October 28, 2021.

Please contact me if you have any questions about the report.

Sincerely,
American Engineering Testing, Inc.

Thomas Evans

Thomas Evans, PE (MN)
Engineer II
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1.0 INTRODUCTION

Minnehaha Creek Watershed District is requesting the performance of a geotechnical exploration for a new project in Hopkins, Minnesota. HDR Engineering is performing the engineering services.

To assist planning and design, you have authorized American Engineering Testing, Inc. (AET) to conduct a subsurface exploration program at the site and conduct soil laboratory testing for the project. This report presents the results of the above services.

2.0 SCOPE OF SERVICES

AET's recent services were performed according to our proposal to you dated October 28, 2021. The authorized scope consists of the following:

- Perform a total of five standard penetration test (SPT) borings to the following depths
    - One SPT boring to a depth of 35 feet.
        - Install a monitoring well.
        - Perform slug testing.
    - Two SPT borings to depths of 50 feet.
    - Two SPT borings to bedrock (expected approximately 80 feet).
        - Perform a 5-foot bedrock core in each borehole.
- Soil laboratory testing.
- Geotechnical engineering review based on this data and preparation of this report.

The slug testing results will be forwarded under separate cover.

These services are intended for geotechnical purposes only. The scope is not intended to explore for the presence or extent of environmental contamination in the soil or groundwater.

3.0 PROJECT INFORMATION

HDR Engineering and Minnehaha Creek Watershed District has requested the performance of SPT borings, the installation of a monitoring well, and the performance of slug testing at 325 Blake Road North in Hopkins, Minnesota.

Information on any proposed structures, such as dimensions and/or locations, have not been provided.

4.0 SUBSURFACE EXPLORATION AND TESTING

4.1 Field Exploration Program

The subsurface exploration program conducted for the project consisted of five SPT borings performed on January 17, 18, 20 and 26, 2022. HDR Engineering determined the number, depth, and locations of the soil borings. The bedrock cores were performed in borings B-1 and B-2. The monitoring well was installed, and the slug testing was performed at boring B-5.

The boring locations are shown on the Boring Location Map in Appendix A. The borings were located by AET personnel. The as-drilled boring locations were determined by AET GPS equipment, and the collected data has an estimated accuracy of plus or minus ⅓-foot in the horizontal direction. The elevations at the boring locations were provided by HDR.

The logs of the borings and details of the methods used appear in Appendix A. The logs contain information concerning soil layering, soil classification, geologic origins, and moisture condition. A density description or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value). The construction log for the monitoring well installed at B-5 (monitoring well named P-5) is attached in the appendix following the boring logs.

4.2 Laboratory Testing

The laboratory test program included visual/manual classification of the soil samples, water content tests, ten hydrometers, and eight sieve analyses. The water content and the percent passing the #200 sieve are shown on the subsurface boring logs adjacent to the samples upon which they were performed. The full sieve analyses and hydrometer curves, as well as a gradation table, are provided in the appendix following the boring logs.

5.0 SITE CONDITIONS

5.1 Subsurface Soils/Geology

The site geology consists of fill soils extending to depths of up to 12 feet below grade underlain by both glacial till and alluvial soils. The fill soils consisted mostly of silty sand and clayey sand. The alluvium consisted of very loose to very dense sand, sand with silt, and silty sand with various gravel contents. The till soils consist of very loose to dense silty sand, as well as stiff to hard clayey sand.

An approximately 5-foot thick layer of topsoil was encountered between the fill and alluvial soils in boring B-3. This layer consisted of clayey sand with organic fines.

Below the alluvium and the till, limestone bedrock of the Platteville Formation and Magnolia Member was encountered and extended to the final coring depths. The sampled limestone was observed to be slightly weathered and very to moderately fractured in boring B-1 and fresh (i.e. minimal weathering) and moderately to slightly fractured in boring B-2.

5.2 Groundwater

The borings were observed for the presence of groundwater prior to switching to the mud rotary drilling method. Groundwater was observed at each boring location at depths as shallow as 8.0 feet (boring B-1).

Groundwater levels can fluctuate due to varying seasonal and annual rainfall and snow melt amounts, as well as other factors.

6.0 ASTM STANDARDS

When we refer to an ASTM Standard in this report, we mean that our services were performed in general accordance with that standard. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

7.0 LIMITATIONS

Within the limitations of scope, budget, and schedule, we have endeavored to provide our services according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, express or implied, is intended.

Appendix A

Appendix A
Geotechnical Field Exploration and Testing
Report No. P-0006986

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling five standard penetration test borings. The locations of the borings appear on the Boring Location Map, preceding the Subsurface Boring Logs in this appendix.

A.2 SAMPLING METHODS

A.2.1 Split-Spoon Samples (SS) - Calibrated to N_{60} Values

Standard penetration (split-spoon) samples were collected in general accordance with ASTM: D1586 with one primary modification. The ASTM test method consists of driving a 2-inch O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30 inches. The sampler is driven a total of 18 inches into the soil. After an initial set of 6 inches, the number of hammer blows to drive the sampler the final 12 inches is known as the standard penetration resistance or N-value. Our method uses a modified hammer weight, which is determined by measuring the system energy using a Pile Driving Analyzer (PDA) and an instrumented rod.

In the past, standard penetration N-value tests were performed using a rope and cathead for the lift and drop system. The energy transferred to the split-spoon sampler was typically limited to about 60% of its potential energy due to the friction inherent in this system. This converted energy then provides what is known as an N_{60} blow count.

The most recent drill rigs incorporate an automatic hammer lift and drop system, which has higher energy efficiency and subsequently results in lower N-values than the traditional N_{60} values. By using the PDA energy measurement equipment, we are able to determine actual energy generated by the drop hammer. With the various hammer systems available, we have found highly variable energies ranging from 55% to over 100%. Therefore, the intent of AET's hammer calibrations is to vary the hammer weight such that hammer energies lie within about 60% to 65% of the theoretical energy of a 140-pound weight falling 30 inches. The current ASTM procedure acknowledges the wide variation in N-values, stating that N-values of 100% or more have been observed. Although we have not yet determined the statistical measurement uncertainty of our calibrated method to date, we can state that the accuracy deviation of the N-values using this method is significantly better than the standard ASTM Method.

A.2.2 Disturbed Samples (DS)/Spin-up Samples (SU)

Sample types described as "DS" or "SU" on the boring logs are disturbed samples, which are taken from the flights of the auger. Because the auger disturbs the samples, possible soil layering and contact depths should be considered approximate.

A.2.3 Sampling Limitations

Unless actually observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

Determining the thickness of "topsoil" layers is usually limited, due to variations in topsoil definition, sample recovery, and other factors. Visual-manual description often relies on color for determination, and transitioning changes can account for significant variation in thickness judgment. Accordingly, the topsoil thickness presented on the logs should not be the sole basis for calculating topsoil stripping depths and volumes. If more accurate information is needed relating to thickness and topsoil quality definition, alternate methods of sample retrieval and testing should be employed.

A.3 CLASSIFICATION METHODS

Soil descriptions shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil descriptions shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

A.4 WATER LEVEL MEASUREMENTS

The groundwater level measurements are shown at the bottom of the boring logs. The following information appears under "Water Level Measurements" on the logs:

- Date and Time of measurement
- Sampled Depth: lowest depth of soil sampling at the time of measurement
- Casing Depth: depth to bottom of casing or hollow-stem auger at time of measurement
- Cave-in Depth: depth at which measuring tape stops in the borehole
- Water Level: depth in the borehole where free water is encountered
- Drilling Fluid Level: same as Water Level, except that the liquid in the borehole is drilling fluid

The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

A.5 LABORATORY TEST METHODS

A.5.1 Water Content Tests

Conducted per AET Procedure 01-LAB-010, which is performed in general accordance with ASTM: D2216 and AASHTO: T265.

A.5.2 Sieve Analysis of Soils (thru #200 Sieve)

Conducted per AET Procedure 01-LAB-040, which is performed in general conformance with ASTM: D6913, Method A.

A.5.3 Particle Size Analysis of Soils (with hydrometer)

Conducted per AET Procedure 01-LAB-050, which is performed in general accordance with ASTM: D422 and AASHTO: T88.

A.6 TEST STANDARD LIMITATIONS

Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

A.7 SAMPLE STORAGE

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q_p:	Pocket Penetrometer strength, tsf (approximate)
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES
(Calibrated Hammer Weight)

The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu≥4 and 1≤Cc≤3[E]	GW	Well graded gravel[F]
			Cu<4 and/or 1>Cc>3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines more than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel[F.G.H]
			Fines classify as CL or CH	GC	Clayey gravel[F.G.H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu≥6 and 1≤Cc≤3[E]	SW	Well-graded sand[I]
			Cu<6 and/or 1>Cc>3[E]	SP	Poorly-graded sand[I]
		Sands with Fines more than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand[G.H.I]
			Fines classify as CL or CH	SC	Clayey sand[G.H.I]
Fine-Grained Soils 50% or more passes the No. 200 sieve (see Plasticity Chart below)	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K.L.M]
			PI<4 or plots below "A" line[J]	ML	Silt[K.L.M]
		organic	$\frac{\text{Liquid limit–oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay[K.L.M.N] Organic silt[K.L.M.O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K.L.M]
			PI plots below "A" line	MH	Elastic silt[K.L.M]
		organic	$\frac{\text{Liquid limit–oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay[K.L.M.P] Organic silt[K.L.M.Q]
Highly organic soil			Primarily organic matter, dark in color, and organic in odor	PT	Peat[R]

Notes

[A] Based on the material passing the 3-in (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60} / D_{10},\qquad Cc = \frac{(D_{30})^2}{D_{10} \text{ x } D_{60}}$

[F] If soil contains ≥15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot is hatched area, soil is a CL-ML silty clay.

[K] If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.

[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.

[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

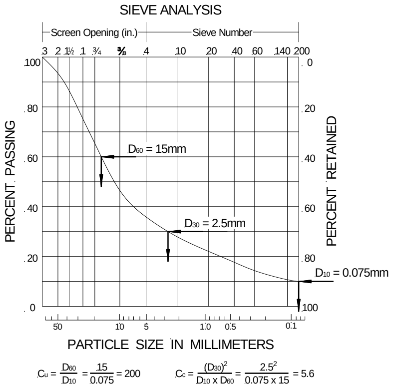
[N] PI≥4 and plots on or above "A" line.

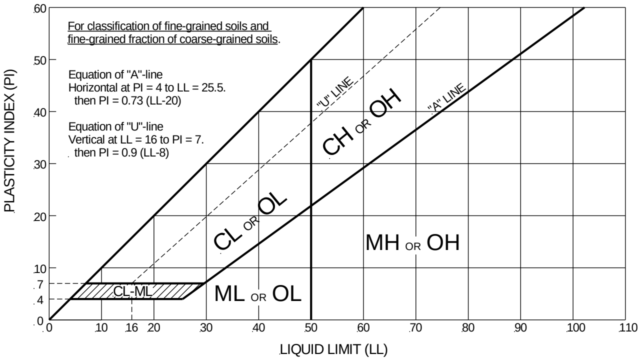
[O] PI<4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

[R] Fiber Content description shown below.





Plasticity Chart

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

Gravel Percentages

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

Consistency of Plastic Soils

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	Greater than 30

Relative Density of Non-Plastic Soils

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

Moisture/Frost Condition
(MC Column)

D (Dry):	Absence of moisture, dusty, dry to touch.
M (Moist):	Damp, although free water not visible. Soil may still have a high water content (over "optimum").
W (Wet/ Waterbearing):	Free water visible, intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.
F (Frozen):	Soil frozen

Layering Notes

Laminations:	Layers less than ½" thick of differing material or color.
Lenses:	Pockets or layers greater than ½" thick of differing material or color.

Peat Description

Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

Organic Description (if no lab tests)

Soils are described as *organic*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *Slightly organic* used for borderline cases.

Root Inclusions

With roots:	Judged to have sufficient quantity of roots to influence the soil properties.
Trace roots:	Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.

AMERICAN ENGINEERING TESTING	**Stormwater and Greenway Project** **325 Blake Rd N, Hopkins, Minnesota**			AET Project No. P-0006986
	Boring Location Map			
	Scale: Shown	Drawn by: TE	Reviewed by: JB	**Date: February 2, 2022**

AMERICAN
ENGINEERING TESTING

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986**
LOG OF BORING NO. **B-1 (p. 1 of 2)**
PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**
SURFACE ELEVATION: **902.2** LATITUDE: **44.931479** LONGITUDE: **-93.384210**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	REC %	RQD IN.	RQD %	%-#200
1	FILL, mostly clayey sand with organic fines, trace roots, black, frozen	FILL		F/M	SU						
2	FILL, mostly sandy gravel with silt, brown										
3			10	M	SS	4					
4											
5			26	M	SS	3					9
6											
7											
8			8	▼ M	SS	½					
9											
10			11	W	SS	½					
11											
12											
13	SAND, a little gravel, fine to medium grained, light brown, waterbearing, very loose to loose (SP)	COARSE ALLUVIUM	4	W	SS	6					3
14											
15			7	W	SS	2					
16											
17											
18			8	W	SS	1					
19											
20			7	W	SS	4					
21											
22											
23	SAND WITH GRAVEL, medium to coarse grained, gray, waterbearing, medium dense (SP)		11	W	SS	6					
24											
25			20	W	SS	5					
26											
27											
28			24	W	SS	6					
29											
30			23	W	SS	7					
31											
32	SILTY SAND, a little gravel, brown, medium dense to loose (SM)	TILL									
33			14	M	SS	14					30
34											
35			10	W	SS	16					
36											
37											
38			8	W	SS	18					
39											

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-11'	**3.25" HSA**							
11-71½'	**RD w/DM**	**1/20/22**	**1:50**	**11.0**	**9.5**	**9.0**		**8.4**
71½-76½'	**NQ Core**	**1/20/22**	**1:55**	**11.0**	**9.5**	**8.9**		**8.0**
BORING COMPLETED: **1/20/22**								
DR: **SG** LG: **SB** Rig: **41**								

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986**

LOG OF BORING NO. **B-1 (p. 2 of 2)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

LATITUDE: **44.931479** LONGITUDE: **-93.384210**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS WC	REC %	RQD IN.	RQD %	%-#200
41	SILTY SAND, a little gravel, brown, medium dense to loose (SM) *(continued)*	TILL *(continued)*	9	W	SS	15					
42	SAND WITH SILT, a little gravel, fine to medium grained, brown, waterbearing, medium dense (SP-SM)	COARSE ALLUVIUM									
43			12	M	SS	13					5
44											
45	SILTY SAND, a little gravel, fine to medium grained, brown, wet, medium dense (SM)		16	W	SS	3					
46											
47	SILTY SAND, a little gravel, brown, loose to medium dense to loose (SM)	TILL									
48			10	W	SS	18					
49											
50			9	W	SS	16					
51											
52											
53											
54											
55			10	W	SS	18					
56											
57											
58											
59											
60			11	W	SS	18					
61											
62											
63											
64											
65			6	W	SS	18					
66											
67											
68											
69											
70	WEATHERED LIMESTONE, light brown	PLATTEVILLE FORMATION MAGNOLIA MEMBER	100/0		SS	0					
71											
72	LIMESTONE, gray to light gray, fossiliferous Weathering: Slightly weathered Fracturing: Very to moderately fractured Stratification: Thickly bedded Hardness: Hard										
73											
74					NQ	55		92	25	42	
75											
76											

END OF BORING

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986** LOG OF BORING NO. **B-2 (p. 1 of 2)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

SURFACE ELEVATION: **906.9** LATITUDE: **44.931170** LONGITUDE: **-93.384414**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS WC	REC %	RQD IN.	RQD %	%-#200
1	FILL, mostly silty sand, a little gravel, brown, frozen	FILL		F	SU						
3	FILL, mostly sand with silt, a little clayey sand and gravel, brown		6	M	SS	4					
5	FILL, mostly silty sand, a little gravel, brown		8	M	SS	5					
8			9	M	SS	4					
10	FILL, mostly gravelly silty sand, with brick, brown		16	▼ M	SS	5					
13	GRAVELLY SAND, fine to medium grained, brown, waterbearing, medium dense (SP)	COARSE ALLUVIUM	24	W	SS	7					4
15	SAND, a little gravel, fine to medium grained, light brown, waterbearing, medium dense (SP)		20	W	SS	10					
18			21	W	SS	8					
20			22	W	SS	7					
23			20	W	SS	8					
25			20	W	SS	10					
28	SANDY GRAVEL, medium to coarse grained, brown, dense (GW)		31	W	SS	6					5
30	SILTY SAND, a little gravel, fine to medium grained, brown, medium dense to very loose to dense (SM)	TILL	21	W	SS	22					
33			4	W	SS	18					
35			4	W	SS	18					
38			5	W	SS	18					

DEPTH:	DRILLING METHOD
0-14½'	3.25" HSA
14½-74½'	RD w/DM
74½-79½'	NQ Core

BORING COMPLETED: **1/18/22**

DR: **SG** LG: **SB** Rig: **41**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/18/22	12:45	13.5	12.0	11.9		9.9
1/18/22	1:00	13.5	12.0	11.9		10.3

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-LAT-LONG P-0006986.GPJ AET+CPT+WELL.GDT 3/8/22

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986**

LOG OF BORING NO. **B-2 (p. 2 of 2)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

LATITUDE: **44.931170** LONGITUDE: **-93.384414**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	REC %	RQD IN.	RQD %	%-#200
41	SILTY SAND, a little gravel, fine to medium grained, brown, medium dense to very loose to dense (SM) *(continued)*	TILL *(continued)*	8	W	SS	18					
42											
43			7	W	SS	18					
44											
45			15	W	SS	18					
46											
47											
48			18	W	SS	18					
49											
50			6	W	SS	18					
51											
52											
53											
54											
55											
56			19	W	SS	5					
57											
58											
59											
60			16	W	SS	4					
61											
62											
63											
64											
65			14	W	SS	18					25
66											
67											
68											
69											
70			36	W	SS	5					
71											
72											
73											
74	WEATHERED LIMESTONE, light brown	PLATTEVILLE FORMATION MAGNOLIA MEMBER									
75	LIMESTONE, light brownish gray, fossiliferous Weathering: Fresh Fracturing: Moderately to slightly fractured Stratification: Thickly bedded Hardness: Hard		100/.1	M	SS	1					
76											
77					NQ	55		92	42	70	
78											
79											
	END OF BORING										

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986** LOG OF BORING NO. **B-3 (p. 1 of 2)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

SURFACE ELEVATION: **905.5** LATITUDE: **44.930319** LONGITUDE: **-93.382243**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS WC	DEN	LL	PL	%-#200
1	FILL, mostly clayey sand with organic fines, a little gravel, trace roots, black, frozen	FILL		F	SU		14				
2	FILL, mixture of clayey sand and silty sand with gravel, dark brown and brown										
3			29	M	SS	15	8				
4											
5	FILL, mixture of sand with silt and sandy lean clay, a little gravel, trace roots, brown, dark brown and gray		10	M	SS	16	8				
6											
7	CLAYEY SAND WITH ORGANIC FINES, a little gravel, trace roots, dark brown, soft to stiff, laminations of silty sand (SC)	TOPSOIL									
8			3	M	SS	17	25				39
9				▼							
10			9	M	SS	16	33				
11											
12	SILTY SAND, a little gravel, medium to fine grained, gray, wet, loose (SM)	COARSE ALLUVIUM									
13			9	M	SS	5					14
14	SILTY SAND WITH GRAVEL, medium to fine grained, brown, wet, very loose (SM)										
15			4	W	SS	5					
16											
17	SAND WITH SILT AND GRAVEL, medium to fine grained, brown, waterbearing, loose to medium dense (SW-SM)										
18			5	W	SS	4					7
19											
20			12	W	SS	½					
21											
22											
23			15	W	SS	6					
24											
25	SAND WITH SILT, a little gravel, fine to medium grained, grayish brown, waterbearing, dense (SP-SM)		32	W	SS	6					
26											
27	CLAYEY SAND, a little gravel, brownish gray, hard to stiff to hard, laminations of silty sand (SC)	TILL									
28			37	W	SS	12	12				33
29											
30			19	W	SS	13	12				
31											
32											
33			14	W	SS	18	12				
34											
35			17	W	SS	13	12				
36											
37											
38			85	W	SS	10	13				
39											

DEPTH:	DRILLING METHOD
0-19½'	**3.25" HSA**
19½-49½'	**RD w/DM**

BORING COMPLETED: **1/17/22**

DR: **SG** LG: **SB** Rig: **41**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/17/22	**9:45**	**16.0**	**14.5**	**14.3**		**10.6**
1/17/22	**9:55**	**16.0**	**14.5**	**14.1**		**9.3**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-LAT-LONG P-0006986.GPJ AET+CPT+WELL.GDT 3/8/22

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986** LOG OF BORING NO. **B-3 (p. 2 of 2)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

LATITUDE: **44.930319** LONGITUDE: **-93.382243**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
41		TILL *(continued)*	14	W	SS	14	12				
42	SILTY SAND, a little gravel, brownish gray, medium dense to dense to medium dense (SM/SC)										
43			21	W	SS	12					27
44											
45			15	W	SS	7					
46											
47											
48			41	W	SS	18					
49											
50			22	W	SS	18					
51	**END OF BORING**										

AMERICAN
ENGINEERING TESTING

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986**   LOG OF BORING NO. **B-4 (p. 1 of 2)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

SURFACE ELEVATION: **907.8**   LATITUDE: **44.929710**   LONGITUDE: **-93.382108**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
							FIELD & LABORATORY TESTS				
1	FILL, mostly gravelly silty sand, dark brown	FILL		F	SU						
2	FILL, mostly silty sand, a little gravel, dark brown										
3	FILL, mixture of silty sand and clayey sand, a little gravel, dark brown		23	F/M	SS	18					
4											
5			15	M	SS	12					
6											
7	SAND WITH SILT, a little gravel, fine to medium grained, light brown, moist, medium dense to dense (SP-SM)	COARSE ALLUVIUM									
8			33	M	SS	12					5
9											
10			24	M	SS	15					
11				▼							
12											
13	SAND, a little gravel, fine to medium grained, brown, waterbearing, medium dense to dense (SP)		19	W	SS	12					
14											
15			31	W	SS	10					
16											
17											
18			16	W	SS	9					
19											
20			26	W	SS	10					
21											
22											
23			40	W	SS	6					
24											
25	SANDY GRAVEL WITH SILT, fine to medium grained, brown, wet, dense (GP-GM)		39	W	SS	12					5
26											
27											
28			44	W	SS	12					
29	SILTY SAND, a little gravel, brown, wet, dense to loose to medium dense (SM)										
30			28	W	SS	16					
31											
32											
33			31	M	SS	16					
34											
35			48	M	SS	18	14				
36											
37											
38			17	W	SS	12					
39											

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½'	**3.25" HSA**							
14½-49½'	**RD w/DM**	**1/18/22**	**9:22**	**13.5**	**12.0**	**11.9**		**11.5**
		1/18/22	**9:30**	**13.5**	**12.0**	**11.8**		**11.5**
BORING COMPLETED: **1/18/22**								
DR: **SG** LG: **SB** Rig: **41**								

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP W-LAT-LONG P-0006986.GPJ AET+CPT+WELL.GDT 3/8/22

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986** LOG OF BORING NO. **B-4 (p. 2 of 2)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

LATITUDE: **44.929710** LONGITUDE: **-93.382108**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
41	SILTY SAND, a little gravel, brown, wet, dense to loose to medium dense (SM) *(continued)*	COARSE ALLUVIUM *(continued)*	6	M	SS	0					
42											
43			13	W	SS	12					16
44											
45			6	W	SS	18					
46											
47											
48			8	W	SS	18					
49											
50			14	W	SS	3					
51	**END OF BORING**										

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986**
LOG OF BORING NO. **B-5 (p. 1 of 1)**
PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**
SURFACE ELEVATION: **907.3** LATITUDE: **44.930157** LONGITUDE: **-93.382573**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	FILL, mostly silty sand, with gravel, brown, frozen	FILL		F	SU						
2	FILL, mostly silty sand, a little gravel, brown										
3			13	M	SS	4					
4											
5			5	M	SS	6					
6											
7	FILL, mixture of clayey sand with organic fines and silty sand, black and brown										
8			15	M	SS	12	19				
9											
10	SILTY SAND WITH GRAVEL, brown, moist, medium dense (SM)	COARSE ALLUVIUM	19	▼ M	SS	12					12
11											
12	SAND WITH SILT AND GRAVEL, fine to medium grained, brown, waterbearing, medium dense (SP-SM)										
13			11	W	SS	13					7
14											
15			16	W	SS	4					
16											
17	SAND, a little gravel, fine to medium grained, brown, waterbearing, medium dense (SP)										
18			26	W	SS	3					
19											
20			19	W	SS	10					
21											
22											
23			24	W	SS	10					
24											
25			23	W	SS	10					
26											
27											
28			26	W	SS	12					
29	SAND WITH SILT AND GRAVEL, fine to medium grained, brown, wet, very dense to dense (SP-SM)										
30			111	W	SS	10					8
31											
32											
33			74	W	SS	16					
34											
35			50	W	SS	10					
36	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-14'	**3.25" HSA**
14-34½'	**RD w/DM**

WATER LEVEL MEASUREMENTS						
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/25/22	**10:40**	**13.5**	**12.0**	**11.8**		**10.6**
1/25/22	**10:50**	**13.5**	**12.0**	**11.7**		**10.5**

BORING COMPLETED: **1/26/22**

DR: **SG** LG: **SB** Rig: **41**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

Monitoring Well/Piezometer Log

AET Job No.: P-0006986

Well No.: P-5

Project: Stormwater and Greenway Project, 325 Blake Rd N

Unique Well No.: 843599

Location: Hopkins, MN

Drilling Method: 4.25" HSA

Date Installed: 1/26/22

Drilling Fluids (type):

Project Manager: Tommy Evans

Completed by: SG

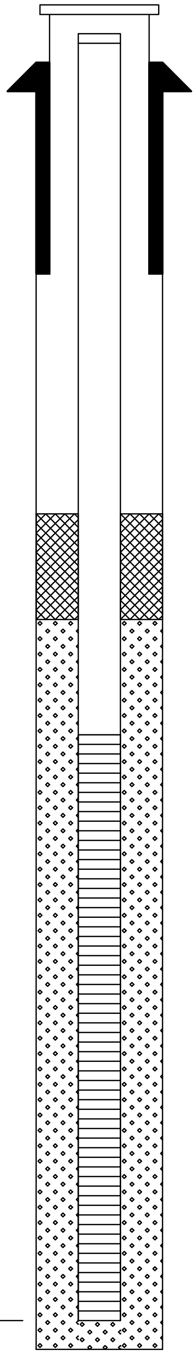
Annular Space Details

Type of Surface Seal: Portland

Type of Annular Sealant: Bentonite Cement Grout

Type of Bentonite Seal (Granular Pellet): N/A

Type of Sand Pack: #40 Red Flint



3.0 Top of Protective Casing

3.0 Top of Riser Pipe

0.0 Ground Surface

N/A Top of Annular Sealant

4.0 Bottom of Protective Casing

N/A Top of Seal

28.0 Top of Sand

31.5 Top of Screen

Do 8.25

36.5 Bottom of Screen

36.5' Bottom of Borehole

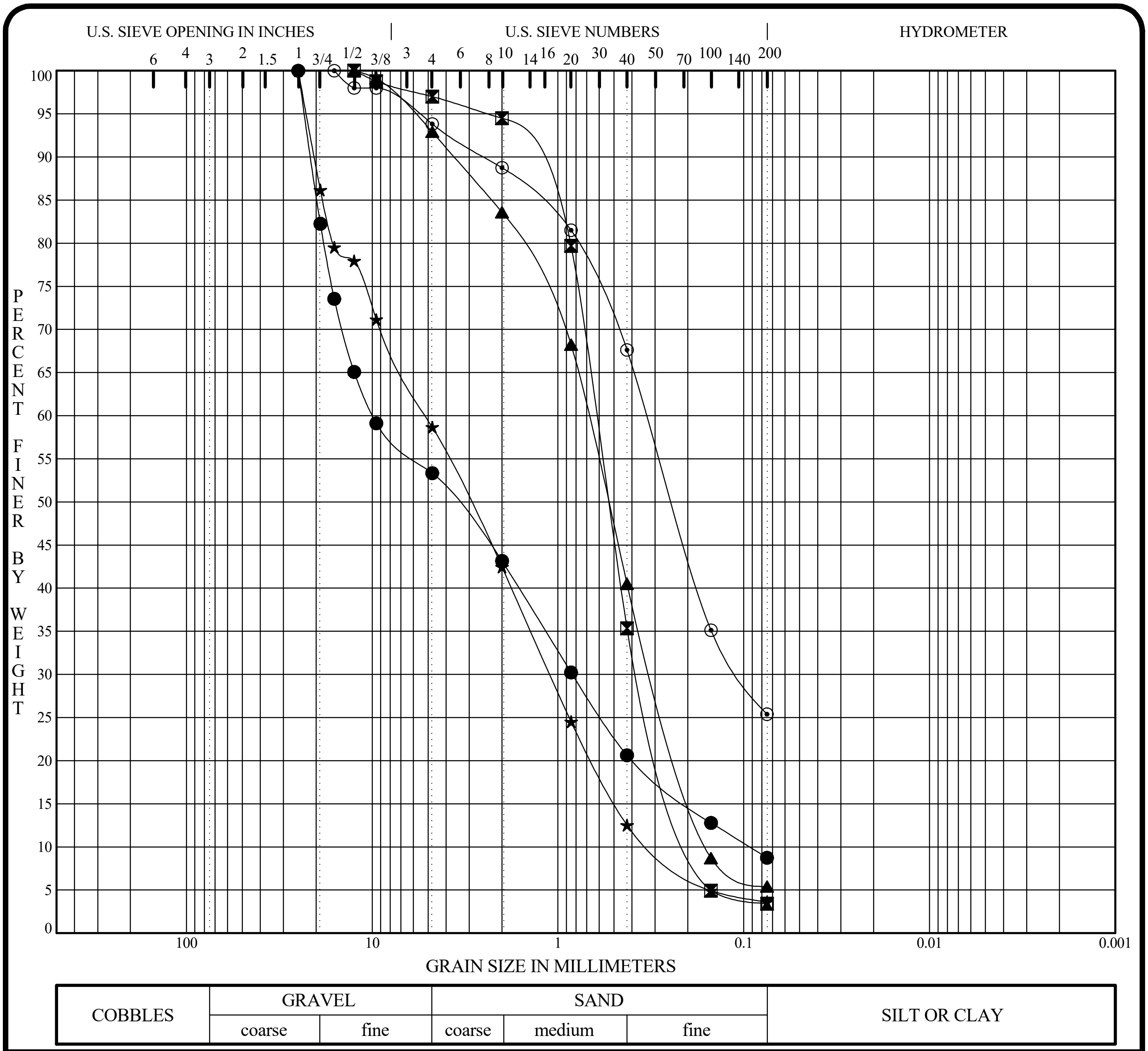
Well Construction Materials

	Stainless Steel Specify Type	PVC Specify Type	Other Specify Type
Riser Coupling Joint	---	---	---
Riser Pipe Above w.t.	---	---	---
Riser Pipe Below w.t.	---	---	---
Screen	---	---	---
Protective Posts	---	---	---
Protective Casing	---	---	---

Measurements

to 0.1 ft (where applicable)

Protective Casing Length	7'
Riser Pipe Length	31.5
Screen Length	5.0
Screen Slot Size	.010
Top of Riser Elevation	
Ground Surface Elevation	
Depth to Water	
Water Elevation	
Other	



Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
● **B-1**	**4.5'**	**Sandy gravel with silt (GP-GM)**					**0.76**	**106.2**
☒ **B-1**	**12.0'**	**Sand, a little gravel (SP)**					**1.12**	**3.5**
▲ **B-1**	**42.0'**	**Sand with silt, a little gravel (SP-SM)**					**0.84**	**4.4**
★ **B-2**	**12.0'**	**Gravelly sand (SP)**					**0.79**	**17.0**
⊙ **B-2**	**64.5'**	**Silty sand, a little gravel (SM)**						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-1**	**4.5'**	**25.00**	**9.89**	**0.836**	**0.0931**	**46.7**	**44.6**	**8.7**	
☒ **B-1**	**12.0'**	**12.50**	**0.62**	**0.354**	**0.1785**	**3.0**	**93.6**	**3.4**	
▲ **B-1**	**42.0'**	**12.50**	**0.69**	**0.301**	**0.1565**	**7.1**	**87.5**	**5.4**	
★ **B-2**	**12.0'**	**25.00**	**5.12**	**1.104**	**0.3010**	**41.3**	**55.0**	**3.6**	
⊙ **B-2**	**64.5'**	**16.00**	**0.33**	**0.104**		**6.2**	**68.4**	**25.4**	

PROJECT **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

AET JOB NO. **P-0006986**
DATE **1/18/22**

AMERICAN ENGINEERING TESTING

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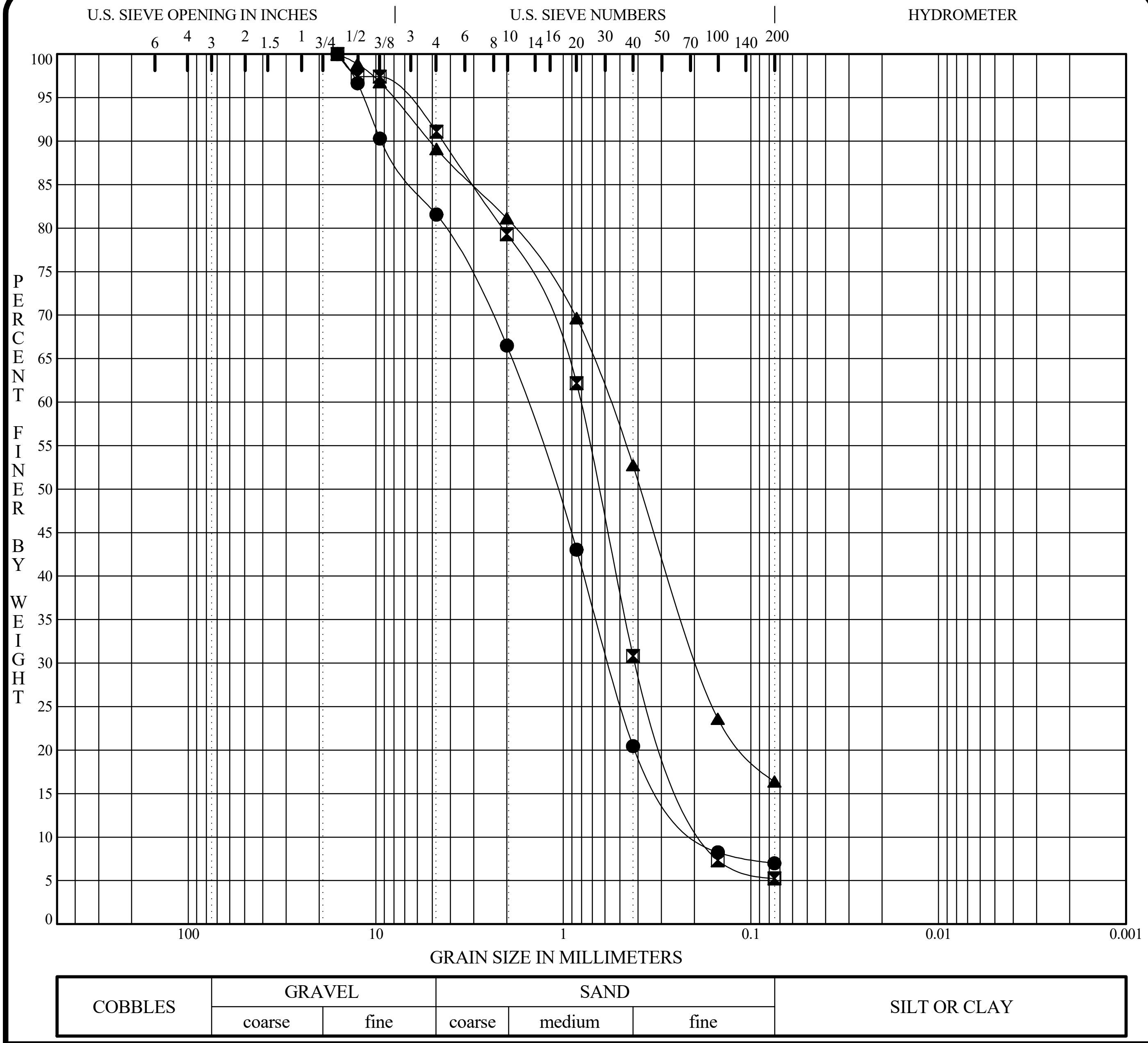
GRADATION CURVES



Specimen Identification			Classification	MC%	LL	PL	PI	Cc	Cu
●	**B-3**	**17.0'**	**Sand with silt and gravel (SW-SM)**					**1.18**	**9.1**
⧗	**B-4**	**7.0'**	**Sand with silt, a little gravel (SP-SM)**					**1.23**	**4.8**
▲	**B-4**	**42.0'**	**Silty sand, a little gravel (SM)**						

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-3**	**17.0'**	**16.00**	**1.58**	**0.570**	**0.1743**	**18.4**	**74.6**	**7.0**	
⧗	**B-4**	**7.0'**	**16.00**	**0.81**	**0.410**	**0.1688**	**8.9**	**85.8**	**5.2**	
▲	**B-4**	**42.0'**	**16.00**	**0.57**	**0.189**		**10.9**	**72.7**	**16.4**	

PROJECT **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

AET JOB NO. **P-0006986**
DATE **1/18/22**

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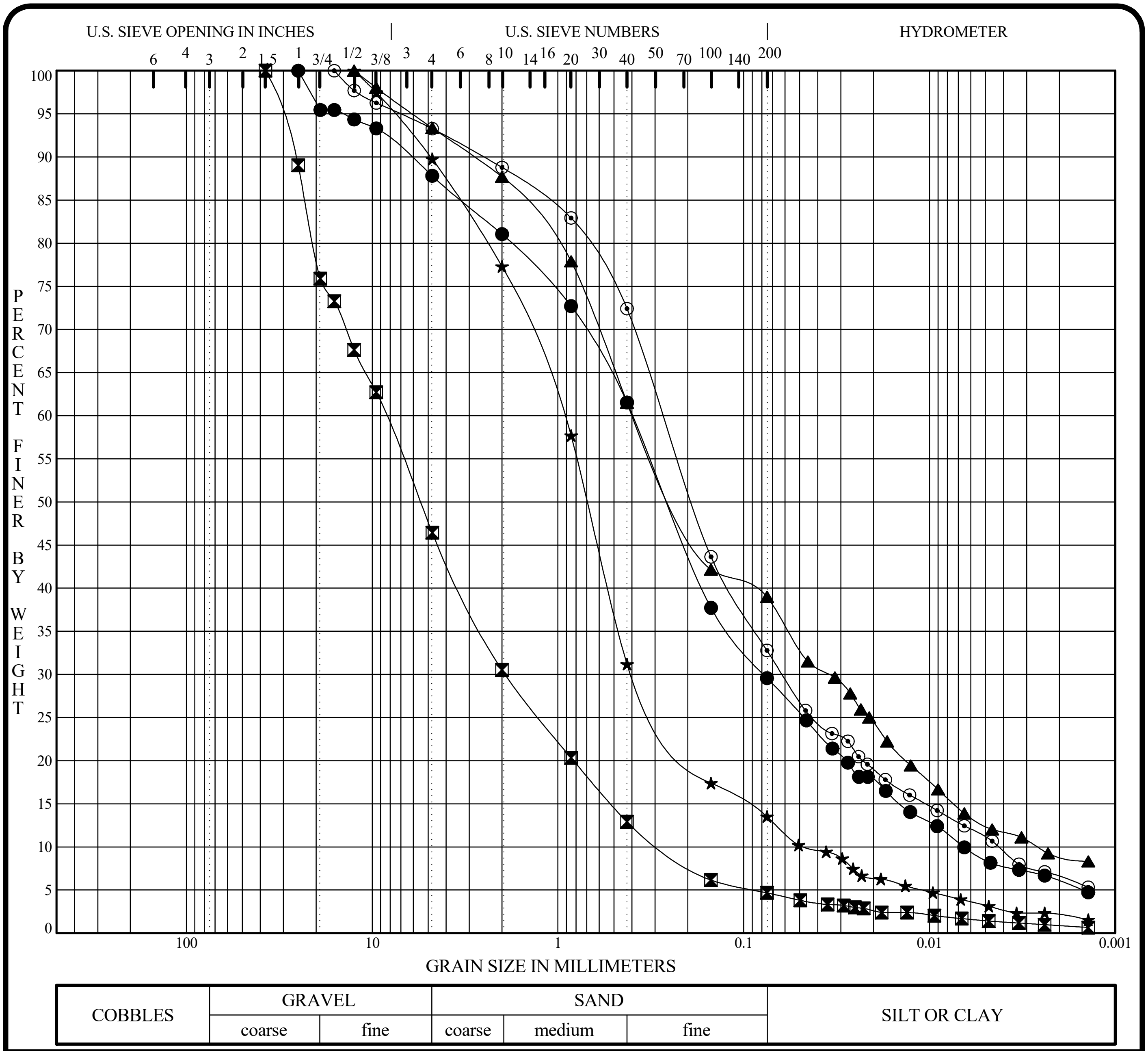
GRADATION CURVES



Specimen Identification			Classification	MC%	LL	PL	PI	Cc	Cu
●	**B-1**	**32.0'**	**Silty sand, a little gravel (SM)**					**2.33**	**60.7**
⧗	**B-2**	**27.0'**	**Sandy gravel (GW)**					**1.60**	**31.2**
▲	**B-3**	**7.0'**	**Silty sand, a little gravel (SM)**	**25**				**1.15**	**148.9**
★	**B-3**	**12.0'**	**Silty sand, a little gravel (SM)**					**3.48**	**20.4**
⊙	**B-3**	**27.0'**	**Silty sand, a little gravel (SM)**	**12**				**3.34**	**64.0**

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1**	**32.0'**	**25.00**	**0.40**	**0.078**	**0.0065**	**12.2**	**58.2**	**21.1**	**8.5**
⧗	**B-2**	**27.0'**	**37.50**	**8.46**	**1.917**	**0.2715**	**53.6**	**41.8**	**3.2**	**1.4**
▲	**B-3**	**7.0'**	**12.50**	**0.39**	**0.034**	**0.0026**	**6.6**	**54.4**	**26.5**	**12.5**
★	**B-3**	**12.0'**	**12.50**	**0.94**	**0.389**	**0.0461**	**10.2**	**76.2**	**10.3**	**3.2**
⊙	**B-3**	**27.0'**	**16.00**	**0.27**	**0.062**	**0.0042**	**6.7**	**60.5**	**21.7**	**11.1**

PROJECT **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

AET JOB NO. **P-0006986**
DATE **1/17/22**

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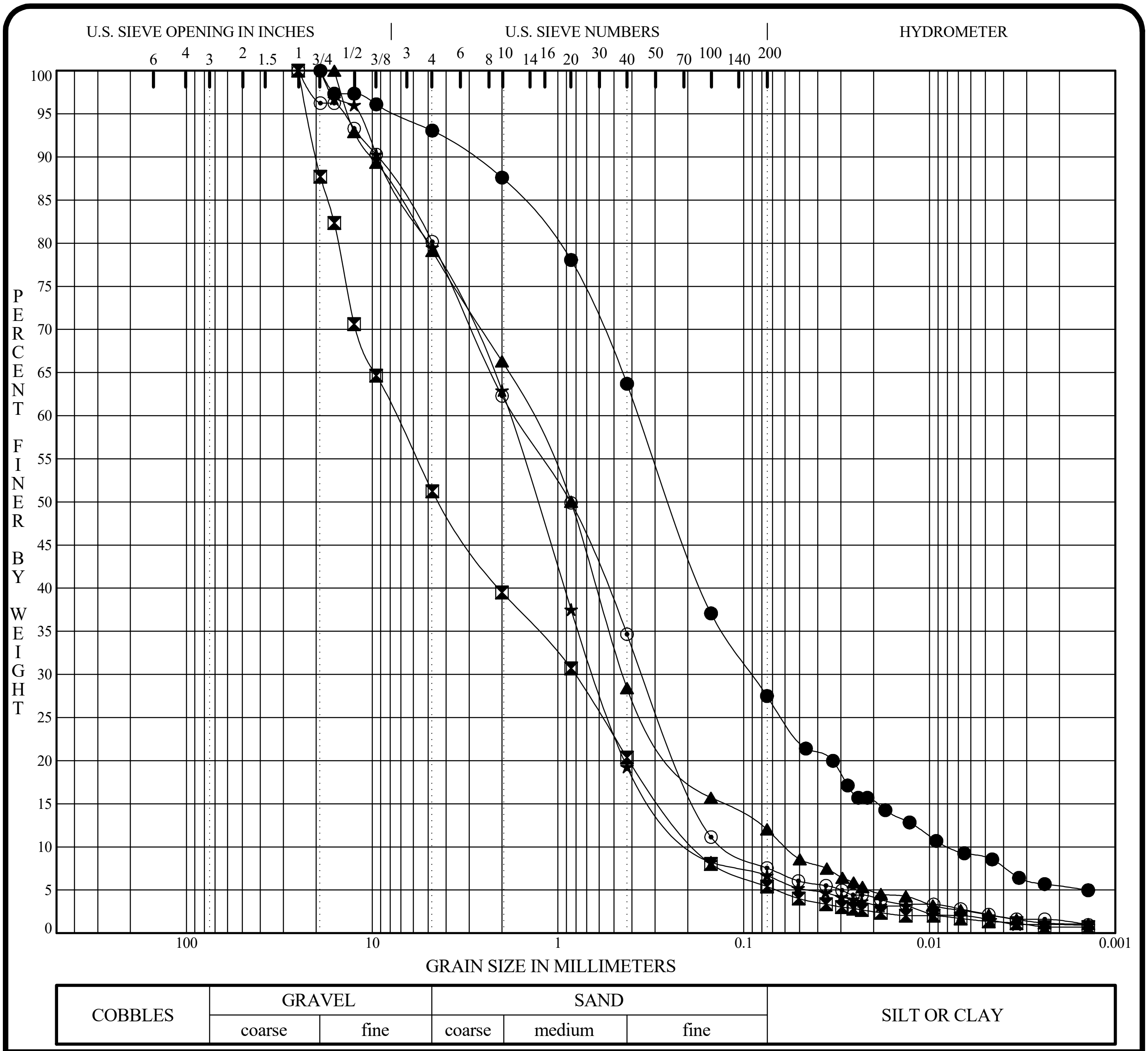
GRADATION CURVES



Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **B-3 42.0'**	**Silty sand, a little gravel (SM)**					**2.82**	**47.3**
⧗ **B-4 24.5'**	**Sandy gravel with silt (GP-GM)**					**0.50**	**42.2**
▲ **B-5 9.5'**	**Silty sand with gravel (SM)**					**2.36**	**24.3**
★ **B-5 12.0'**	**Sand with silt and gravel (SW-SM)**					**1.27**	**10.2**
⊙ **B-5 29.5'**	**Sand with silt and gravel (SP-SM)**					**0.58**	**14.2**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-3 42.0'**	**19.00**	**0.37**	**0.090**	**0.0078**	**6.9**	**65.6**	**18.8**	**8.7**
⧗ **B-4 24.5'**	**25.00**	**7.47**	**0.812**	**0.1773**	**48.8**	**45.8**	**4.0**	**1.4**
▲ **B-5 9.5'**	**16.00**	**1.44**	**0.447**	**0.0591**	**20.9**	**67.1**	**9.9**	**2.2**
★ **B-5 12.0'**	**19.00**	**1.81**	**0.639**	**0.1774**	**20.5**	**72.8**	**5.1**	**1.6**
⊙ **B-5 29.5'**	**25.00**	**1.71**	**0.346**	**0.1204**	**19.8**	**72.6**	**5.3**	**2.2**

PROJECT **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

AET JOB NO. **P-0006986**

DATE **1/26/22**

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GRADATION CURVES

Gradation and Hydrometer Results Table
Percent Passing Each Sieve

Stormwater and Greenway Project, 325 Blake Rd
AET Project Number P-0006986

	Sieve Size											
Sample Location	**1.5"**	**1"**	**3/4"**	**5/8"**	**1/2"**	**3/8"**	**#4**	**#10**	**#20**	**#40**	**#100**	**#200**
B-1, 4.5-6'		100	82	74	65	59	53	43	30	21	13	8.7
B-1, 12-13.5'					100	99	97	94	80	35	5	3.4
B-1, 32-33.5'		100	95	95	94	93	88	81	73	62	38	29.6
B-1, 42-43.5'					100	99	93	84	68	40	9	5.4
B-2, 12-13.5'		100	86	80	78	71	59	42	25	13	5	3.6
B-2, 27-28.5'	100	89	76	73	68	63	46	31	20	13	6	4.7
B-2, 64.5-66'				100	98	98	94	89	82	68	35	25.4
B-3, 7-8.5'					100	98	93	88	78	62	42	39.0
B-3, 12-13.5'					100	97	90	77	58	31	17	13.5
B-3, 17-18.5'				100	97	90	82	66	43	20	8	7.0
B-3, 27-28.5'				100	98	96	93	89	83	72	44	32.8
B-3, 42-43.5'			100	97	97	96	93	88	78	64	37	27.5
B-4, 7-8.5'				100	97	97	91	79	62	31	7	5.2
B-4, 24.5-26'		100	88	82	71	65	51	40	31	20	8	5.4
B-4, 42-43.5'				100	99	97	89	81	70	53	24	16.4
B-5, 9.5-11'				100	93	89	79	66	50	28	16	12.0
B-5, 12-13.5'			100	97	96	90	80	63	38	19	8	6.7
B-5, 29.5-31'		100	96	96	93	90	80	62	50	35	11	7.6

Hydrometer Results									
B-1, 32-33.5'		**B-2, 27-28.5'**		**B-3, 7-8.5'**		**B-3, 12-13.5'**		**B-3, 27-28.5'**	
Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing
0.046	24.7	0.0496	3.8	0.0452	31.5	0.0507	10.2	0.0465	25.8
0.0333	21.4	0.0354	3.3	0.0323	29.6	0.036	9.4	0.0335	23.1
0.0275	19.8	0.029	3.2	0.0267	27.8	0.0295	8.6	0.0275	22.3
0.024	18.1	0.0252	3.0	0.0234	25.9	0.0258	7.5	0.0241	20.5
0.0215	18.1	0.0226	2.9	0.0211	25.0	0.0232	6.7	0.0216	19.6
0.0172	16.5	0.0181	2.4	0.0169	22.2	0.0183	6.3	0.0173	17.8
0.0127	14.0	0.0132	2.4	0.0126	19.4	0.0135	5.5	0.0128	16.0
0.0091	12.4	0.0094	2.0	0.009	16.7	0.0096	4.7	0.0091	14.2
0.0065	9.9	0.0067	1.7	0.0065	13.9	0.0068	3.9	0.0065	12.4
0.0047	8.2	0.0048	1.4	0.0046	12.0	0.0048	3.1	0.0046	10.7
0.0033	7.3	0.0033	1.2	0.0032	11.1	0.0034	2.3	0.0033	8.0
0.0024	6.7	0.0024	1.0	0.0023	9.2	0.0024	2.3	0.0024	7.1
0.0014	4.7	0.0014	0.7	0.0014	8.3	0.0014	1.5	0.0014	5.3
B-3, 42-43.5'		**B-4, 24.5-26'**		**B-5, 9.5-11'**		**B-5, 12-13.5'**		**B-5, 29.5-31'**	
Particle Size (mm)	Percent Passing	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
0.0463	21.4	0.0506	4.0	0.0499	8.5	0.0511	5.2	0.0508	6.0
0.0331	20.0	0.0361	3.3	0.0357	7.5	0.0363	4.7	0.0361	5.5
0.0276	17.1	0.0296	3.0	0.0294	6.4	0.0298	4.2	0.0296	5.0
0.0242	15.7	0.0257	2.9	0.0256	5.9	0.0258	3.9	0.0258	4.4
0.0216	15.7	0.0231	2.7	0.023	5.3	0.0232	3.7	0.0231	4.4
0.0173	14.3	0.0183	2.4	0.0183	4.5	0.0184	3.2	0.0183	3.9
0.0128	12.8	0.0134	2.0	0.0134	4.3	0.0134	3.2	0.0134	3.3
0.0092	10.7	0.0095	2.0	0.0096	3.2	0.0096	2.1	0.0095	3.3
0.0065	9.3	0.0068	1.7	0.0068	2.7	0.0068	2.0	0.0068	2.8
0.0046	8.5	0.0048	1.4	0.0048	2.1	0.0047	1.5	0.0048	2.2
0.0033	6.4	0.0034	1.1	0.0034	1.6	0.0034	1.0	0.0034	1.6
0.0024	5.7	0.0024	0.7	0.0024	1.2	0.0024	1.0	0.0024	1.6
0.0014	5.0	0.0014	0.7	0.0014	1.1	0.0014	0.9	0.0014	1.0

Appendix B

Geotechnical Report Limitations and Guidelines for Use

Appendix B
Geotechnical Report Limitations and Guidelines for Use
Report No. P-0006986

B.1 REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by GBA[1], of which, we are a member firm.

B.2 RISK MANAGEMENT INFORMATION

B.2.1 Understand the Geotechnical Engineering Services Provided for this Report

Geotechnical engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical engineering services is typically a geotechnical engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

B.2.2 Geotechnical Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client.

Likewise, geotechnical engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do <u>not</u> rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. If you are the least bit uncertain about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

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[1] Geoprofessional Business Association, 1300 Piccard Drive, LL14, Rockville, MD 20850
Telephone: 301/565-2733: www.geoprofessional.org, 2019

B.2.3 Read the Full Report

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. Read and refer to the report in full.

B.2.4 You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, always inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

B.2.5 Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

B.2.6 This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations only after observing actual subsurface conditions exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.

B.2.7 This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

B.2.8 Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical engineering report, along with any attachments or appendices, with your contract documents, but be certain to note conspicuously that you've included the material for information purposes only. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, only from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and be sure to allow enough time to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

B.2.9 Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled “limitations,” many of these provisions indicate where geotechnical engineers’ responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

B.2.10 Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a “phase-one” or “phase-two” environmental site assessment – differ significantly from those used to perform a geotechnical engineering study. For that reason, a geotechnical engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated subsurface environmental problems have led to project failures. If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

B.2.11 Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer’s services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, proper implementation of the geotechnical engineer’s recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. Geotechnical engineers are not building-envelope or mold specialists.

April 1, 2022

HDR Engineering, Inc.
701 Xenia Avenue South, Suite 600
Minneapolis, MN 55416

Attn: Ms. Greta Backman
Greta.Backman@HDRinc.com

RE: Instantaneous Change in Head Tests Summary Report
Stormwater and Greenway Project
325 Blake Road North
Hopkins, Minnesota
AET Project No. P-0006986

Dear Ms. Backman:

PURPOSE

American Engineering Testing (AET) has completed instantaneous change in head tests (slug tests) in one monitoring well located at 325 Blake Road North in Hopkins, Minnesota. The slug tests were performed to calculate hydraulic conductivity values of soils (sediment) hydraulically connected to the well. This report presents the results of these tests.

TEST PROCEDURES

Slug tests were performed on February 9, 2022, in monitoring well B-5 (P-5) installed by AET in accordance with your specifications. The approximate location of the monitoring well B-5 is depicted on the **Boring Location Map**. The well consisted of 2-inch diameter PVC screen, 5 feet in length, with an attached riser pipe. The screened interval for the well was approximately between 31.5 feet and 36.5 feet below ground surface (bgs).

The boring log for this well shows the presence of a combination of coarse-grained soils and some fine-grained soils. The fine-grained soils were primarily silt. The coarse-grained soils included sands and gravel. The boring log is included in **Appendix A**. The screened interval was chosen based upon your specifications. The well construction log is included in **Appendix B**.

Prior to performing slug tests, AET developed the monitoring well to establish a hydraulic connection with the aquifer within the well screen interval of monitoring. Well development activities consisted of surging and purging groundwater by uplifting and descending a submersible groundwater pump throughout the groundwater column within the screened interval of the completed well. The groundwater pumped from the well was discharged to a volumetric measuring device (e.g., 5-gallon bucket) and then subsequently discharged to the ground surface outside the well. Visible water clarity during and after well development activities was used to evaluate the efficacy of well development activities.

In general, brown, cloudy or turbid discharge water may indicate a poor hydraulic connection to the surrounding aquifer, whereas clear discharge water may indicate an established connection between the screened well pack and surrounding aquifer. Wells that purge dry during well development activities may be limited by the low hydraulic conductivity of the surrounding geologic materials.

Monitoring well B-5 did not purge dry during well development activities. Total volume of water purged from the well during development activities was 125 gallons and the appearance of the discharge water at the end of development activities was clear, indicating an adequate hydraulic connection was established between the screened well pack and surrounding aquifer.

Slug tests were performed in general accordance with ASTM: D4044-96. Slug testing consisted of measuring temporal changes in water levels in the tested wells upon the quick introduction and then quick removal of a solid cylinder (i.e., slug) in the water column. The introduction and removal of the slug are referred to as “slug in” and “slug out” tests, respectively. Three “slug in” and “slug-out” tests were performed on B-5. The groundwater level was measured in the wells from top-of-casing (TOC) prior to starting the test and after the test was completed.

Temporal changes in water level were measured with a water level probe deployed within each monitoring well. The probe consisted of a down-hole pressure transducer set in the well and positioned within two feet below the maximum depth of the slug. The pressure transducer was connected to an electronic data logger that recorded the temporal water level changes. The water level changes were recorded following a logarithmically decaying schedule set to record in seconds, with many measurements recorded at one half second intervals during the beginning of the test. The time between recordings increased during the test until it reached 15 minutes between measurements, at which point it then began recording changes in the water level at constant rate of one measurement every 15 minutes, if applicable. The resulting recording produced a set of time-displacement water level data for each test.

The time-displacement water data for each “slug in” and “slug out” test were used to calculate the hydraulic conductivity values for each well using curve matching analysis methods with the Bouwer-Rice unconfined solutions. Curve matching analysis was performed using Aqtesolv® Pro v. 4.50 computer software or fit by hand, using professional judgement, when applicable. Data from a total of 6 slug tests were analyzed for the wells, 3 of which were “slug in” and 3 were “slug out”.

TEST RESULTS

Appendix C includes the three sets of analyzed slug testing data. The data were graphed with normalized head values relative to the static water level. The graphs show the time-displacement data for the test, and the best-fit line plotted that is used for obtaining the estimated hydraulic conductivity based on the Bouwer-Rice solution.

The depth to groundwater measured at monitoring well B-5 from TOC prior to inserting any test equipment in the well was 13.64 feet.

A water level measurement was also taken after the test was completed.

Hydraulic conductivity values were obtained from curve matching the Bouwer and Rice solution for unconfined conditions in B-5. The calculated values from the slug test data are as follows:

B-5:
Run 1 – Slug In = 1.314 x 10^{-2} cm/sec
Run 2 – Slug In = 1.159 x 10^{-2} cm/sec
Run 3 – Slug In = 1.047 x 10^{-2} cm/sec
Slug In Average = 1.173 x 10^{-2} cm/sec

Run 1 – Slug Out = 1.037 x 10^{-2} cm/sec
Run 2 – Slug Out = 8.884 x 10^{-3} cm/sec
Run 3 – Slug Out = 1.009 x 10^{-2} cm/sec
Slug Out Average = 9.781 x 10^{-3} cm/sec

B-5 Average = 1.076 x 10^{-2} cm/sec

The average hydraulic conductivity value from the slug test data for the wells on-site was calculated to be 1.076 x 10^{-2} centimeters per second. These values are consistent with hydraulic conductivity of sediments such as silty sands to clean sands (Freeze & Cherry, 1979).

STANDARD OF CARE

AET has endeavored to perform its services for this project in a manner consistent with the level of skill and care ordinarily exercised by other members of the profession currently practicing in this area, under similar budgetary and time constraints. No additional warranty, expressed or implied, is made.

This report is based on our current understanding of the project and conditions at the Site. If conditions differing from our findings are identified, AET should be immediately contacted to review these conditions. Any alterations to this report will be communicated to HDR Engineering, Inc., and any other involved parties HDR Engineering, Inc. may reasonably request. If you have any questions regarding the information presented, or if AET can be of additional service, please contact Jake Dalbec at (651) 603-6624 or jdalbec@teamaet.com.

Sincerely,
American Engineering Testing, Inc.

Jake Dalbec

Jake T. Dalbec, PG (MN, WI)
Senior Geologist
Phone: (651) 603-6624
Email: jdalbec@teamaet.com

Eric Hesse, PE (MN, WI, IA, ND, SD, NE, AZ)
Environmental Division Manager
Phone: (651) 659-1307
Email: ehesse@teamaet.com

Attachments: Boring Location Map
Appendix A – Boring Log
Appendix B – Monitoring Well/Piezometer Construction Log
Appendix C – Slug Testing Data
Appendix D – References

Cc: Ms. Kerrie Berg, PE, HDR Engineering, Inc.

Figures

Stormwater and Greenway Project
325 Blake Rd N, Hopkins, Minnesota

Boring Location Map

AET Project No. P-0006986

Scale: Shown

Drawn by: TE

Reviewed by: JB

Date: February 2, 2022

AMERICAN
ENGINEERING TESTING

Appendix A

Boring Log

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986**

LOG OF BORING NO. **B-5 (p. 1 of 1)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

SURFACE ELEVATION: **907.3** LATITUDE: **44.930157** LONGITUDE: **-93.382573**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	FILL, mostly silty sand, with gravel, brown, frozen	FILL		F	SU						
2	FILL, mostly silty sand, a little gravel, brown										
3			13	M	SS	4					
4											
5			5	M	SS	6					
6											
7	FILL, mixture of clayey sand with organic fines and silty sand, black and brown										
8			15	M	SS	12	19				
9											
10	SILTY SAND WITH GRAVEL, brown, moist, medium dense (SM)	COARSE ALLUVIUM	19	▼ M	SS	12					12
11											
12	SAND WITH SILT AND GRAVEL, fine to medium grained, brown, waterbearing, medium dense (SP-SM)										
13			11	W	SS	13					7
14											
15			16	W	SS	4					
16											
17	SAND, a little gravel, fine to medium grained, brown, waterbearing, medium dense (SP)										
18			26	W	SS	3					
19											
20			19	W	SS	10					
21											
22											
23			24	W	SS	10					
24											
25			23	W	SS	10					
26											
27											
28			26	W	SS	12					
29	SAND WITH SILT AND GRAVEL, fine to medium grained, brown, wet, very dense to dense (SP-SM)										
30			111	W	SS	10					8
31											
32											
33			74	W	SS	16					
34											
35			50	W	SS	10					
36	**END OF BORING**										

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14'	**3.25" HSA**							
14-34½'	**RD w/DM**	**1/25/22**	**10:40**	**13.5**	**12.0**	**11.8**		**10.6**
		1/25/22	**10:50**	**13.5**	**12.0**	**11.7**		**10.5**
BORING COMPLETED: **1/26/22**								
DR: **SG** LG: **SB** Rig: **41**								

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

Appendix B

Monitoring Well/Piezometer Construction Log

AMERICAN ENGINEERING TESTING

Monitoring Well/Piezometer Log

AET Job No.: P-0006986

Well No.: P-5

Project: Stormwater and Greenway Project, 325 Blake Rd N

Unique Well No.: 843599

Location: Hopkins, MN

Drilling Method: 4.25" HSA

Date Installed: 1/26/22

Drilling Fluids (type):

Project Manager: Tommy Evans

Completed by: JD, Revised 4/1/22

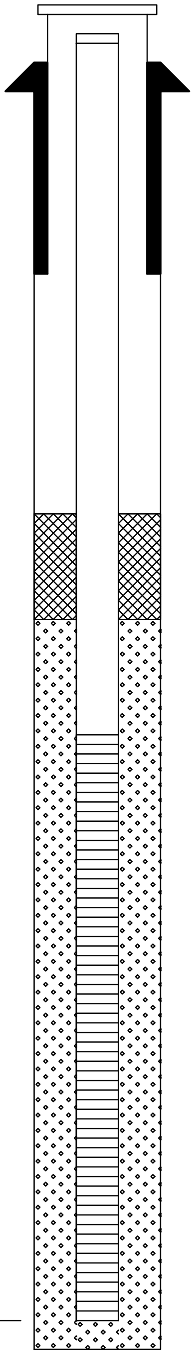
Annular Space Details

Type of Surface Seal: Portland

Type of Annular Sealant: Bentonite Cement Grout

Type of Bentonite Seal (Granular Pellet): N/A

Type of Sand Pack: #40 Red Flint



3.0 Top of Protective Casing

2.9 Top of Riser Pipe

0.0 Ground Surface

N/A Top of Annular Sealant

4.0 Bottom of Protective Casing

N/A Top of Seal

28.0 Top of Sand

31.5 Top of Screen

Do 8.25

36.5 Bottom of Screen

36.5' Bottom of Borehole

Well Construction Materials

	Stainless Steel Specify Type	PVC Specify Type	Other Specify Type
Riser Coupling Joint	---	2" FT Sch 40	---
Riser Pipe Above w.t.	---	2" FT Sch 40	---
Riser Pipe Below w.t.	---	2" FT Sch 40	---
Screen	---	2" FT Sch 40	---
Protective Posts	---	---	---
Protective Casing	---	---	---

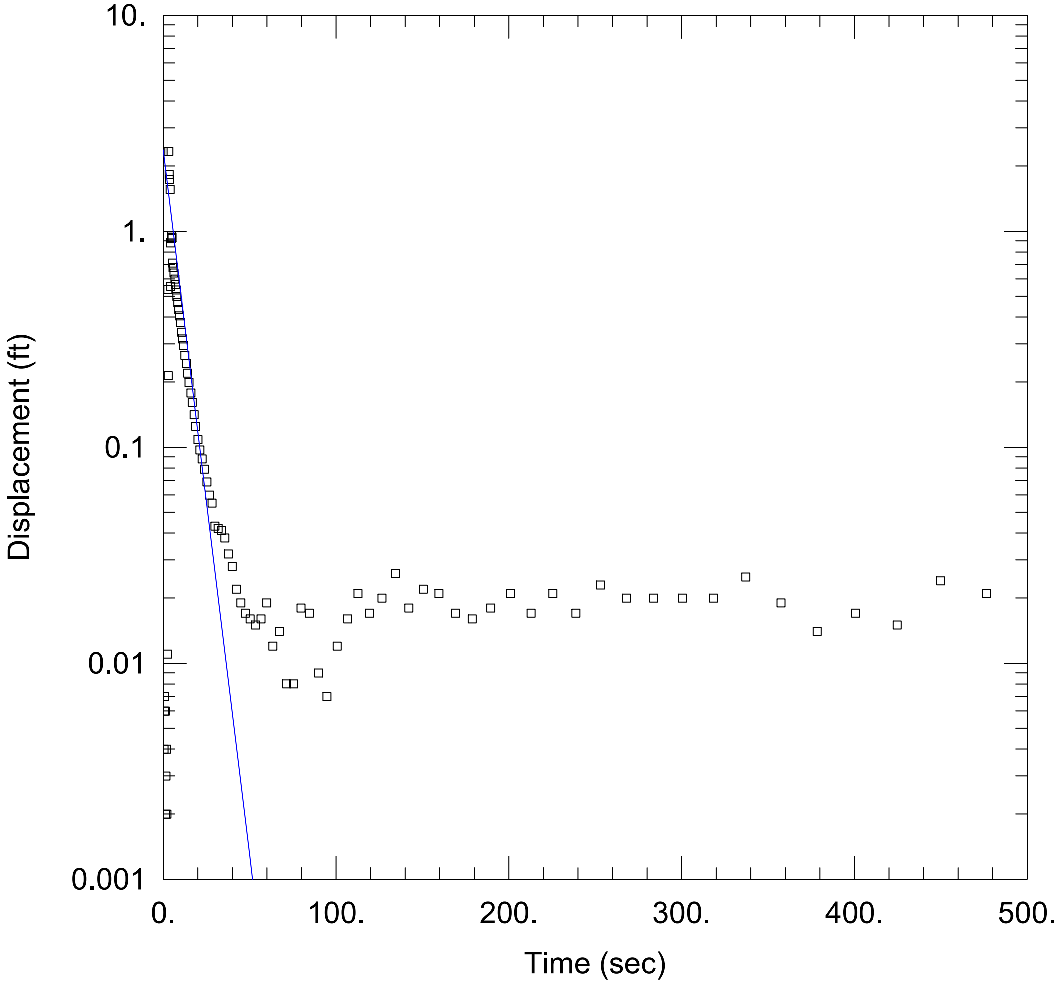
Measurements

to 0.1 ft (where applicable)

Protective Casing Length	7'
Riser Pipe Length	31.5
Screen Length	5.0
Screen Slot Size	.010
Top of Riser Elevation	910.2
Ground Surface Elevation	907.3
Depth to Water	10.5
Water Elevation	896.8
Other	

Appendix C

Slug Testing Data



RUN 1 IN

Data Set: X:\...\B-5 Run 1 IN.aqt
Date: 04/01/22 Time: 12:15:18

PROJECT INFORMATION

Company: American Engineering Testing
Client: HDR Engineering, Inc.
Project: P-0006986
Location: Hopkins, MN
Test Well: B-5
Test Date: 2/9/22

AQUIFER DATA

Saturated Thickness: 25.61 ft
Anisotropy Ratio (Kz/Kr): 1.

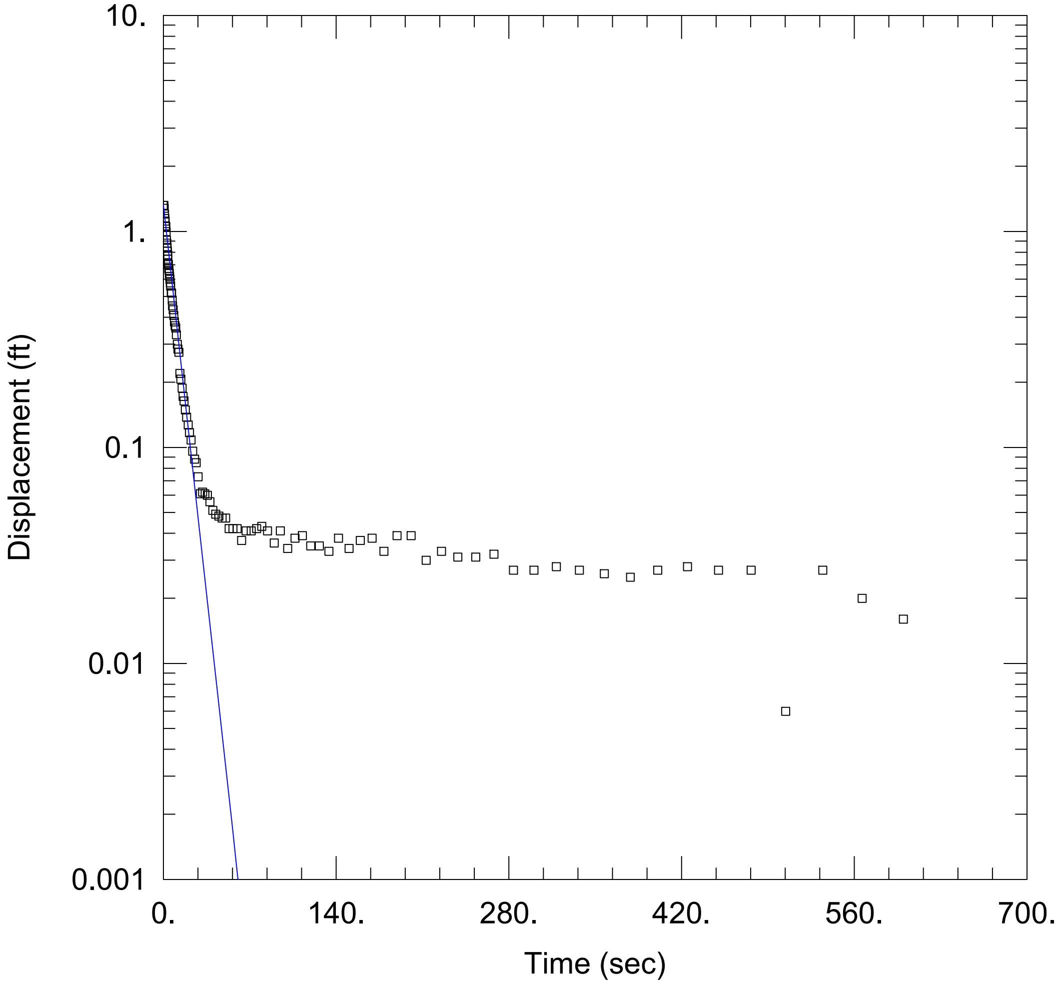
WELL DATA (B-5)

Initial Displacement: 2.336 ft
Total Well Penetration Depth: 25.61 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 25.61 ft
Screen Length: 5. ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.01314 cm/sec
y0 = 2.374 ft



RUN 1 OUT

Data Set: X:\...\B-5 Run 1 OUT.aqt
Date: 04/01/22 Time: 12:16:24

PROJECT INFORMATION

Company: American Engineering Testing
Client: HDR Engineering, Inc.
Project: P-0006986
Location: Hopkins, MN
Test Well: B-5
Test Date: 2/9/22

AQUIFER DATA

Saturated Thickness: 25.61 ft
Anisotropy Ratio (Kz/Kr): 1.

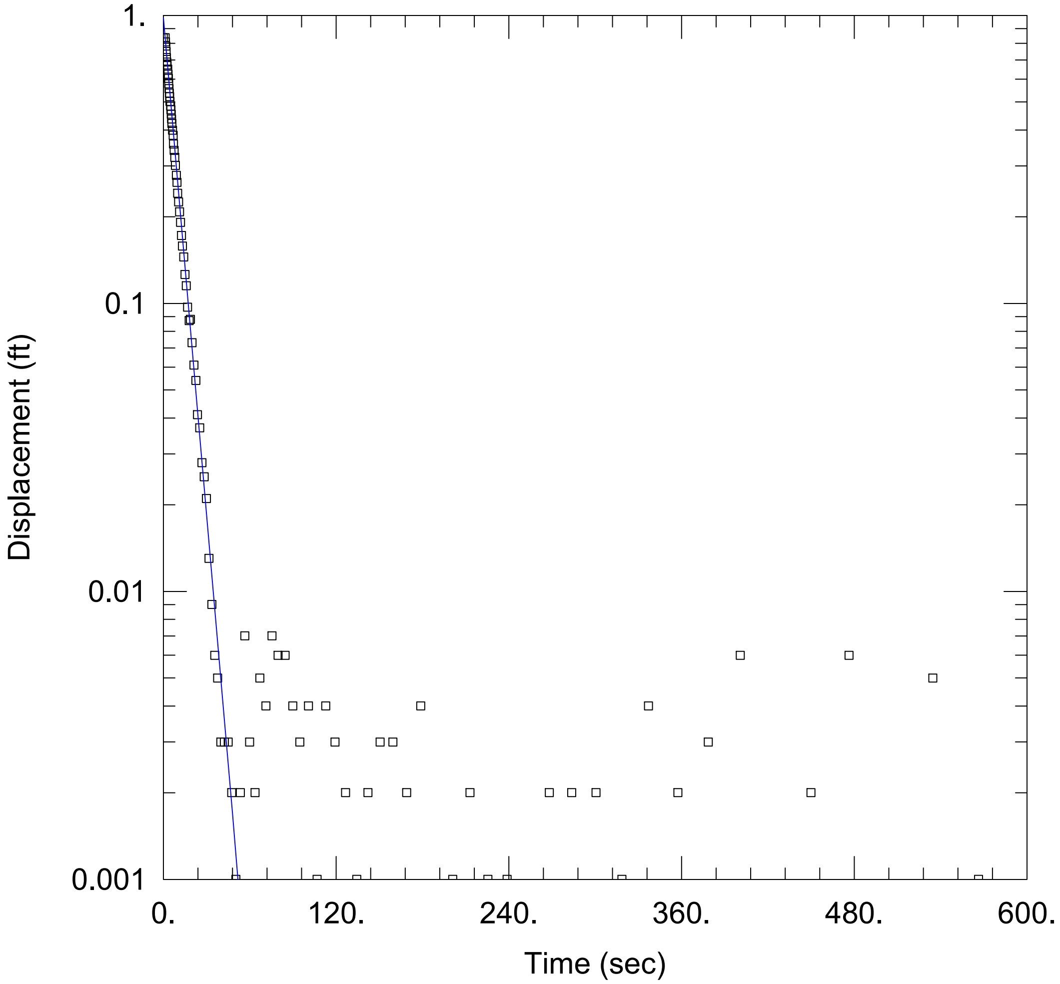
WELL DATA (B-5)

Initial Displacement: 1.32 ft
Static Water Column Height: 25.61 ft
Total Well Penetration Depth: 25.61 ft
Screen Length: 5. ft
Casing Radius: 0.0833 ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.01037 cm/sec
y0 = 1.326 ft



RUN 2 IN

Data Set: X:\...\B-5 Run 2 IN.aqt
Date: 04/01/22
Time: 12:17:15

PROJECT INFORMATION

Company: American Engineering Testing
Client: HDR Engineering, Inc.
Project: P-0006986
Location: Hopkins, MN
Test Well: B-5
Test Date: 2/9/22

AQUIFER DATA

Saturated Thickness: 25.61 ft
Anisotropy Ratio (Kz/Kr): 1.

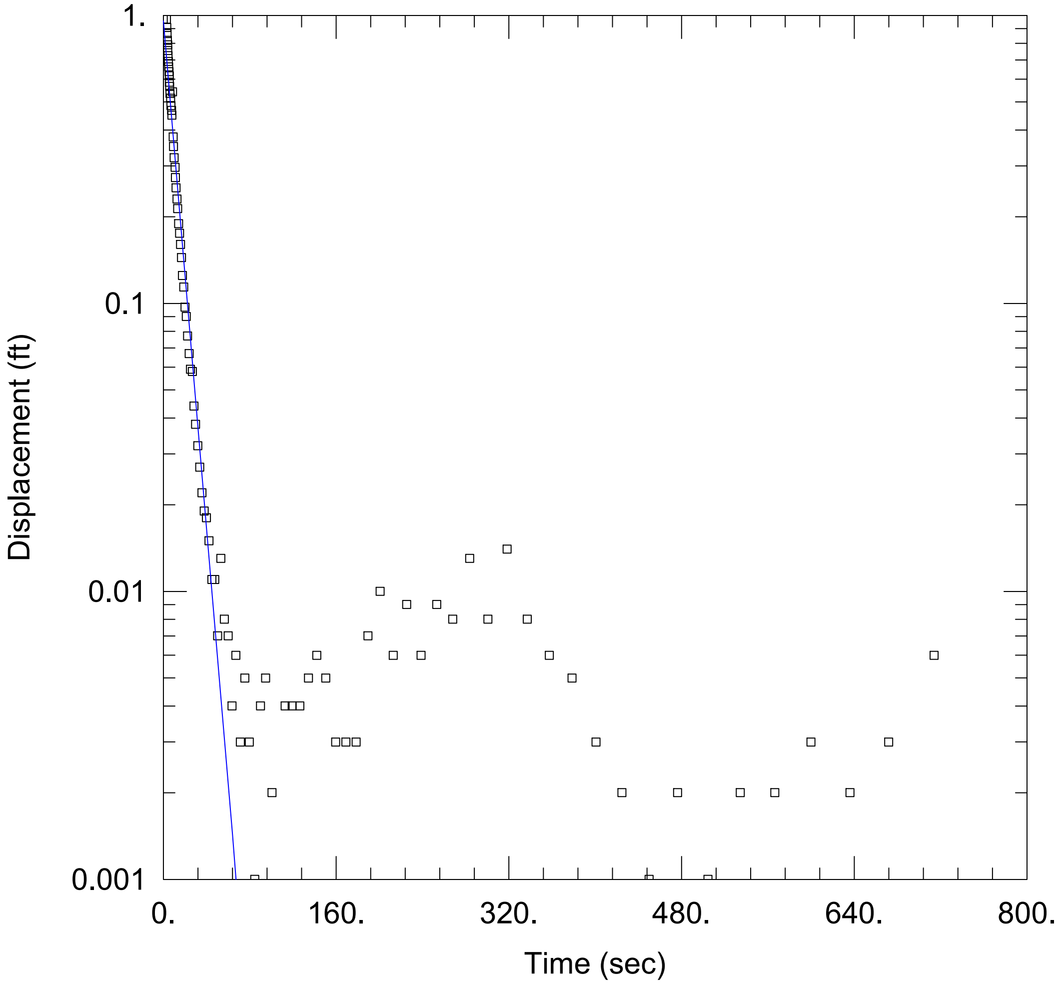
WELL DATA (B-5)

Initial Displacement: 0.836 ft
Static Water Column Height: 25.61 ft
Total Well Penetration Depth: 25.61 ft
Screen Length: 5. ft
Casing Radius: 0.0833 ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.01159 cm/sec
y0 = 0.9814 ft



RUN 2 OUT

Data Set: X:\...\B-5 Run 2 OUT.aqt
Date: 04/01/22 Time: 12:17:35

PROJECT INFORMATION

Company: American Engineering Testing
Client: HDR Engineering, Inc.
Project: P-0006986
Location: Hopkins, MN
Test Well: B-5
Test Date: 2/9/22

AQUIFER DATA

Saturated Thickness: 25.61 ft Anisotropy Ratio (Kz/Kr): 1.

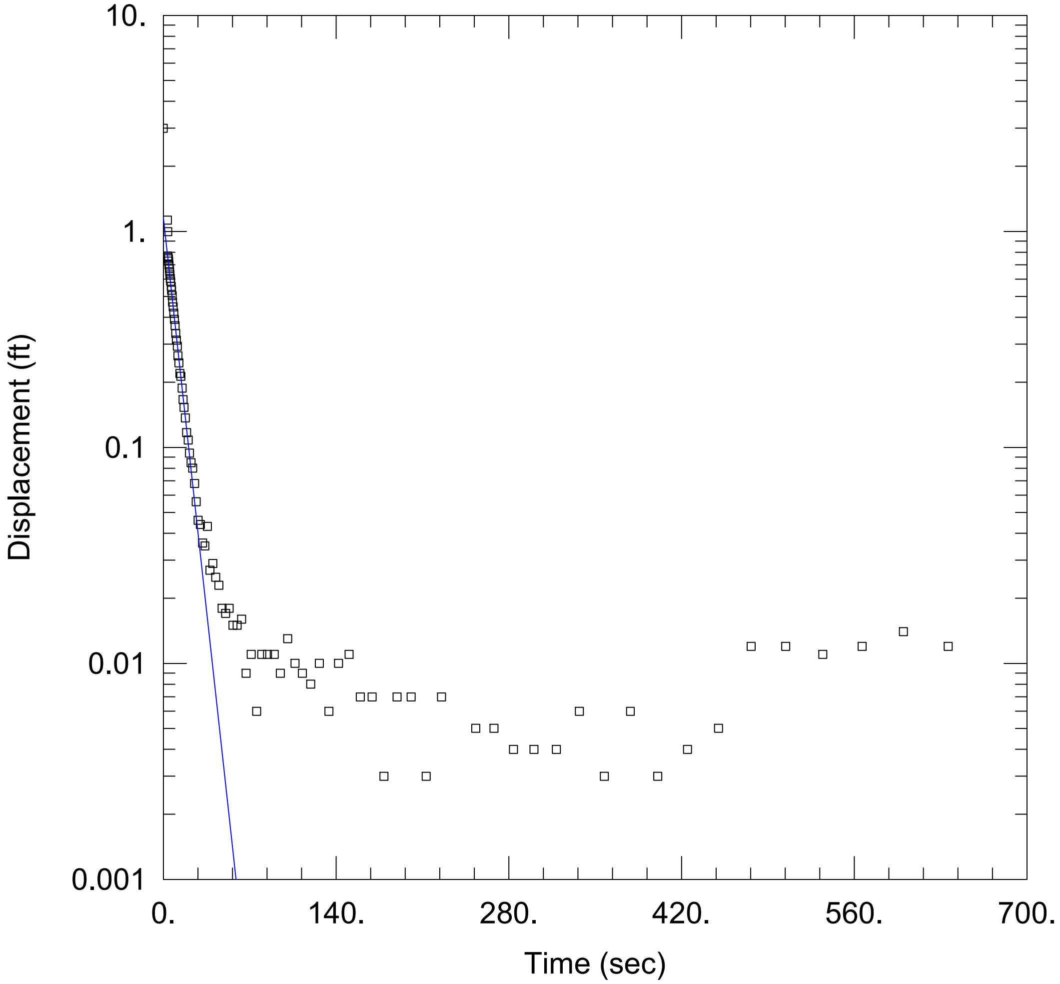
WELL DATA (B-5)

Initial Displacement: 0.97 ft
Total Well Penetration Depth: 25.61 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 25.61 ft
Screen Length: 5. ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.008884 cm/sec y0 = 0.9552 ft



RUN 3 IN

Data Set: X:\...\B-5 Run 3 IN.aqt
Date: 04/01/22 Time: 12:18:27

PROJECT INFORMATION

Company: American Engineering Testing
Client: HDR Engineering, Inc.
Project: P-0006986
Location: Hopkins, MN
Test Well: B-5
Test Date: 2/9/22

AQUIFER DATA

Saturated Thickness: 25.61 ft Anisotropy Ratio (Kz/Kr): 1.

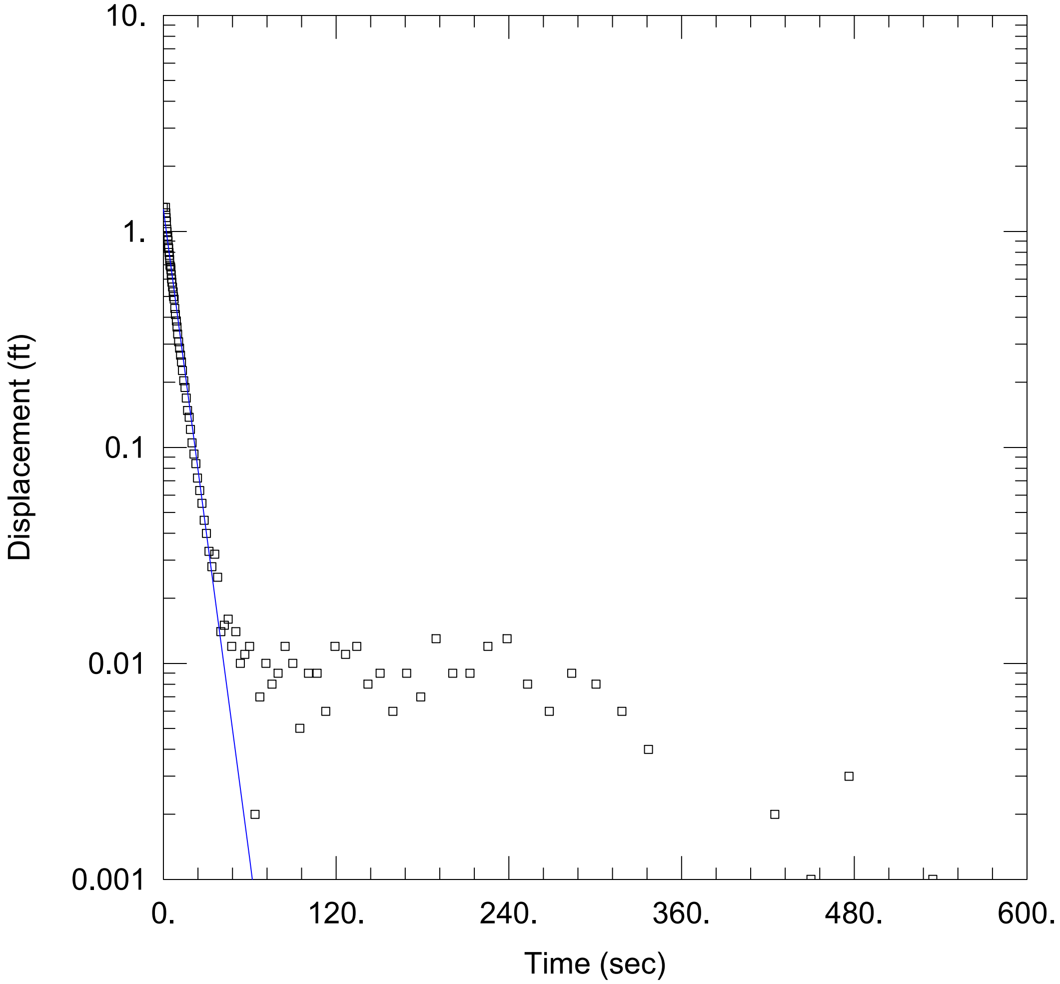
WELL DATA (B-5)

Initial Displacement: 3.004 ft Static Water Column Height: 25.61 ft
Total Well Penetration Depth: 25.61 ft Screen Length: 5. ft
Casing Radius: 0.0833 ft Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.01047 cm/sec y0 = 1.152 ft



RUN 3 OUT

Data Set: X:\...\B-5 Run 3 OUT.aqt
Date: 04/01/22
Time: 12:18:46

PROJECT INFORMATION

Company: American Engineering Testing
Client: HDR Engineering, Inc.
Project: P-0006986
Location: Hopkins, MN
Test Well: B-5
Test Date: 2/9/22

AQUIFER DATA

Saturated Thickness: 25.61 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (B-5)

Initial Displacement: 1.292 ft
Total Well Penetration Depth: 25.61 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 25.61 ft
Screen Length: 5. ft
Well Radius: 0.0833 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.01009 cm/sec
y0 = 1.262 ft

Appendix D

References

References

Freeze and Cherry, 1979. Groundwater. Prentice-Hall, Inc., 29p.

Attachment B

Existing Well Monitoring Data:

- Existing Monitoring Well Logs
- Piezometer Data from the University of Minnesota 2013 Report
- Wenck 2017 Groundwater Monitoring Report
- Wenck 2016 Technical Memo

MWMO

Protect it. Pass it on.

MISSISSIPPI
WATERSHED
MANAGEMENT
ORGANIZATION

MINNEHAHA CREEK
WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

Baseflow Restoration in Minnehaha Creek Watershed with Stormwater Infiltration

MWMO Watershed Bulletin: 2014-3
Prepared for the MWMO by:
University of Minnesota

Appendix IV. Piezometer Installation Details

Shallow monitoring wells were installed at 4 sites along the creek as described in Section 3.3. At each site, three to four 2-in diameter, PVC wells were installed in the riparian zone approximately perpendicular to flow in the creek. A plan view of piezometer locations is provided in Figure 12. The following sections provide greater detail as to piezometer installations and observed stratigraphy for each of the sites.

Jidana Wetland

All wells at the Jidana wetland site were hand-augered to a depth ranging from 3 to 5.5 ft below the surface. Vegetation at the site transitioned from cattails (edge of the channel to piezometer 2 as labled in Figure A.5.), to *Phragmites* (piezometer 1), to trees (piezometer A). All piezometers were screened in the sandy aquifer underlying up to 4 feet of organic material at the site. Piezometers were screened across the bottom-most 10-inches of the PVC pipe. The aquifer was comprised predominantly of coarse sand interspersed with gravel and small rocks (up to 3-inches in diameter). With the exception of piezometer 1, which was dry from August 2012 to March 2013, the water table remained above screened sections.

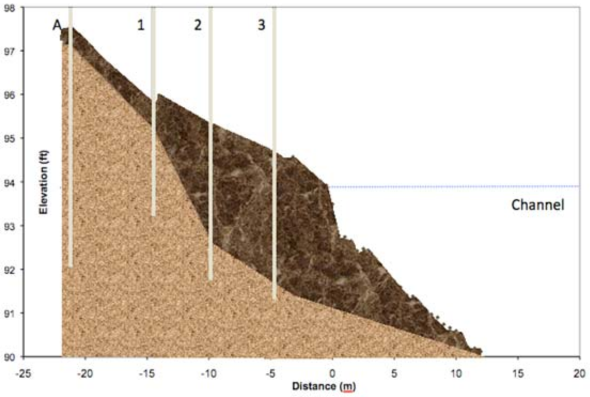


Figure A.5. Cross-section of wells installed at the Jidana wetland. The cross section is comprised of a layer of organic material (dark brown shading) up to 4-ft thick near the stream underlain by a layer of coarse sand and gravel/cobble (light brown shading) to which the 10-in screened interval at the bottom of all wells is open.

Lahti Wetland

Two sets of piezometers were installed at the Lahti wetland (Figure 12). Piezometers at the upstream end of the site were installed during the spring of 2013. Piezometers 1 and 3 were installed by hand while a drill rig was used to install piezometers 2s and 2d. Cattails were the dominant vegetation type from the channel to piezometer 1. A layer of organic material with a relatively uniform thickness of 4 to 5 ft was encountered at this site. Although at different depths (Figure A.6.), all piezometers were open to the same sand and gravel aquifer underlying the layer of organic material. An additional bore hole was augered near the location of piezometers 2s and 2d to discern the presence of any low permeability layers within the aquifer. Such a layer, consisting of silty-clay till, was encountered at a depth of 45 ft. The water table remained perched above the ground surface at all piezometers from June to early August, 2013.

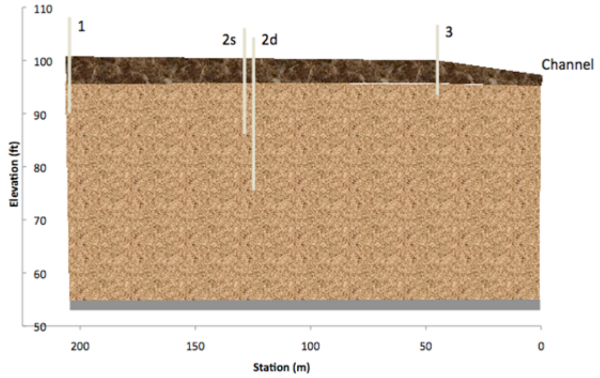


Figure A.6. Cross-section of wells installed on the upstream end of the Lahti wetland site. A relatively uniform, 4-ft thick organic layer (brown shading), overlays the sandy aquifer (light brown shading). The 10-in screened interval of all piezometers is open to the sandy aquifer. A confining sandy clay layer (dark gray shading) was encountered at a depth of about 45 ft in a boring conducted near piezometers 2s and 2d. Note that the extension of this layer across the rest of the site is assumed.

The second set of piezometers was installed approximately 1000 ft downstream (Figure A.7.) Grasses, namely *Phragmites,* were the dominant vegetation type across this site. A relatively thick (about 6 ft) organic layer was encountered immediately below the ground surface. A 10-inch screened section at the bottom of all piezometers was open to the sand and gravel aquifer underlying this organic layer. A thin clay layer was encountered between the organic and sandy aquifer at piezometers 1 and 2.

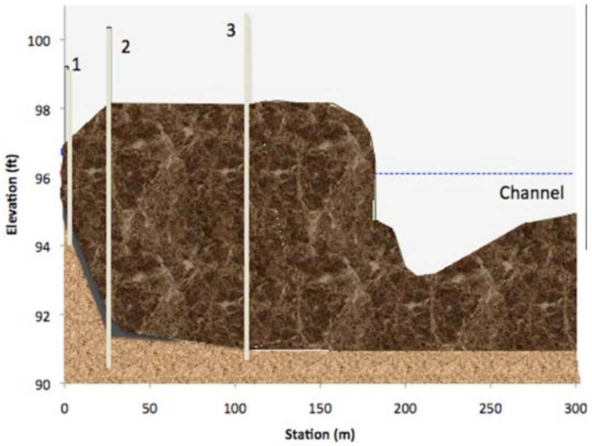


Figure A.7. Cross-section of wells installed on the downstream end of the Lahti wetland site. A thick layer (up to 6 ft) of organic soil (brown shading) overlays a layer of gleyed, silty sand (light brown shading) to which the 10-in screened interval of all piezometers is open. A thin clay layer (solid gray shading) capping the sand layer was observed at Piezometers 1 and 2. The piezometric head in piezometer 3 was greater than the ground surface throughout monitoring in 2013.

Blake Cold Storage Site

Soil characteristics within the riparian area immediately adjacent to the site were examined with a hand auger (Figure A.8.). Piezometer installation was also completed with a hand auger in July 2012. A silt layer ranging in thickness from 1 to 3 feet overlays a relatively compacted till layer (Figure A.9.) Compared to the other sites, this gravely sand layer was more difficult to penetrate with the hand auger. Additional soil explorations of the lawn area between the wooded riparian area and parking lot of the Cold Storage plant were conducted by a drill rig (Figure A.8.). Borings in the lawn area indicated the presence of a 7 to 12 ft layer of silty- to clayey- sand fill material overlying a silty-sand aquifer.

Figure A.8. Approximate locations of piezometer installations (solid red circles) within wooded riparian area of creek and soil borings completed with a drill rig (black and white circles) in the upslope lawn area.

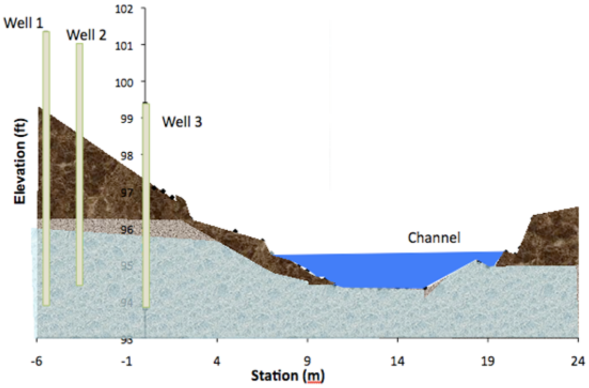


Figure A.9. Cross-section of wells installed at the Cold Storage site on Blake Road. Underlying a 1-2 foot layer of silt (dark brown shading) is a thick layer of compacted loamy sand till with large gravel and stones embedded throughout. The 10-in screened interval of all wells is open to this layer.

Utley Park

Soil stratigraphy was initially explored by hand auger during 2012 in the lawn area immediately adjacent the stream. In general, the site is overlain by about 0.5 ft of top soil, underlain by about 2 ft of compacted clay. A graveley sand layer was encountered below the clay layer; however, the diameter of gravel in this layer was too large to permit penetration with the hand auger. Due to interest in this site as a location in which groundwater may be perched, subsequent borings and piezometer installations were conducted during the spring of 2013. Figure A.10. illustrates the location and depth of piezometers relative to the stream channel. A relatively low conductivity till layer was encountered at a depth of 50 ft.

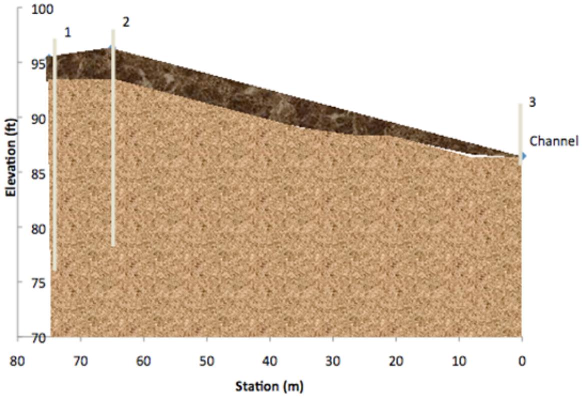


Figure A.10. Cross-section of wells installed at the Utley Park site in Edina. Underlying a 1-2 foot layer of silty-clay fill material (dark brown shading) is a thick layer of compacted loamy sand till with large gravel and stones embedded throughout. The 10-in screened interval of all wells is open to this layer.

WENCK File #B0185-0069
October 31, 2017

Phase II Environmental Site Assessment Addendum: Groundwater Monitoring Report

Hopkins Cold Storage
325 Blake Road North
Hopkins, MN

Prepared for:

Minnehaha Creek Watershed
District and Hennepin County

15320 Minnetonka Blvd.
Minnetonka, MN 55345

Responsive partner.
Exceptional outcomes.

Prepared by:

WENCK Associates, Inc.
1802 Wooddale Drive
Woodbury, MN 55125-2937
Phone: 651-294-4580
Fax: 651-228-1969

Table 1
Summary of Historical Groundwater Elevation Data
Hopkins Cold Storage
325 North Blake Road, Hopkins, Minnesota
Wenck Project No. B0185-0069
October 2017

Well ID No.	**MW-1**	**MW-2**	**MW-3**	**MW-4**	**MW-5**
Northing*	150415.50	150517.00	150584.90	150923.70	151019.30
Easting*	499515.50	499862.80	500400.80	500049.10	499471.00
TOC Elevation (ft above MSL)	909.13	907.19	911.27	907.59	913.49
Ground Elevation (ft above MSL)	907.0	907.0	909.1	905.5	910.8
Top of Screen Elevation (ft above MSL)	899.2	897.8	899.8	897.5	901.8
Bottom of Screen Elevation (ft above MSL)	889.2	887.8	889.8	887.5	891.8

Date of Measurement	**MW-1**	**MW-2**	**MW-3**	**MW-4**	**MW-5**
08/22/17	898.24	897.79	897.05	897.50	898.37
09/19/17	897.57	897.23	896.73	897.26	896.77

Notes: Horizontal coordinates values shown are the North American Datum of 1988, Hennepin County coordinate system

2016 Aerial Photograph (Source: MN GEO)

Path: L:\0185\0069\mxd\Sample Location Map.mxd
Date: 8/28/2017 Time: 11:20:55 AM User: larmb0777

Legend

▭	Subject Property
⊕	Monitoring Wells
⊗	Soil Borings
▲	Spoil Vapor

*Monitoring wells were converting from soil borings for soil and gw sampling

MCWD	WENCK Responsive partner. Exceptional outcomes.	AUG 2017
Boring Locations Map		Figure 3

Appendix A

Soil Boring Logs

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LOG OF BORING SB-1

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started	: 8/16/17	Operator	: Todd
Date Completed	: 8/16/17	Logged By	: CJA
Contractor	: Range Environmental	Checked By	: MLH
Drilling Method	: Push Probe		
Sampling Method	: Macro Core		

Water Levels
▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: 2.5'

Depth in Feet	Surf. Elev. 913	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	913	Bit		Bituminous surface			
		Fill		Gravel base			
		Fill		SAND, well graded, some silt, slight clay, gravel and organics, dark brown/black, slightly moist (Fill)		0.5-2.5'	0.1
		GW/SP		GRAVELLY SAND, medium to coarse grained, some cobbles, light brown, dry to slightly moist (Outwash)			0.4
5	908					5-7.5'	0.8
							0.6
10	903			No Recovery @ 10-15' rock in shoe			
15	898	GW/SP		GRAVELLY SAND, medium to coarse grained, some cobbles, light brown, wet (Outwash)	▼		1.3
							1.0
				End of boring @ 20'			
20							

Elevation estimated from Google Earth.

08-24-2017 C:\Users\andcj0675\Desktop\Cold Storage Boring Logs\SB-1.bor

WENCK

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LOG OF BORING SB-2

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started	: 8/16/17	Operator	: Todd
Date Completed	: 8/16/17	Logged By	: CJA
Contractor	: Range Environmental	Checked By	: MLH
Drilling Method	: Push Probe		
Sampling Method	: Macro Core		

Water Levels

▼ Water Level

Boring Depth: 20'

Estimated Depth of Fill: 9'

Depth in Feet	Surf. Elev. 912	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912	Bit		Bituminous surface			1.0
		Fill		Gravel base		0.5-2.5'	
		Fill		SILT, slight clay, sand, gravel and organics, black, slightly moist (Fill)			
		Fill		GRAVELLY SAND, well graded, brown, slightly moist, some lenses of black organic silt in part (Fill)			0.6
5	907	Fill		SANDY GRAVEL, very fine to coarse, brown, slightly moist, some brown and black silt in part (Fill)			0.8
							0.4
		GW/SP		GRAVELLY SAND, medium to coarse grained, some cobbles, light brown, moist (Outwash)	▼		
10	902			Becoming wet @ 10'		10-12.5'	0.5
							0.6
15	897			Becoming coarse grained @ 15'			0.3
							0.4
20				End of boring @ 20'			

Elevation estimated from Google Earth.

WENCK
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LOG OF BORING SB-3

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started : 8/16/17
Date Completed : 8/16/17
Contractor : Range Environmental
Drilling Method : Push Probe
Sampling Method : Macro Core

Operator : Todd
Logged By : CJA
Checked By : MLH

Water Levels
▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: 5'

Depth in Feet	Surf. Elev. 912	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912	Bit	■	Bituminous surface			
		Fill	🟧	Gravel base			
		Fill	■	SILTY CLAY, some organics, slight sand and cobbles, soft, black, slightly moist (Fill)		0.5-2.5'	1.9
		Fill	🟫	GRAVELLY SAND, well graded, loose, brown, slightly moist, (Fill)			
		Fill	🟫	CLAYEY SILT, soft, brown, moist (Fill)			0.9
		Fill	🟫	SANDY GRAVEL, very fine to coarse, some cobbles, brown, slightly moist, (Fill)			
5	907	SP	░	SAND, fine to medium grained, moderately dense, light brown, moist (Outwash)			1.0
							1.3
10	902					10-12.5'	2.9
		SP	░	SAND, coarse grained, slight gravel and cobbles, light brown, very moist (Outwash) Becoming wet @ 14'	▼		2.7
15	897			No Recovery @ 15-20' rock in shoe			
20				End of boring @ 20'			

Elevation estimated from Google Earth.

Responsive partner. Exceptional outcomes.

LOG OF BORING SB-4

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started : 8/16/17
Date Completed : 8/16/17
Contractor : Range Environmental
Drilling Method : Push Probe
Sampling Method : Macro Core

Operator : Todd
Logged By : CJA
Checked By : MLH

Water Levels
▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: 10'

Depth in Feet	Surf. Elev. 912	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912	Bit		Bituminous surface			
		Fill		GRAVELLY SAND, fine to coarse grained, brown, dry (Fill)			1.6
		Fill		SANDY CLAY, some silt, slight organics, dark brown, moist, (Fill)			2.5
5	907	Fill		GRAVELLY SAND, fine to coarse grained, brown, slightly moist (Fill)		5-7.5'	2.6
		Fill		SANDY CLAY, some silt, slight organics, dark brown, moist (Fill)			
		Fill		GRAVELLY SAND, fine to coarse grained, some silt in part, slight to moderate petroleum odor, brown, moist (Fill)			140.5
10	902	GW/SP		GRAVELLY SAND, coarse grained, some cobbles, light brown, wet (Outwash) Moderate to strong petroleum odor from 10-13'	▼	10-12.5'	216.8
							2.7
15	897	SP		SAND, fine to medium grained, light brown, wet (Outwash)		15-17.5'	0.9
							0.7
				End of boring @ 20'			
20							

Elevation estimated from Google Earth.

08-24-2017 C:\Users\andcj0675\Desktop\Cold Storage Boring Logs\SB-4.bor

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Responsive partner. Exceptional outcomes.

LOG OF BORING SB-5

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started	: 8/16/17	Operator	: Todd
Date Completed	: 8/16/17	Logged By	: CJA
Contractor	: Range Environmental	Checked By	: MLH
Drilling Method	: Push Probe		
Sampling Method	: Macro Core		

Water Levels

▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: 6.5'

Depth in Feet	Surf. Elev. 911	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	911	Fill	🟫	GRAVEL, some sand and silt, brown, dry (Fill)			
		Fill	⬛	CLAYEY SAND, some silt and organics, black, moist (Fill)			0.6
		Fill	🟫	GRAVELLY SAND, fine to coarse grained, brown, slightly moist, some black organic silt in part (Fill)		2.5-5'	0.8
5	906	Fill	🟫	GRAVELLY SAND, medium grained, brown, dry (Fill)			0.8
		OL	⬛	ORGANIC SILT, slight sand and clay, soft, black, moist (Swamp Deposit)			
		GW/SP	▨	SANDY GRAVEL, coarse grained, some cobbles, light brown, slightly moist (Outwash)		7.5-10'	1.2
10	901			Becoming wet @ 10'	▼		1.4
							0.7
15	896						0.9
							0.9
20				End of boring @ 20'			

Elevation estimated from Google Earth.

Responsive partner. Exceptional outcomes.

LOG OF BORING SB-6

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started : 8/16/17
Date Completed : 8/16/17
Contractor : Range Environmental
Drilling Method : Push Probe
Sampling Method : Macro Core

Operator : Todd
Logged By : CJA
Checked By : MLH

Water Levels
▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: 10'

Depth in Feet	Surf. Elev. 912	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912	Fill	■	GRAVEL, some sand and silt, brown, dry (Fill)			1.2
		Fill	■	CLAYEY SAND, some silt and organics, dark brown/black, moist (Fill)			
		Fill	■	SILT, slight sand and clay, soft, brown, moist (Fill)			1.2
		Fill	■	GRAVELLY SAND, fine to coarse grained, brown, slightly moist (Fill)			
5	907	Fill	■	GRAVELLY SAND, fine to coarse grained, brown, slightly moist, some black silt with sand and clay in part (Fill)		5-7.5'	1.5
		Fill	■	SILT, some sand, clay and organics, dark brown/black, moist, some brown gravelly sand in part (Fill)			1.3
10	902	GW/SP	▨	SANDY GRAVEL, coarse grained, some cobbles, light brown, wet (Outwash)	▼	10-12.5'	2.1 1.8
15	897	GW/SP	▨	GRAVELLY SAND, fine to coarse grained, slight cobbles, light brown, wet (Outwash)			1.0
		GW	▨	GRAVEL, some sand and cobbles, light brown, wet (Outwash) End of boring @ 20'			1.1
20							

Elevation estimated from Google Earth.

08-24-2017 C:\Users\andcj0675\Desktop\Cold Storage Boring Logs\SB-6.bor

WENCK
Responsive partner. Exceptional outcomes.

LOG OF BORING SB-7

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

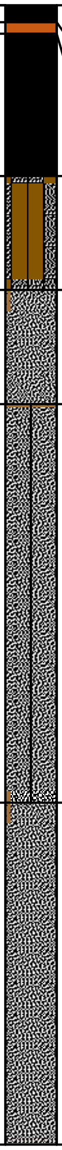
Project # B0185-0077

Date Started : 8/16/17
Date Completed : 8/16/17
Contractor : Range Environmental
Drilling Method : Push Probe
Sampling Method : Macro Core

Operator : Todd
Logged By : CJA
Checked By : MLH

Water Levels
▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: 0.5'



Depth in Feet	Surf. Elev. 912	USCS	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912	Bit	Bituminous surface			
		Fill	Gravel base			0.7
		OL	ORGANIC SILT, some clay, soft, black, moist (Swamp Deposit)			
		ML	CLAYEY SILT, soft, brown, moist (Outwash)		2.5-5'	1.5
5	907	SP	SAND, fine to medium grained, coarsening downward, moderately dense, light brown, moist (Outwash)			1.4
		GW/SP	GRAVELLY SAND, fine to coarse grained, slight cobbles, light brown, slightly to very moist (Outwash)			2.1
10	902				10-12.5'	3.0
			Becoming wet @ 12'	▼		
						2.7
		SP	SAND, fine to very fine grained, light brown, wet (Outwash)			
15	897					1.2
						1.4
			End of boring @ 20'			
20						

Elevation estimated from Google Earth.

WENCK
Responsive partner. Exceptional outcomes.

LOG OF BORING SB-8

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started : 8/16/17
Date Completed : 8/16/17
Contractor : Range Environmental
Drilling Method : Push Probe
Sampling Method : Macro Core

Operator : Todd
Logged By : CJA
Checked By : MLH

Water Levels
▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: 2'

Depth in Feet	Surf. Elev. 914	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	914	Bit		Bituminous surface			
		Fill		Gravel base			0.5
		Fill		SANDY CLAY, some organics, black, moist (Fill)		1-2'	
		OL		ORGANIC SILT, some clay, soft, black, moist (Swamp Deposit)			0.9
		SM		SILTY SAND, some clay, soft, brown, moist (Outwash)			
5	909	GW		GRAVEL, some sand, slight cobbles, light brown, dry to slightly moist (Outwash)			0.5
							0.5
10	904						1.6
		GW/SP		GRAVELLY SAND, medium grained, slight cobbles, light brown, moist (Outwash)			
				Becoming wet @ 13'	▼		0.6
15	899						0.8
							0.9
20				End of boring @ 20'			

Elevation estimated from Google Earth.

LOG OF BORING SB-9

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started	: 8/17/17	Operator	: Dave
Date Completed	: 8/17/17	Logged By	: CJA
Contractor	: Range Environmental	Checked By	: MLH
Drilling Method	: Push Probe		
Sampling Method	: Macro Core		

Water Levels

▼ Water Level

Boring Depth: 20'

Estimated Depth of Fill: No Fill Observed

Depth in Feet	Surf. Elev. 912	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912	ML		SILT, some organics, trace very fine sand and clay, dark brown/black, slightly moist (Topsoil)		0-2.5'	0.0
		SP		SAND, medium grained, light brown, dry (Outwash)			
		GW/SP		GRAVELLY SAND, medium to coarse grained, some cobbles, light brown, dry to moist (Outwash)			
							0.0
5	907						0.0
							0.0
10	902			Becoming wet @ 10'	▼		0.1
							0.3
15	897						0.4
							0.4
20		SC		CLAYEY SAND, stiff, light brown, wet (Outwash)			
				End of boring @ 20'			

Elevation estimated from Google Earth.

WENCK

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LOG OF BORING SB-10

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started	: 8/17/17	Operator	: Dave
Date Completed	: 8/17/17	Logged By	: CJA
Contractor	: Range Environmental	Checked By	: MLH
Drilling Method	: Push Probe		
Sampling Method	: Macro Core		

Water Levels

▼ Water Level

Boring Depth: 20'

Estimated Depth of Fill: 0.5'

Depth in Feet	Surf. Elev. 912	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912	Bit		Bituminous surface			
		Fill		Gravel base			
		GW/SP		GRAVELLY SAND, medium to coarse grained, some cobbles, light brown, dry (Outwash)		0.5-2.5'	0.4
							0.5
5	907	SP		SAND, fine to medium grained, slight gravel, moderately dense, light brown, moist (Outwash)			1.5
							1.1
		GW/SP		GRAVELLY SAND, fine to coarse grained, some cobbles, light brown, moist (Outwash)			
10	902						1.6
				Becoming wet @ 12'	▼		
							0.8
15	897						1.0
							0.6
20				End of boring @ 20'			

Elevation estimated from Google Earth.

LOG OF BORING SB-11

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN

Phase II Investigation

Project # B0185-0077

Date Started : 8/17/17
Date Completed : 8/17/17
Contractor : Range Environmental
Drilling Method : Push Probe
Sampling Method : Macro Core

Operator : Dave
Logged By : CJA
Checked By : MLH

Water Levels
▼ Water Level

Boring Depth: 20'
Estimated Depth of Fill: ~1'

Depth in Feet	Surf. Elev. 912	USCS	GRAPHIC	DESCRIPTION	Water Level	Soil Sample Interval	PID Result (PPM)
0	912						
		Fill		SAND, well graded very fine to coarse grained, slight silt and clay, brown, moist (Possible Fill)			
				GRAVELLY SAND, very fine to medium grained, some cobbles, light brown, dry to slightly moist (Outwash)		1-2'	0.2
							0.5
5	907						
							1.5
		GW/SP					
							0.8
10	902						
							1.2
					▼		
				SANDY GRAVEL, coarse grained, slight cobbles, light brown, wet (Outwash)			0.9
15	897						
							1.6
		GW					
							1.1
				End of boring @ 20'			
20							

Elevation estimated from Google Earth.

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Responsive partner. Exceptional outcomes.

LOG OF BORING MW-1

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN
Phase II Investigation
Project # B0185-0077

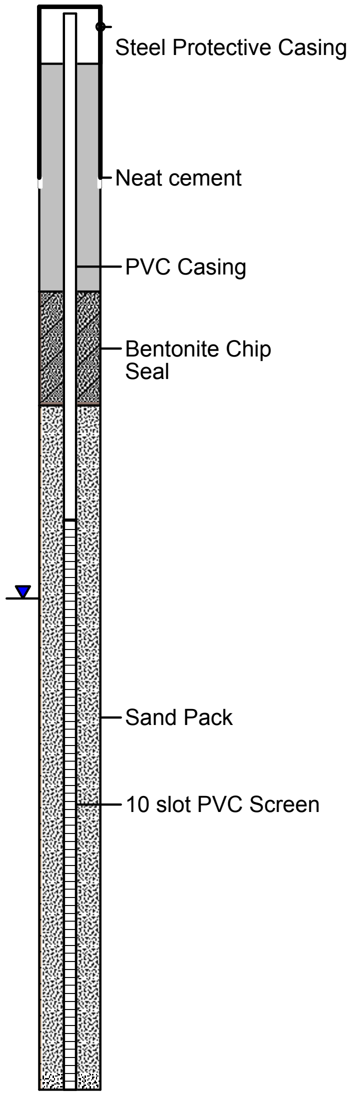
Date Started : 8/15/17
Date Completed : 8/15/17
Hole Diameter : 5.75
Drilling Method : Push Probe
Sampling Method : Macro Core

Drilling Contractor : Range Environmental
Driller : Todd
Drilling Assistant : N/A
Logged By : CJA

Location: SW portion of property near Blake Rd N

Depth in Feet	Surf Elev 912	USCS	GRAPHIC	DESCRIPTION	PID (PPM)	Soil Analytical Collected
0	912	Fill	▨	SILT, some sand, some roots, loose, dark brown, moist (Fill)	0.1	
		GW/SP	▨	GRAVELLY SAND, fine to coarse grained, slight cobbles, moderately dense, light brown, moist (Outwash)	0.1	
5	907				0.3	
					0.2	
10	902			Becoming wet @ 10'	0.7	
		GW	▨	GRAVEL, some sand and cobbles, strong petroleum odor, dark grey, wet (Outwash)	655.5	12.5-15
15	897	GW	▨	SANDY GRAVEL, some cobbles, strong petroleum odor, dark grey, wet (Outwash)	408.1	
		GW	▨	SANDY GRAVEL, some cobbles, brown, wet (Outwash)	2.1	
				End of boring @ 20'		
20						

Well: MW-1
TOC Elev.: TBD



Monitoring well installed using hollow stem auger after sampling soil using push probe.
Surface elevation approximated from google earth.
Water level measured at 11.28' below top of casing on 8/16/17.
Well casing stickup ~1.9' above ground surface.

WENCK
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LOG OF BORING MW-2

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN
Phase II Investigation
Project # B0185-0077

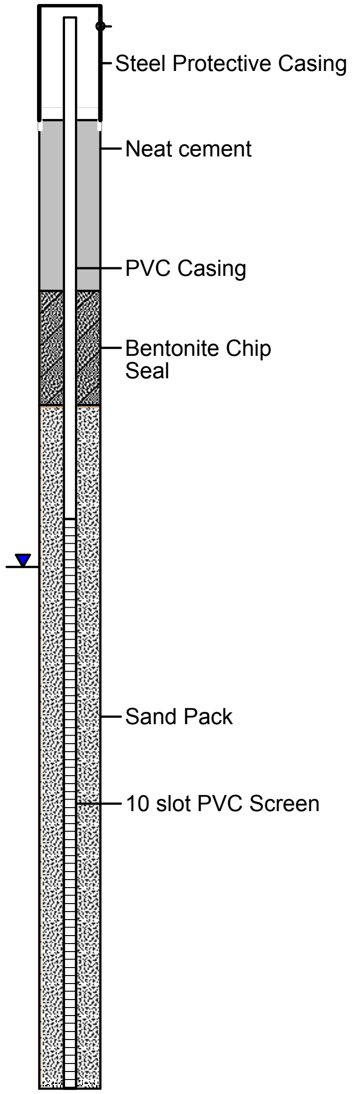
Date Started : 8/15/17
Date Completed : 8/15/17
Hole Diameter : 5.75
Drilling Method : Push Probe
Sampling Method : Macro Core

Drilling Contractor : Range Environmental
Driller : Todd
Drilling Assistant : N/A
Logged By : CJA

Location: South loading dock finished at grade.

Depth in Feet	Surf Elev 912	USCS	GRAPHIC	DESCRIPTION	PID (PPM)	Soil Analytical Collected
0	912	Bit		Bituminous surface.		
		Fill		Gravel base.		0.5-1'
		Fill		SAND, fine to medium grained, slight gravel, brown, dry (Fill)	0.5	
				GRAVELLY SAND, fine to coarse grained, some gravel, slightly dense, light brown, dry (Outwash)		
					0.6	
5	907			Becoming with some cobbles @ 5'		
					0.7	
		GW/SP			0.6	
10	902			Becoming moist @ 10'		
					0.8	
				Becoming wet @ 13'		
					1.0	
15	897					
					0.7	
		SP		SAND, fine to medium grained, dense, light brown, wet (Outwash)		
					0.7	
20				End of boring @ 20'		

Well: MW-2
TOC Elev.: TBD



Monitoring well installed using hollow stem auger after sampling soil using push probe.
Surface elevation approximated from google earth.
Water level measured at 9.64' below top of casing on 8/17/17.
Well finished at grade, casing ~2" below ground surface.

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LOG OF BORING MW-3

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN
Phase II Investigation
Project # B0185-0077

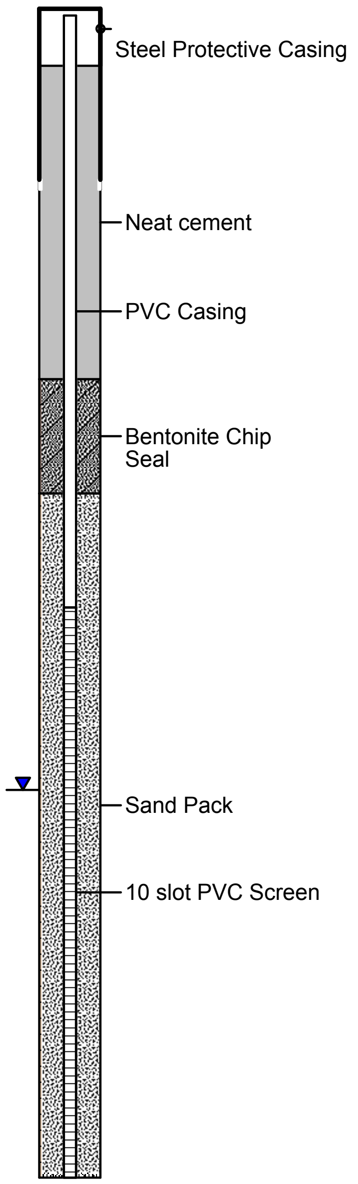
Date Started : 8/15/17
Date Completed : 8/15/17
Hole Diameter : 5.75
Drilling Method : Push Probe
Sampling Method : Macro Core

Drilling Contractor : Range Environmental
Driller : Todd
Drilling Assistant : N/A
Logged By : CJA

Location: Northeast portion of property

Depth in Feet	Surf Elev 914	USCS	GRAPHIC	DESCRIPTION	PID (PPM)	Soil Analytical Collected
0	914	Fill		SILT, some sand, some roots, loose, dark brown/black, moist (Fill)	0.1	0-2'
		GW/SP		GRAVELLY SAND, fine to coarse grained, some gravel, loose to slightly dense, light brown, dry to moist (Outwash)	0.0	
5	909				0.0	
					0.1	
10	904					
					1.3	10-12.5'
		GW		GRAVEL, some sand, slight cobbles, light brown, wet (Outwash)	0.8	
15	899	GW		SANDY GRAVEL, coarse, slight cobbles, light brown, wet (Outwash)	1.0	
					0.7	
				End of boring @ 20'		
20						

Well: MW-3
TOC Elev.: TBD



Monitoring well installed using hollow stem auger after sampling soil using push probe.
Surface elevation approximated from google earth.
Water level measured at 14.60' below top of casing on 8/16/17.
Well casing stickup ~2' above ground surface.

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LOG OF BORING MW-4

(Page 1 of 1)

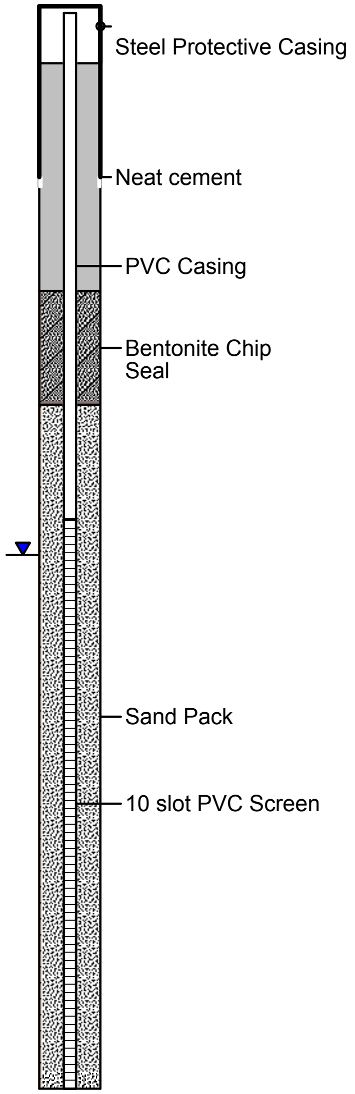
Cold Storage
325 Blake Rd N
Hopkins, MN
Phase II Investigation
Project # B0185-0077

Date Started	: 8/16/17	Drilling Contractor	: Range Environmental
Date Completed	: 8/16/17	Driller	: Todd
Hole Diameter	: 5.75	Drilling Assistant	: N/A
Drilling Method	: Push Probe	Logged By	: CJA
Sampling Method	: Macro Core		

Location: North portion of property behind building

Depth in Feet	Surf Elev 910	USCS	DESCRIPTION	PID (PPM)	Soil Analytical Collected
0	910	Fill	SAND, well graded, very fine to coarse, some silt, brown, moist (Fill)		
		Fill	Gravel base (Fill)		
		Fill	SILTY CLAY, slight sand, gravel and organics, slightly stiff, dark brown/black, moist (Fill)	0.2 0.4	1-2'
5	905	SP	SAND, medium to coarse grained, slight to some gravel, slight cobbles, slightly dense, light brown, slightly moist (Outwash)	0.6 1.2	7.5-10'
10	900	GW/SP	GRAVELLY SAND, fine to coarse grained, slight cobbles, slightly dense, moist (Outwash) Becoming wet @ 11'	1.1 1.0	
15	895	GW	SANDY GRAVEL, coarse, some cobbles, light brown, wet (Outwash) End of boring @ 20'	1.1 1.3	
20					

Well: MW-4
TOC Elev.: TBD



Monitoring well installed using hollow stem auger after sampling soil using push probe.
Surface elevation approximated from google earth.
Water level measured at 10.53' below top of casing on 8/16/17.
Well casing stickup ~2' above ground surface.

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LOG OF BORING MW-5

(Page 1 of 1)

Cold Storage
325 Blake Rd N
Hopkins, MN
Phase II Investigation
Project # B0185-0077

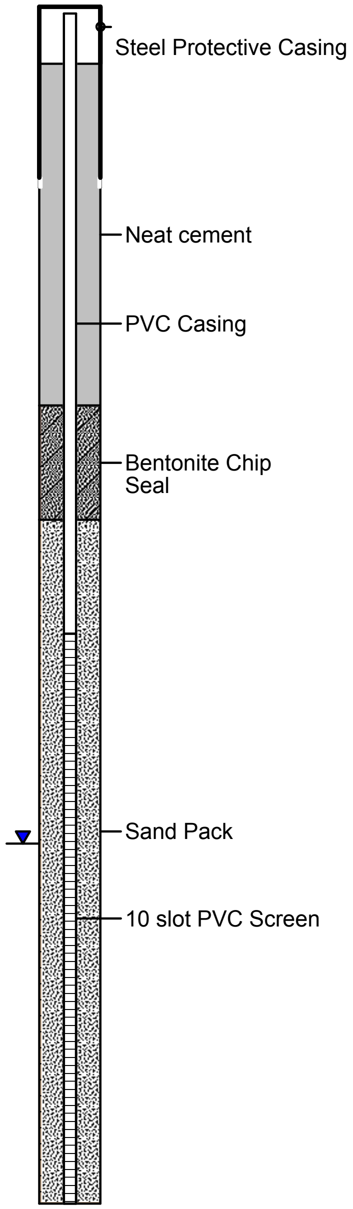
Date Started : 8/16/17
Date Completed : 8/16/17
Hole Diameter : 5.75
Drilling Method : Push Probe
Sampling Method : Macro Core

Drilling Contractor : Range Environmental
Driller : Todd
Drilling Assistant : N/A
Logged By : CJA

Location: NW portion of propery near Blake Rd N

Depth in Feet	Surf Elev 916	USCS	GRAPHIC	DESCRIPTION	PID (PPM)	Soil Analytical Collected
0	916	Fill		SILT, some roots/organics, slight sand and clay, loose, dark brown/black, moist (Fill)	0.0	0-2.5'
		GW/SP		GRAVELLY SAND, meduim to coarse grained,slight cobbles, slightly dense, light brown, slightly moist (Outwash) becoming with some cobbles @ 5'	0.0	
5	911				0.5	5-7.5'
					1.1	
10	906				1.2	
		SP		SAND, fine grained, slight silt, light brown, moist (Outwash)		
		GW/SP		GRAVELLY SAND, coarse grained, some cobbles, light brown, very moist (Outwash) Becoming wet @ 14'	0.9	
15	901				1.0	
		GW		GRAVEL, slight sand and silt, light brown, wet (Outwash) End of boring @ 20'	0.9	
20						

Well: MW-5
TOC Elev.: TBD



Monitoring well installed using hollow stem auger after sampling soil using push probe.
Surface elevation approximated from google earth.
Water level measured at 15.58' below top of casing on 8/16/17.
Well casing stickup ~1.7' above ground surface.

Technical Memo

WENCK
ASSOCIATES
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Exceptional outcomes.

To: Michael Hayman, Project Manager, Minnehaha Creek Watershed District

From: Chris Meehan, Wenck Associates, Inc.
Mark Schroeher, Wenck Associates, Inc.
Erik Megow, Wenck Associates, Inc.

Date: January 7, 2016

Subject: Storm Water Treatment Concepts at 325 Blake Road

Minnehaha Creek Watershed District (MCWD) is currently working with a development team to evaluate options for site development at 325 Blake Road in Hopkins, MN. Wenck was tasked to have a better understanding of how much, where and to what extents the storm water will be routed to the site.

Verify Storm Water Volumes

The two major diversion inflows planned for the 325 Blake parcel were the Lake Street Diversion Project –(MCES) and the Powell Road Diversion Project (MCWD). The Powell Road Diversion Project has since been constructed and the Lake Street Diversion is entering final design. As these projects progressed design modifications were required which resulted in a change to the stormwater volumes which would be diverted to 325 Blake. As a result there was a need to determine the current volumes and the necessary footprint for a stormwater BMP on the site.

A HydroCAD model was developed with the updated attributes of the each of the projects to determine the runoff volume that can be directed to the 325 Blake Road stormwater BMP (Table 1). The volumes calculated in the analysis were based on the 1.0 and 1.25-inch 24-hour rainfall events. These two events represent water quality depths used for stormwater BMP sizing.

Table 1 – Runoff Volumes and BMP Footprint Size

Storm Event	**Runoff Volume (ac-ft)**			**BMP Footprint (ac)***
	From Powell	*From Lake St.*	*Total*	
1.0-inch	3.93	1.92	5.85	1.95
1.25-inch	6.23	2.73	8.96	2.99

******The BMP footprint is based on an assumed depth of 3 ft.*

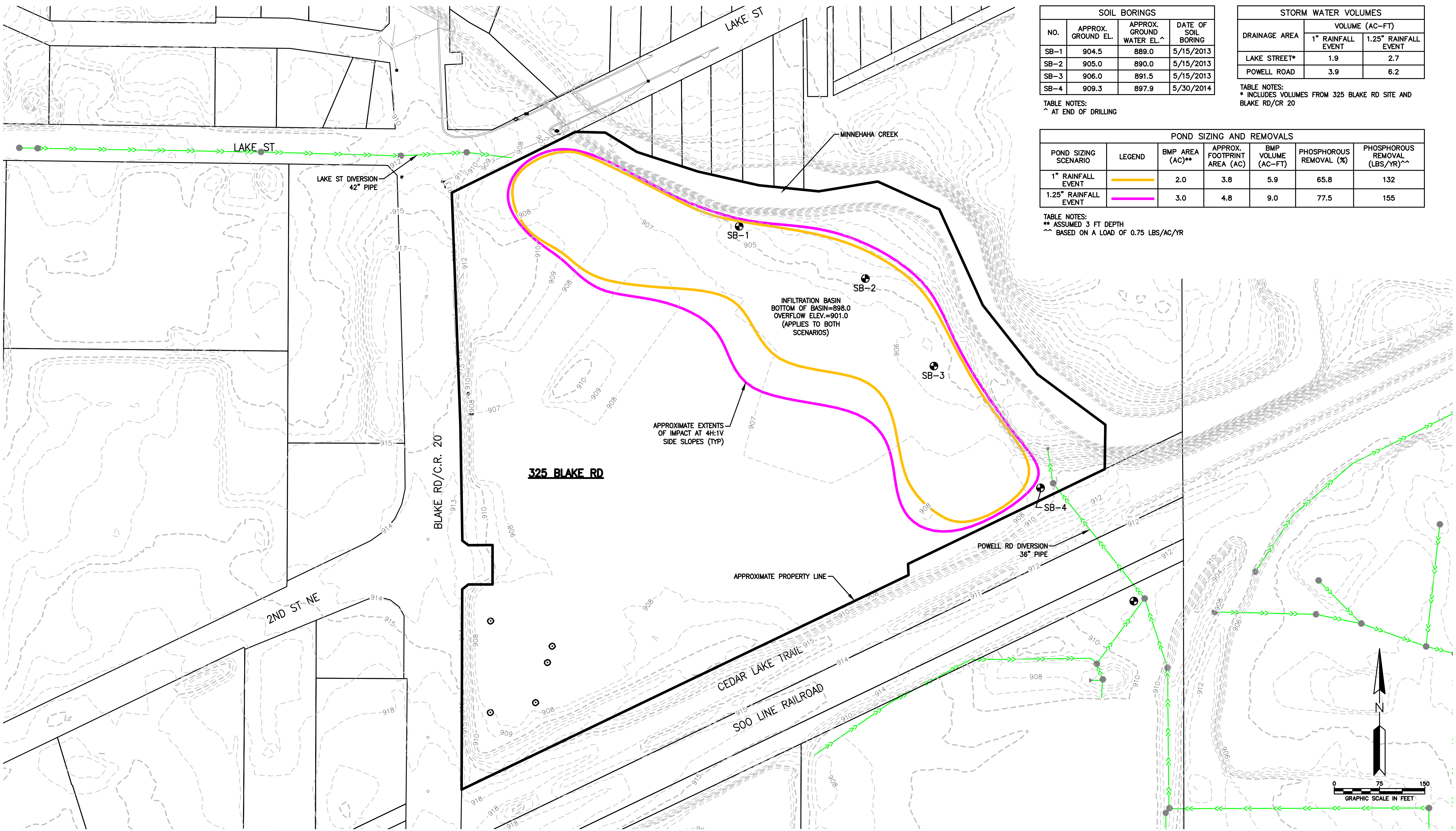
Site Design Refinement

Based on the two rainfall events mentioned above, the footprint of the filtration basins were calculated and placed graphically in Figure 1. The footprints shown in Figure 1 are the overall impact area of each infiltration basin based on side slopes of 4 horizontal to 1 vertical and tie into the existing surface. The BMP depth was assumed as 3 feet from elevation 898.0 to 901.0. These elevations were determined by understanding the approximate groundwater depth (bottom of basin) and the two diversion structure inverts (overflow elevation). The existing site is generally flat with the exception of the northeastern edge of the site going down to the creek, indicating the exact shape and location of the proposed filtration basin will have minimal effect on the earthwork for the site.

Soil borings from both May of 2013 and May 2014 were reviewed to understand the existing groundwater in the area and to determine the filtration basin bottom elevation. A basin bottom elevation of 898.0 was determined based on three feet of separation from the assumed ground water level. The basin overflow elevation is based on the Lake Street and Powell Road Diversions. Lake Street has an overflow elevation of 902.31 at the diversion structure before water would backup into the system. Powell Road has an overflow elevation of 901.06 at the diversion structure before backing up into the system and thus dictates the overflow elevation for the proposed basin.

Construction Cost Estimate

Both an overall component cost estimate and detailed cost estimate for the storm water treatment concepts were developed. The component cost used a combination of the 2013 Feasibility Study estimates and the 2015 325 Blake Demolition report. Assumptions for the estimates are included in each document. The storm water treatment concept is estimated in the range of $1,865,550 to $2,238,660. These costs are higher than the original 2013 feasibility study estimate largely due to the assumed common excavation quantity. The original estimate assumed a common excavation quantity of 34,000 cubic yards based on calculated storm water volumes at the time. The current common excavation quantity is estimated at 62,500 cubic yards and is based on the removing soil material between the bottom of the proposed basin and the existing surface. The common excavation unit cost currently assumes all material will be hauled off site; however, this unit cost could be reduced if some soil material remains on site.



SOIL BORINGS			
NO.	APPROX. GROUND EL.	APPROX. GROUND WATER EL.^	DATE OF SOIL BORING
SB-1	904.5	889.0	5/15/2013
SB-2	905.0	890.0	5/15/2013
SB-3	906.0	891.5	5/15/2013
SB-4	909.3	897.9	5/30/2014

TABLE NOTES:
^ AT END OF DRILLING

STORM WATER VOLUMES		
DRAINAGE AREA	VOLUME (AC-FT)	
	1" RAINFALL EVENT	1.25" RAINFALL EVENT
LAKE STREET*	1.9	2.7
POWELL ROAD	3.9	6.2

TABLE NOTES:
* INCLUDES VOLUMES FROM 325 BLAKE RD SITE AND BLAKE RD/CR 20

POND SIZING AND REMOVALS						
POND SIZING SCENARIO	LEGEND	BMP AREA (AC)**	APPROX. FOOTPRINT AREA (AC)	BMP VOLUME (AC-FT)	PHOSPHOROUS REMOVAL (%)	PHOSPHOROUS REMOVAL (LBS/YR)^^
1" RAINFALL EVENT	🟨	2.0	3.8	5.9	65.8	132
1.25" RAINFALL EVENT	🟪	3.0	4.8	9.0	77.5	155

TABLE NOTES:
** ASSUMED 3 FT DEPTH
^^ BASED ON A LOAD OF 0.75 LBS/AC/YR

REV	REVISION DESCRIPTION	DWN	APP	REV DATE

SEAL

NOT FOR CONSTRUCTION

SUB CONSULTANT

PRIME CONSULTANT

WENCK ASSOCIATES
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PROJECT TITLE
STORM WATER TREATMENT CONCEPTS
AT 325 BLAKE ROAD

MINNEHAHA CREEK
WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

SHEET TITLE
POND SIZING CONFIGURATION

DWN BY	CHK'D	APP'D	DWG DATE	JAN 2016
MJS			SCALE	AS SHOWN

PROJECT NO.	SHEET NO.	REV NO.
0185-0028	FIGURE 1	

Plot Date & Time: 7 January 2016 4:56 PM

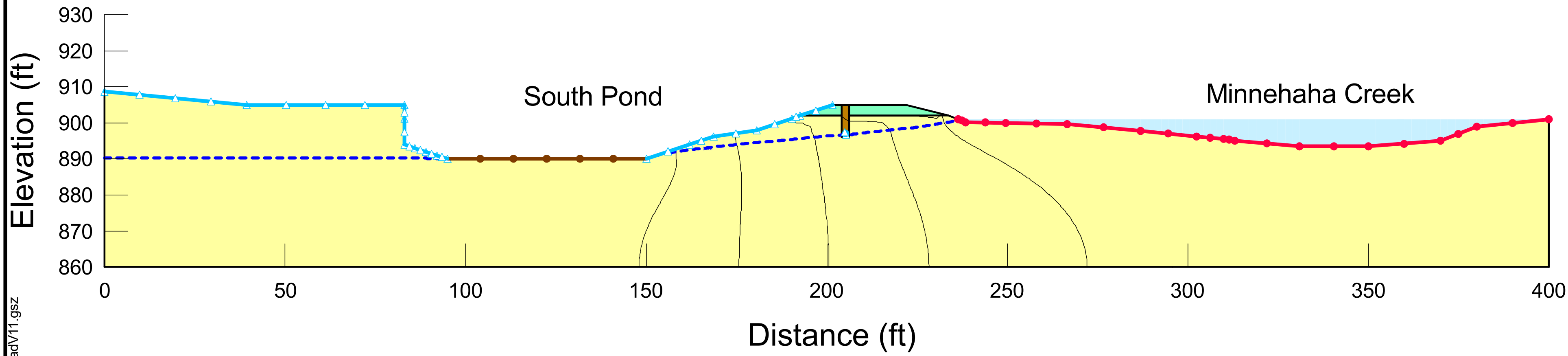
V:\Drafting\0185 MCWD\0028\CAD\Civil\Figure 1.dwg

Attachment C

SEEP/W Seepage Analysis Results

Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
🟧	Coarse Filter Aggregate	Saturated / Unsaturated	Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated	Fill	Fill	0.5	0
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated	Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0

Color	Name	Category	Kind	Parameters
🟫	Empty Pond 890 ft	Hydraulic	Water Total Head	890 ft
🟥	High Creek Elev 901 ft	Hydraulic	Water Total Head	901 ft
🟦	Potential Seepage Face Review	Hydraulic	Water Rate	0 ft³/sec



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Blake Road Regional Stormwater Pond | Computed: KB | Date:05/01/2022

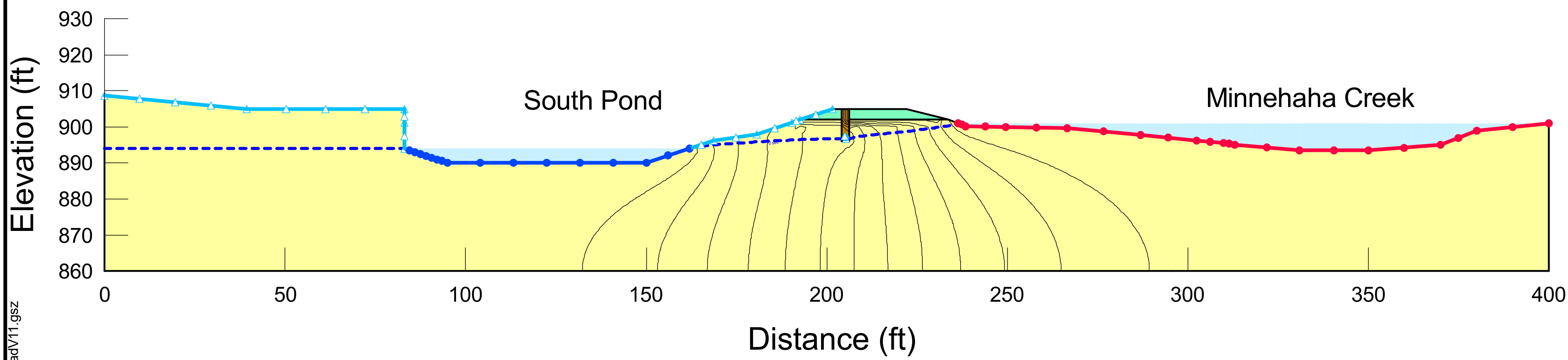
East - West Cross Section | Checked: GB | Date: 05/1/2022

Steady-State Seepage - Case 1: Empty Pond, High Creek

SEEP/W 11.1.2.22321 | Scale: 1:520

Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
🟫	Coarse Filter Aggregate	Saturated / Unsaturated	Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated	Fill	Fill	0.5	0
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated	Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0

Color	Name	Category	Kind	Parameters
🟦	Pond 894 ft	Hydraulic	Water Total Head	894 ft
🟥	High Creek Elev 901 ft	Hydraulic	Water Total Head	901 ft
🟦	Potential Seepage Face Review	Hydraulic	Water Rate	0 ft^3/sec



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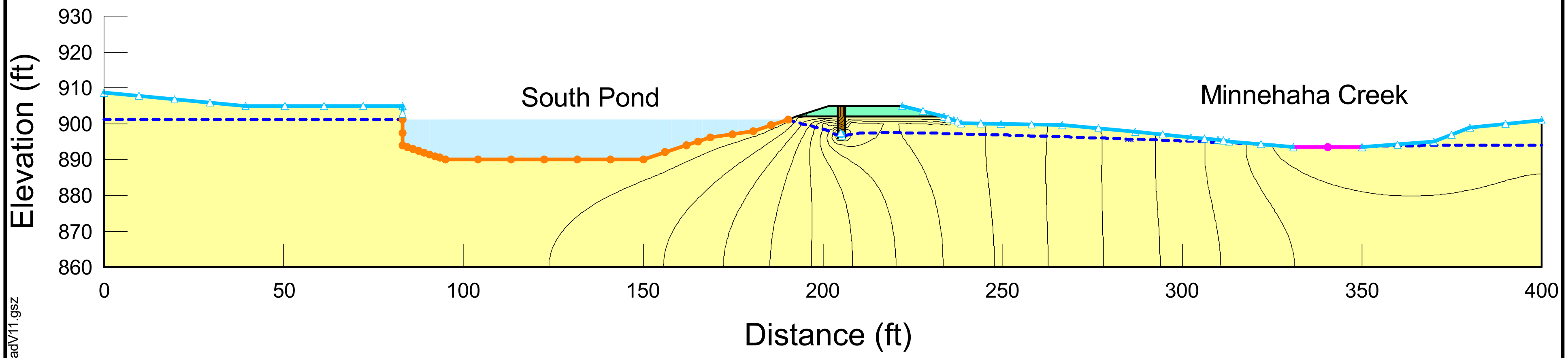
Blake Road Regional Stormwater Pond	Computed: KB	Date:05/01/2022
East - West Cross Section	Checked: GB	Date: 05/1/2022
Steady-State Seepage - Case 1a: 894' Pond, High Creek		
SEEP/W 11.1.2.22321		Scale: 1:520

Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
🟫	Coarse Filter Aggregate	Saturated / Unsaturated	Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated	Fill	Fill	0.5	0
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated	Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0

Color	Name	Category	Kind	Parameters
🟪	E-W Low Creek Elev 893.5 ft	Hydraulic	Water Total Head	893.5 ft
🟧	High Pond Elevation 901.25	Hydraulic	Water Total Head	901.25 ft
🟦	Potential Seepage Face Review	Hydraulic	Water Rate	0 ft^3/sec



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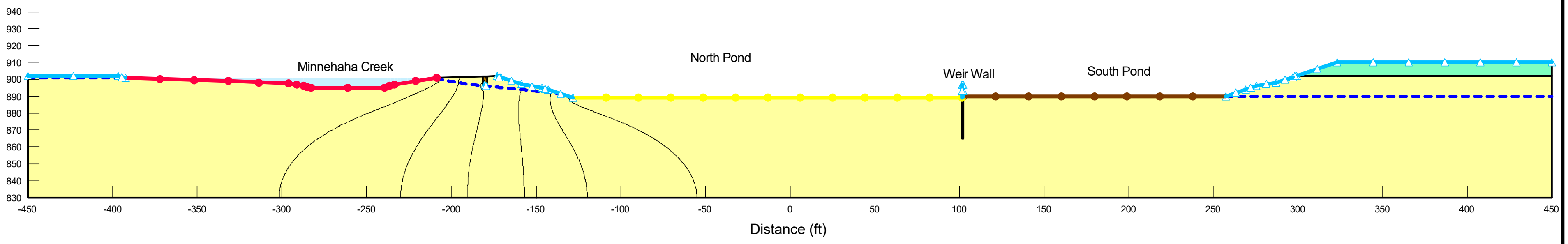
Blake Road Regional Stormwater Pond	Computed: KB	Date:05/01/2022
East - West Cross Section	Checked: GB	Date: 05/1/2022
Steady-State Seepage - Case 2: High Pond, Low Creek		
SEEP/W 11.1.2.22321	Scale: 1:520	

Color	Name	Material Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
🟫	Coarse Filter Aggregate	Saturated / Unsaturated		Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0		
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated		Fill	Fill	0.5	0		
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated		Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0		
🟥	Sheetpile cutoff	Saturated Only	3.28e-08			1	0	0	0

Color	Name	Category	Kind	Parameters
🟨	Empty Pond 889	Hydraulic	Water Total Head	889 ft
🟫	Empty Pond 890 ft	Hydraulic	Water Total Head	890 ft
🟥	High Creek Elev 901 ft	Hydraulic	Water Total Head	901 ft
🟦	Potential Seepage Face Review	Hydraulic	Water Rate	0 ft³/sec



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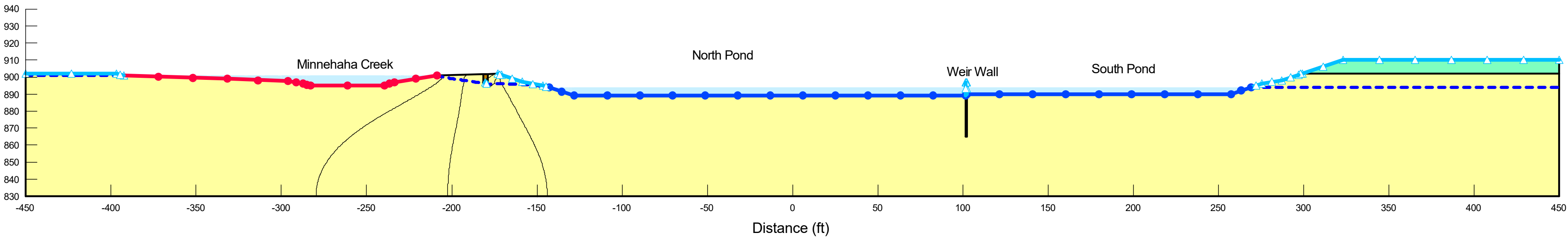
Blake Road Regional Stormwater Pond	Computed: KB	Date:05/01/2022
North - South Cross Section	Checked: GB	Date: 05/1/2022
Steady-State Seepage - Case 1: Empty Pond, High Creek, North Pond		
SEEP/W 11.1.2.22321	Scale: 1:1,120	

Color	Name	Material Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
🟫	Coarse Filter Aggregate	Saturated / Unsaturated		Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0		
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated		Fill	Fill	0.5	0		
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated		Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0		
🟥	Sheetpile cutoff	Saturated Only	3.28e-08			1	0	0	0

Color	Name	Category	Kind	Parameters
🟦	Pond 894 ft	Hydraulic	Water Total Head	894 ft
🟥	High Creek Elev 901 ft	Hydraulic	Water Total Head	901 ft
🟦	Potential Seepage Face Review	Hydraulic	Water Rate	0 ft³/sec



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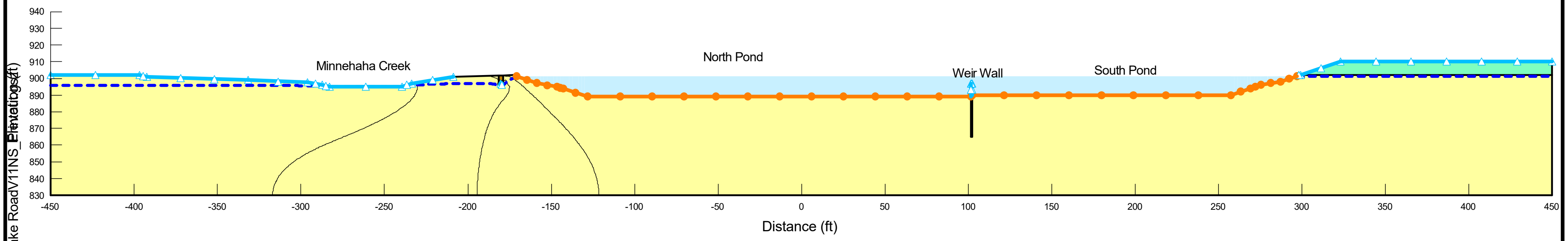
Blake Road Regional Stormwater Pond	Computed: KB	Date:05/01/2022
North - South Cross Section	Checked: GB	Date: 05/1/2022
Steady-State Seepage - Case 1a: 894' Pond, High Creek, North Pond (2)		
SEEP/W 11.1.2.22321	Scale: 1:1,120	

Color	Name	Material Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
🟫	Coarse Filter Aggregate	Saturated / Unsaturated		Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0		
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated		Fill	Fill	0.5	0		
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated		Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0		
🟥	Sheetpile cutoff	Saturated Only	3.28e-08			1	0	0	0

Color	Name	Category	Kind	Parameters
🟧	High Pond Elevation 901.25	Hydraulic	Water Total Head	901.25 ft
🟦	Potential Seepage Face Review	Hydraulic	Water Rate	0 ft³/sec



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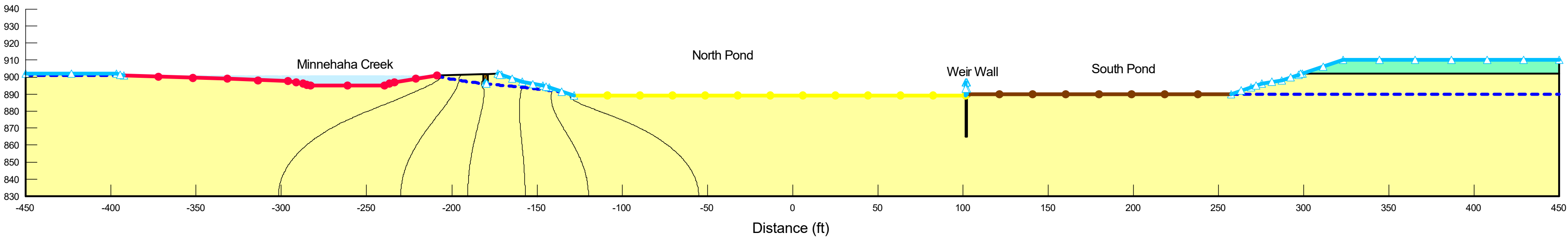
Blake Road Regional Stormwater Pond	Computed: KB	Date:05/01/2022
North - South Cross Section	Checked: GB	Date: 05/1/2022
Steady-State Seepage - Case 2: High Pond, Low Creek, North Pond		
SEEP/W 11.1.2.22321	Scale: 1:1,120	

Color	Name	Material Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
🟧	Coarse Filter Aggregate	Saturated / Unsaturated		Coarse Filter Aggretate	Coarse Aggregate Filter	0.5	0		
🟩	Fill (gravelly, silty to clayey sand)	Saturated / Unsaturated		Fill	Fill	0.5	0		
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Saturated / Unsaturated		Sand - Gravelly, Silty	Sand - Gravelly, silty	0.5	0		
🟥	Sheetpile cutoff	Saturated Only	3.28e-08			1	0	0	0

Color	Name	Category	Kind	Parameters
🟨	Empty Pond 889	Hydraulic	Water Total Head	889 ft
🟫	Empty Pond 890 ft	Hydraulic	Water Total Head	890 ft
🟥	High Creek Elev 901 ft	Hydraulic	Water Total Head	901 ft
🟦	Potential Seepage Face Review	Hydraulic	Water Rate	0 ft³/sec



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HDR

Blake Road Regional Stormwater Pond

Computed: KB

Date:05/01/2022

North - South Cross Section

Checked: GB

Date: 05/1/2022

Steady-State Seepage - Case 1: Empty Pond, High Creek, South Pond

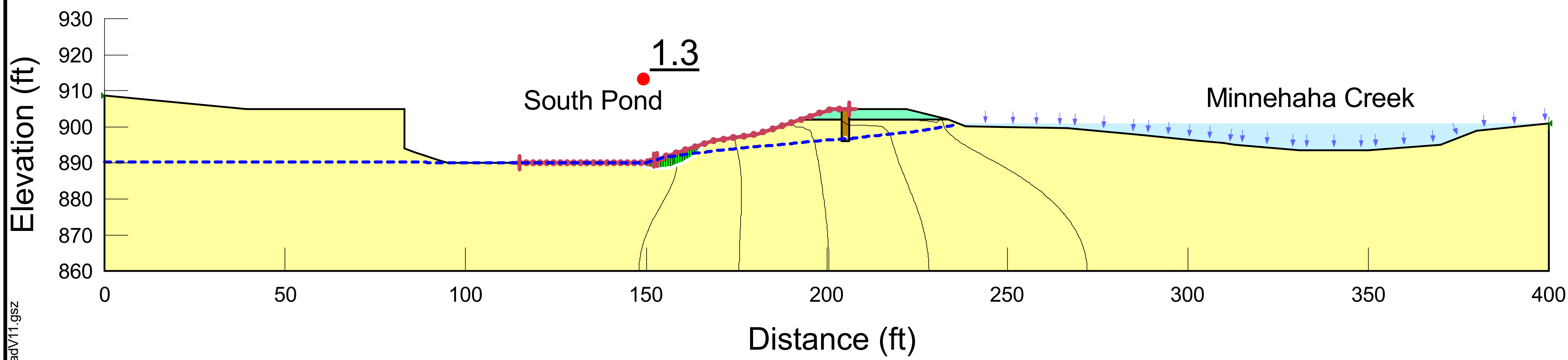
SEEP/W 11.1.2.22321

Scale: 1:1,120

Attachment D

SLOPE/W Slope Stability Analysis Results

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟫	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30



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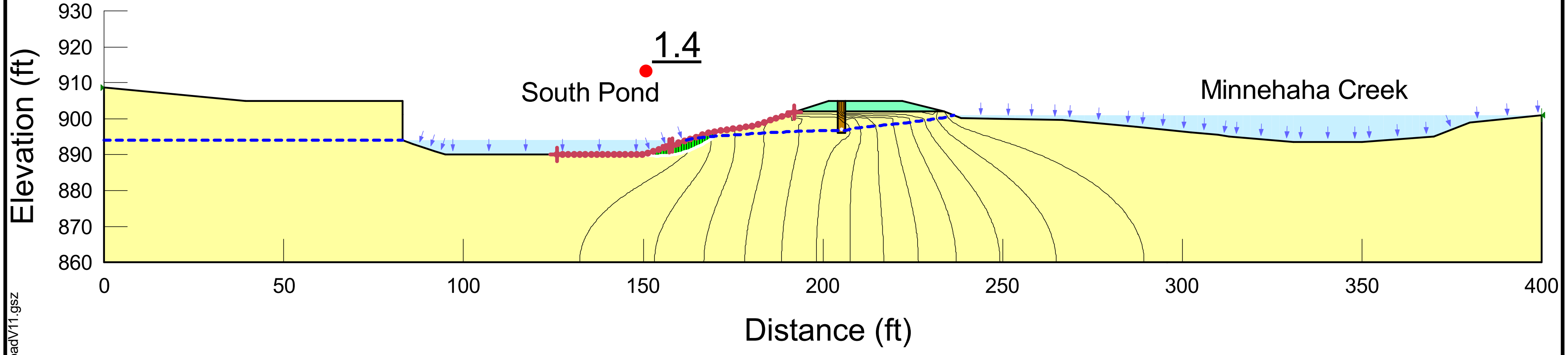
Blake Road Regional Stormwater Pond	Computed: KB	Date:05/01/2022
East - West Cross Section	Checked: GB	Date: 05/1/2022
Case 1: Slope Stability		
SLOPE/W 11.1.2.22321	Scale: 1:520	

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟫	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30



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HDR

Blake Road Regional Stormwater Pond

East - West Cross Section

Case1a: Slope Stability

SLOPE/W 11.1.2.22321

Computed: KB

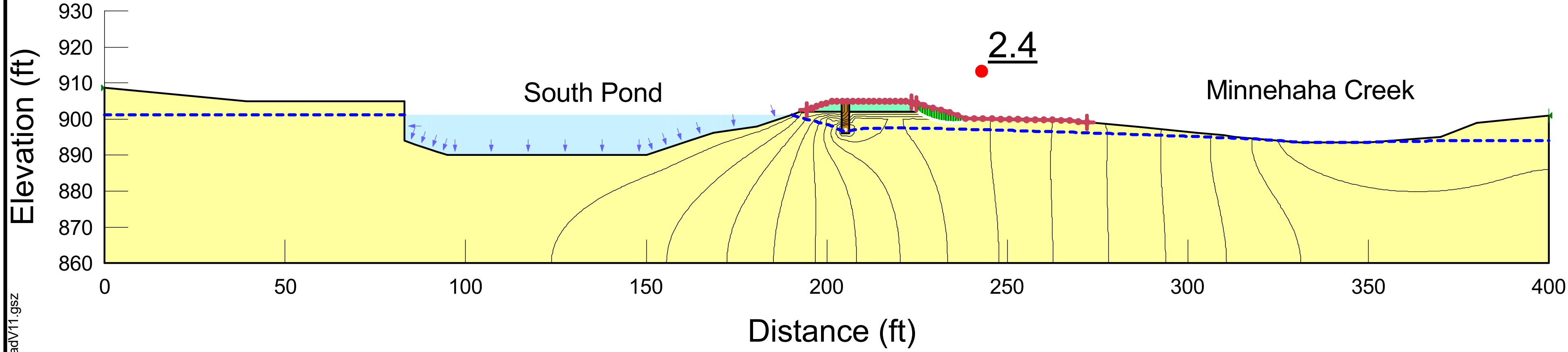
Date:05/01/2022

Checked: GB

Date: 05/1/2022

Scale: 1:520

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟫	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30



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HDR

Blake Road Regional Stormwater Pond

East - West Cross Section

Case 2: Slope Stability

SLOPE/W 11.1.2.22321

Computed: KB

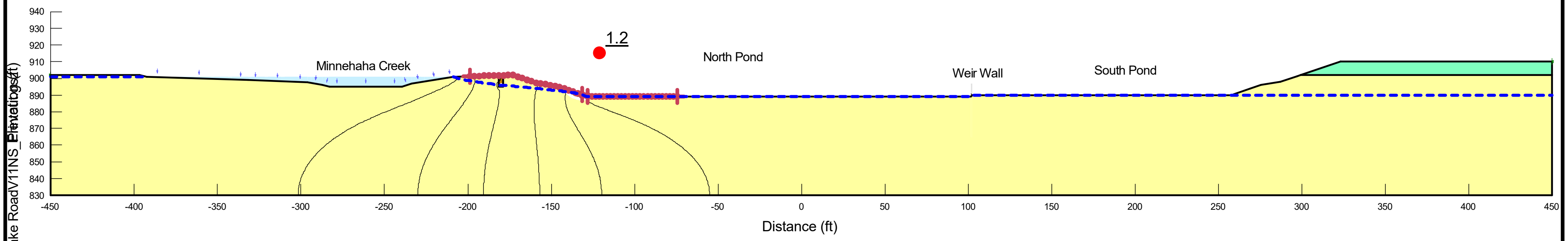
Date:05/01/2022

Checked: GB

Date: 05/1/2022

Scale: 1:520

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟫	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30
🟥	Sheetpile cutoff	(None)			



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Blake Road Regional Stormwater Pond

North - South Cross Section

Case 1: Slope Stability North Pond

SLOPE/W 11.1.2.22321

Computed: KB

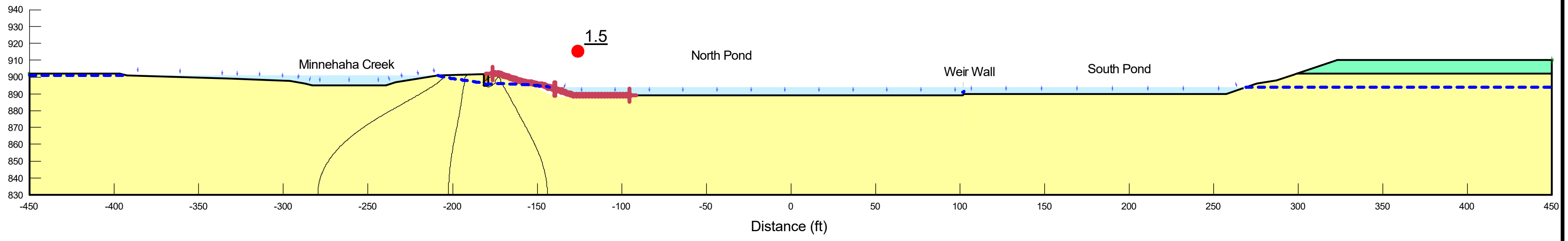
Date:05/01/2022

Checked: GB

Date: 05/1/2022

Scale: 1:1,120

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟧	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30
🟥	Sheetpile cutoff	(None)			



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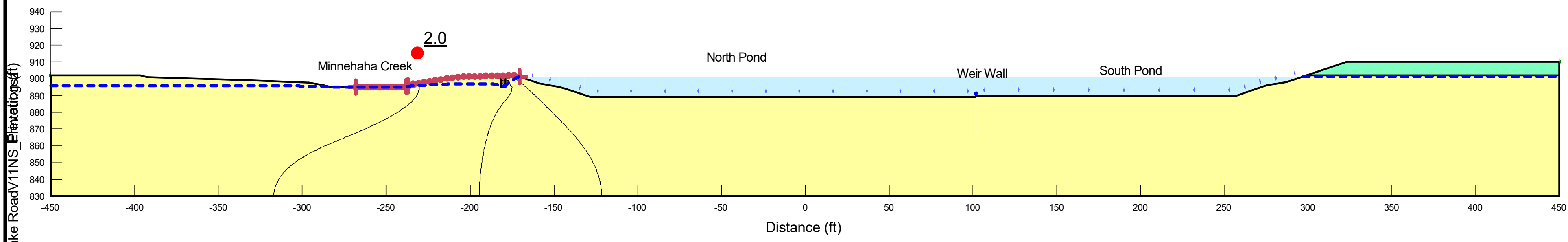
Blake Road Regional Stormwater Pond	Computed: KB	Date:05/01/2022
North - South Cross Section	Checked: GB	Date: 05/1/2022
Case 1a: Slope Stability North Pond		
SLOPE/W 11.1.2.22321	Scale: 1:1,120	

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟫	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30
🟥	Sheetpile cutoff	(None)			



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Blake Road Regional Stormwater Pond

North - South Cross Section

Case 2: Slope Stability North Pond

SLOPE/W 11.1.2.22321

Computed: KB

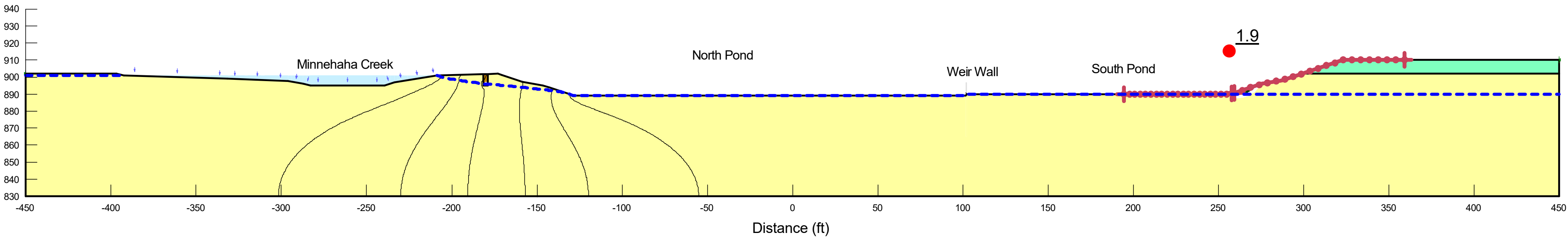
Checked: GB

Date:05/01/2022

Date: 05/1/2022

Scale: 1:1,120

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟫	Coarse Filter Aggregate	Mohr-Coulomb	129	0	37
🟩	Fill (gravelly, silty to clayey sand)	Mohr-Coulomb	125	0	30
🟨	Glacial Outwash (gravelly sand with varying amounts of silt)	Mohr-Coulomb	123	0	30
🟥	Sheetpile cutoff	(None)			



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HDR

Blake Road Regional Stormwater Pond

North - South Cross Section

Case 1: Slope Stability South Pond

SLOPE/W 11.1.2.22321

Computed: KB

Date:05/01/2022

Checked: GB

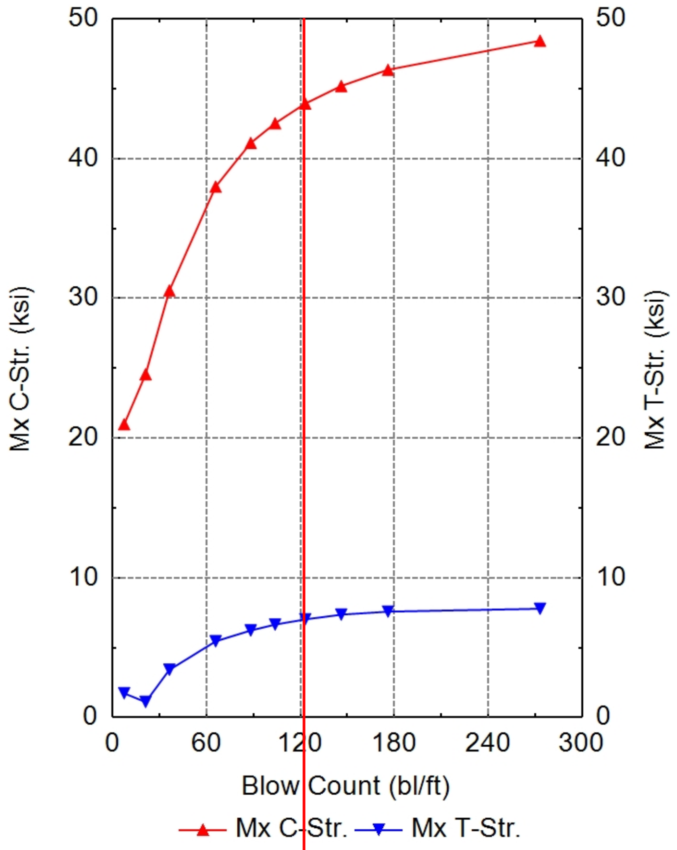
Date: 05/1/2022

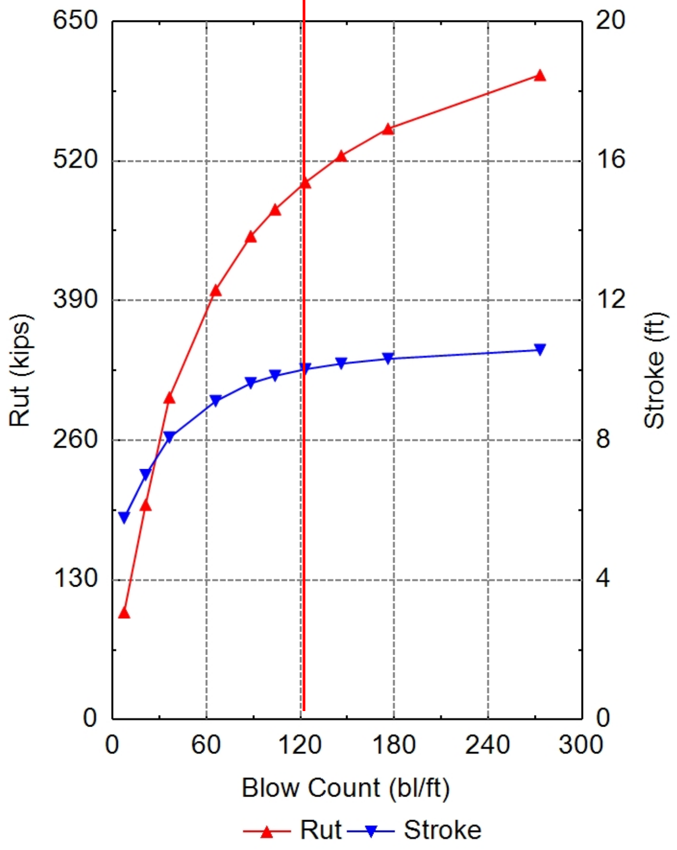
Scale: 1:1,120

Attachment E

Pedestrian Bridge: GRLWEAP Output

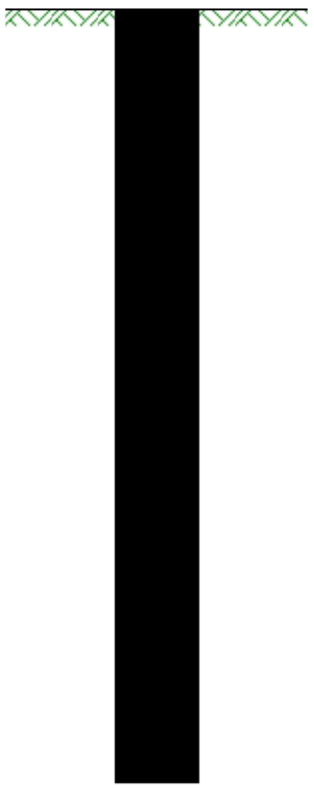
*Demonstrates HP12x53 (fy=50 ksi) can be driven to refusal (10 blows/inch) on rock without overstressing pile and will achieve ultimate capacity of ~500 kips with Delmag D 19-42

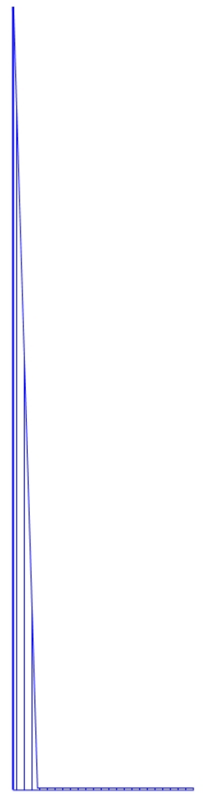




DELMAG D 19-42

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1600.0 (100%)	psi
Helmet Weight	3.200	kips
Hammer Cushion	109976.0	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.050	s/ft
Toe Damping	0.150	s/ft
Pile Length	70.00	ft
Pile Penetration	70.00	ft
Pile Top Area	15.50	in²
RSA	No	

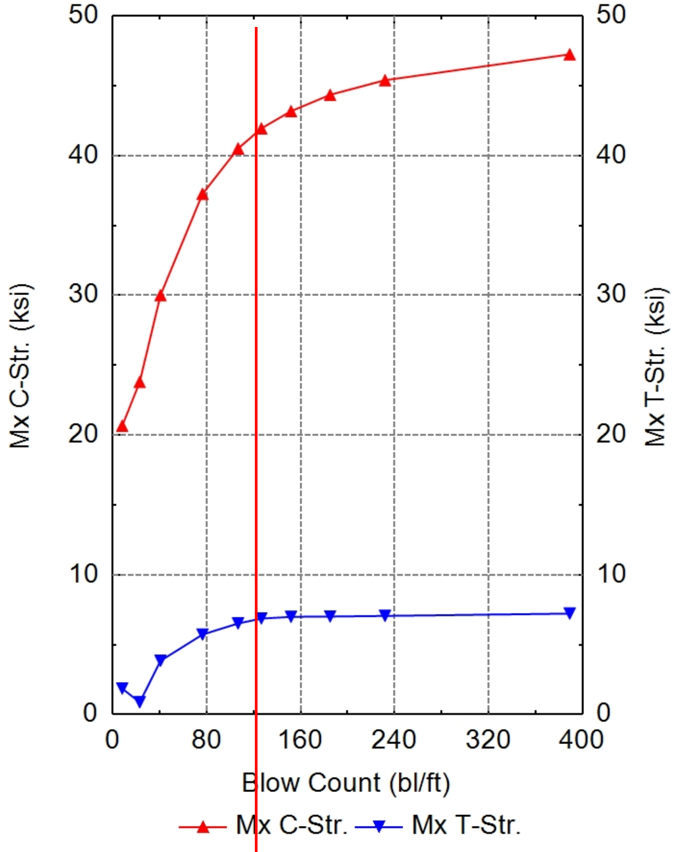

Pile Model

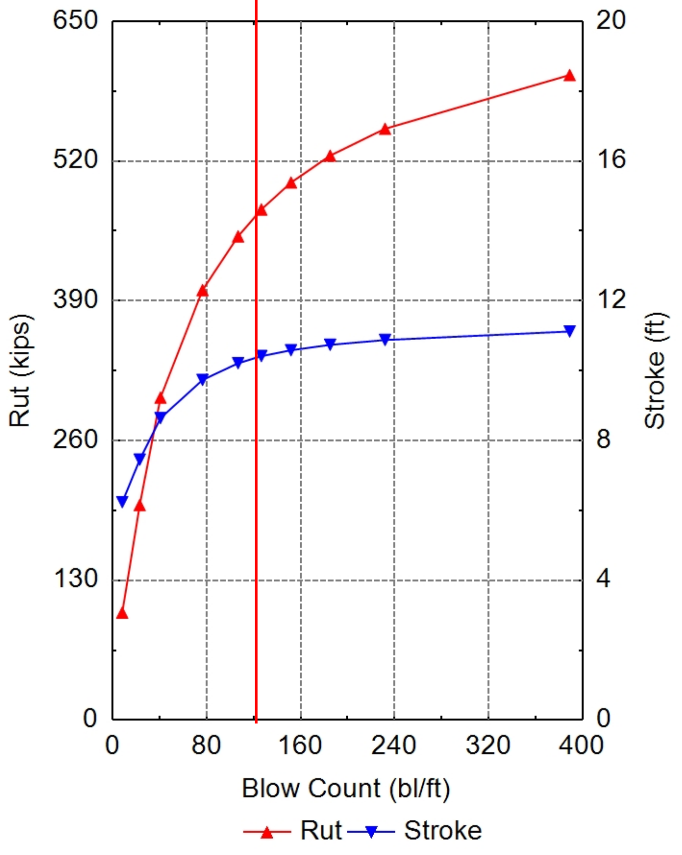

Shaft=90%
(Const. Shaft, ST)

Bearing Graph Summary — DELMAG D 19-42

Rut kips	Mx C-Str. ksi	Top Str. ksi	Mx T-Str. ksi	Blow Ct bl/ft	Stroke ft	ENTHRU kip-ft	Hammer DELMAG	Trans. Ratio %
100.0	20.99	20.90	1.74	7.3	5.77	19.94	D 19-42	46.1
200.0	24.57	24.46	1.11	21.0	7.00	18.69	D 19-42	43.2
300.0	30.56	27.15	3.42	36.2	8.08	20.85	D 19-42	48.2
400.0	37.99	35.87	5.46	65.8	9.12	23.15	D 19-42	53.5
450.0	41.12	39.69	6.23	88.2	9.63	24.35	D 19-42	56.3
475.0	42.52	41.40	6.65	103.8	9.84	24.93	D 19-42	57.7
500.0	43.93	42.99	7.03	123.1	10.03	25.47	D 19-42	58.9
525.0	45.19	44.37	7.36	146.1	10.19	25.87	D 19-42	59.8
550.0	46.35	45.62	7.58	176.0	10.33	26.23	D 19-42	60.7
600.0	48.43	47.83	7.78	273.2	10.58	26.88	D 19-42	62.2

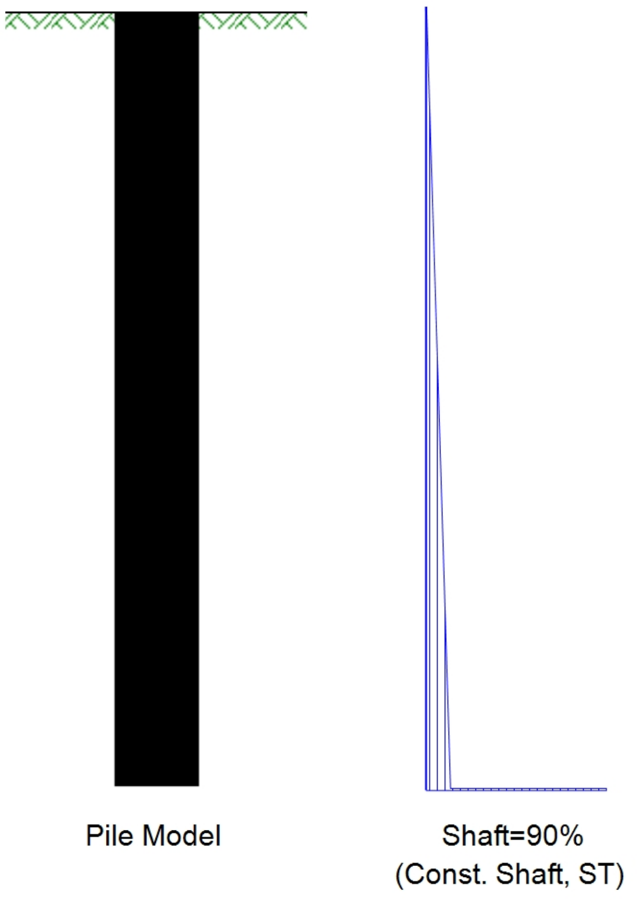
*Demonstrates HP12x53 (fy=50 ksi) can be driven to refusal (10 blows/inch) on rock without overstressing pile and will achieve ultimate capacity of ~450 kips with Delmag D 16-32





DELMAG D 16-32

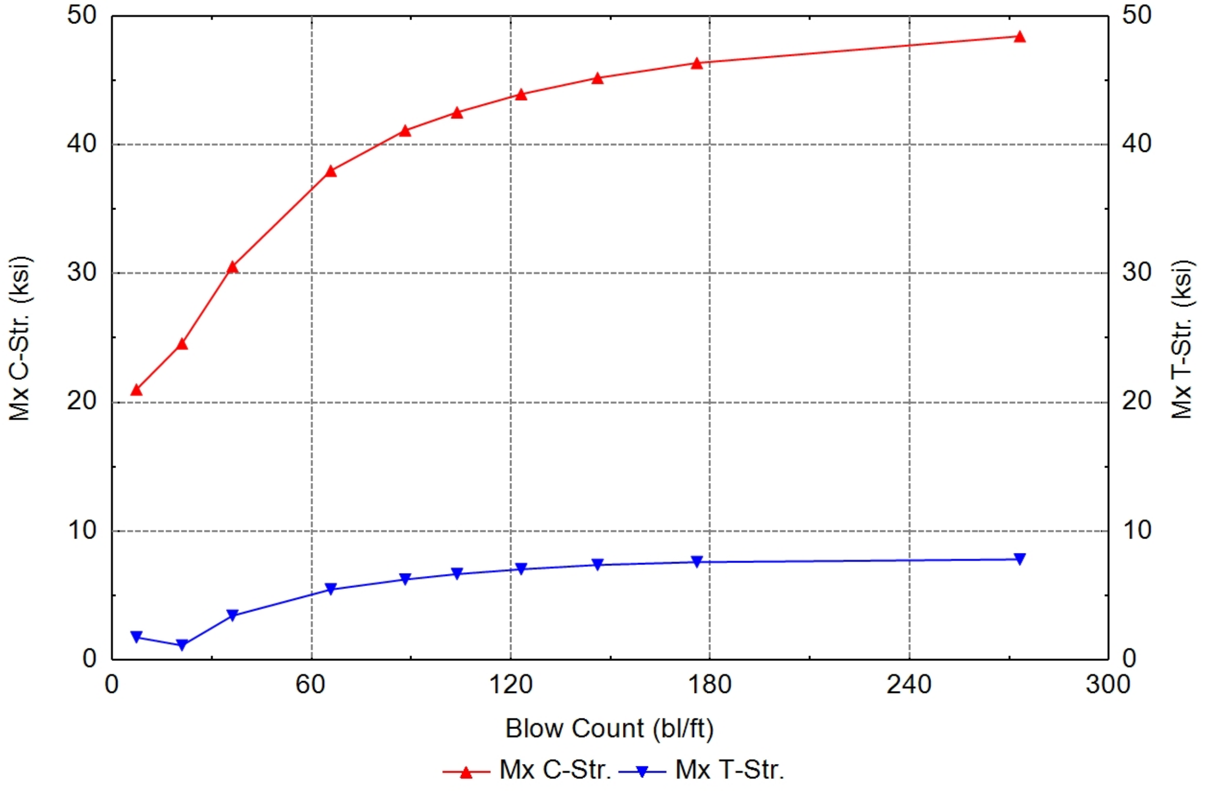
Ram Weight	3.52	kips
Efficiency	0.800	
Pressure	1500.0 (100%)	psi
Helmet Weight	3.200	kips
Hammer Cushion	109976.0	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.050	s/ft
Toe Damping	0.150	s/ft
Pile Length	70.00	ft
Pile Penetration	70.00	ft
Pile Top Area	15.50	in²
RSA	No	

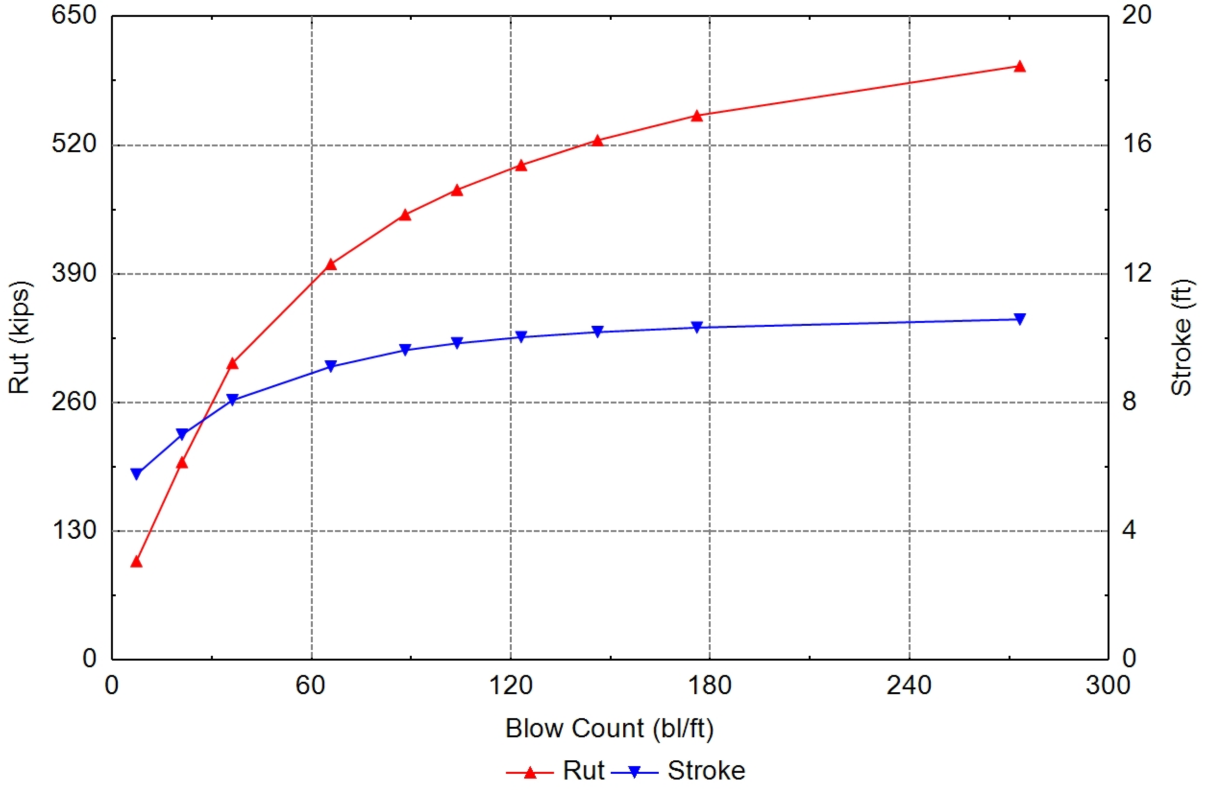


Bearing Graph Summary — DELMAG D 16-32

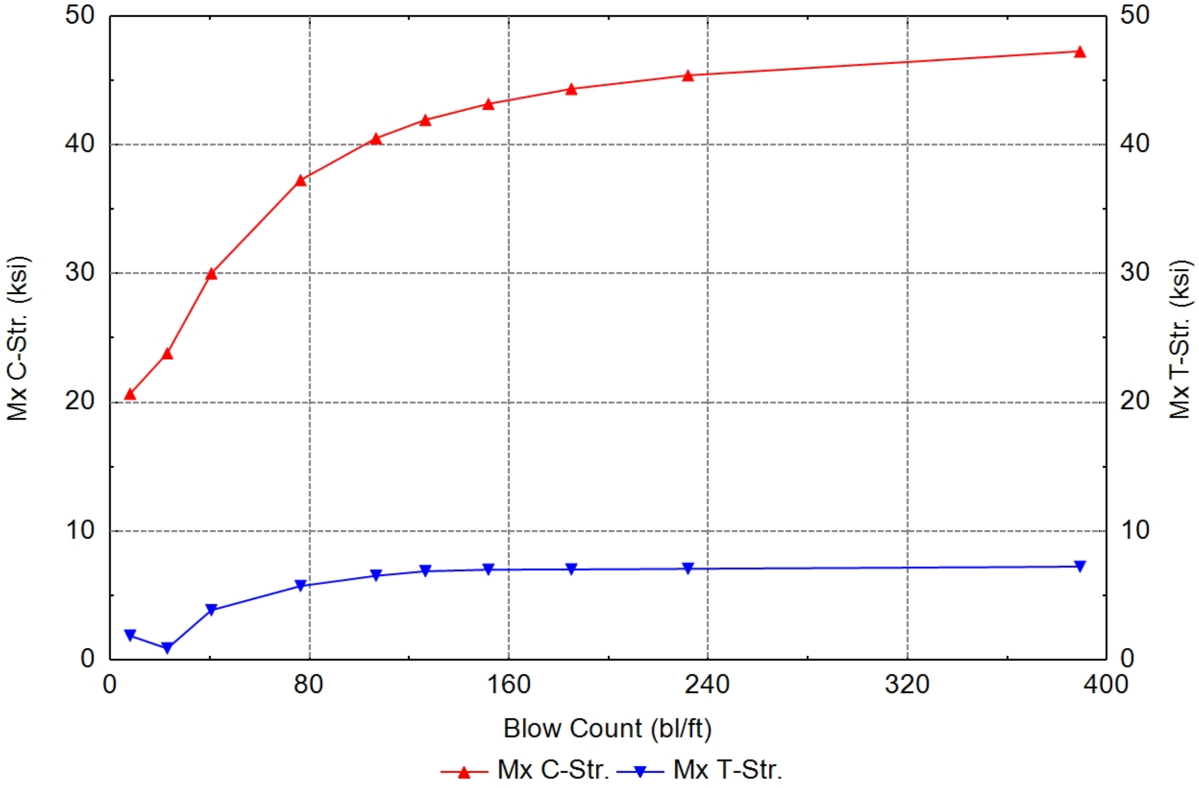
Rut kips	Mx C-Str. ksi	Top Str. ksi	Mx T-Str. ksi	Blow Ct bl/ft	Stroke ft	ENTHRU kip-ft	Hammer DELMAG	Trans. Ratio %
100.0	20.67	20.60	1.86	8.0	6.24	18.10	D 16-32	45.0
200.0	23.80	23.73	0.88	22.9	7.45	17.24	D 16-32	42.9
300.0	30.01	26.48	3.85	40.6	8.64	19.32	D 16-32	48.1
400.0	37.26	34.76	5.73	76.4	9.73	21.38	D 16-32	53.2
450.0	40.50	38.47	6.52	106.7	10.21	22.50	D 16-32	56.0
475.0	41.94	40.10	6.87	126.5	10.42	23.00	D 16-32	57.2
500.0	43.18	41.48	6.99	151.8	10.58	23.36	D 16-32	58.1
525.0	44.35	42.78	7.01	185.1	10.74	23.72	D 16-32	59.0
550.0	45.39	43.96	7.06	231.9	10.88	24.03	D 16-32	59.8
600.0	47.24	46.02	7.22	389.2	11.12	24.55	D 16-32	61.1

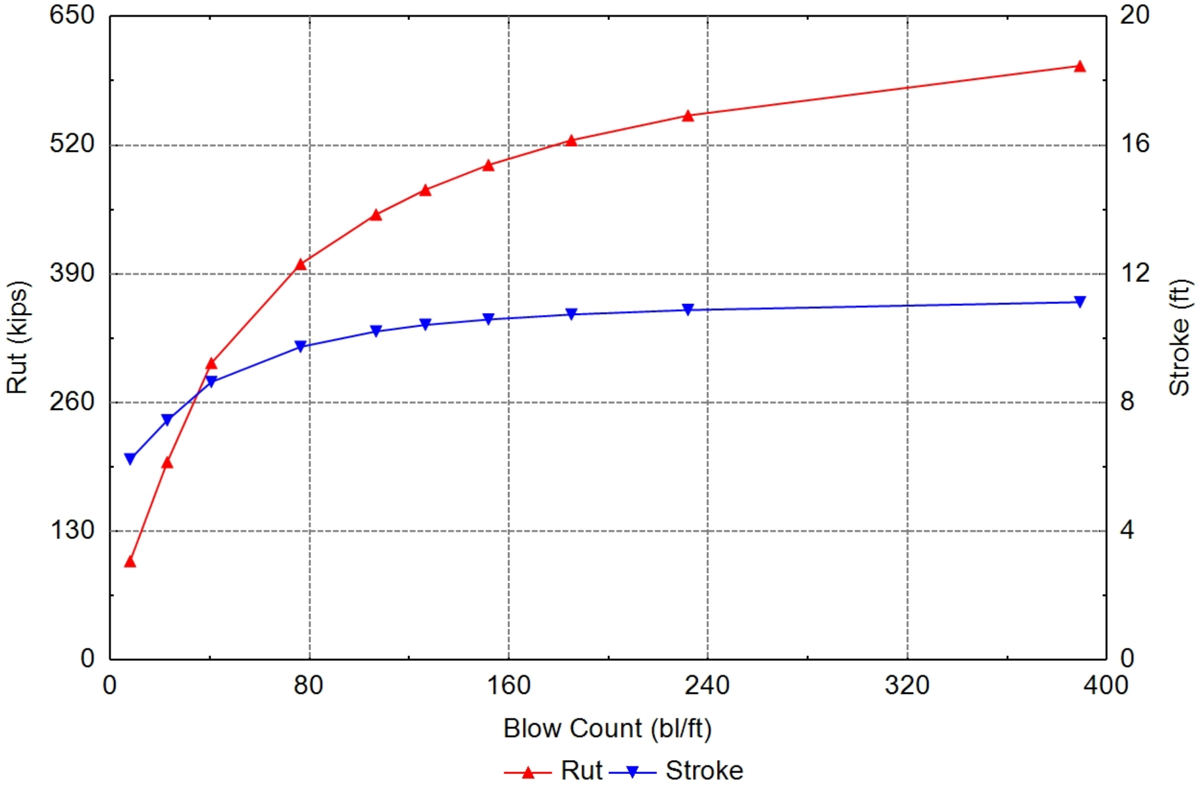
Bearing Graph Summary for DELMAG D 19-42





Bearing Graph Summary for DELMAG D 16-32





Bearing Graph Summary for DELMAG D 19-42

Rut kips	Mx C-Str. ksi	Top Str. ksi	Mx T-Str. ksi	Blow Ct bl/ft	Stroke ft	ENTHRU kip-ft	Hammer DELMAG	Trans. Ratio %
100.0	20.99	20.90	1.74	7.3	5.77	19.94	D 19-42	46.1
200.0	24.57	24.46	1.11	21.0	7.00	18.69	D 19-42	43.2
300.0	30.56	27.15	3.42	36.2	8.08	20.85	D 19-42	48.2
400.0	37.99	35.87	5.46	65.8	9.12	23.15	D 19-42	53.5
450.0	41.12	39.69	6.23	88.2	9.63	24.35	D 19-42	56.3
475.0	42.52	41.40	6.65	103.8	9.84	24.93	D 19-42	57.7
500.0	43.93	42.99	7.03	123.1	10.03	25.47	D 19-42	58.9
525.0	45.19	44.37	7.36	146.1	10.19	25.87	D 19-42	59.8
550.0	46.35	45.62	7.58	176.0	10.33	26.23	D 19-42	60.7
600.0	48.43	47.83	7.78	273.2	10.58	26.88	D 19-42	62.2

Bearing Graph Summary for DELMAG D 16-32

Rut kips	Mx C-Str. ksi	Top Str. ksi	Mx T-Str. ksi	Blow Ct bl/ft	Stroke ft	ENTHRU kip-ft	Hammer DELMAG	Trans. Ratio %
100.0	20.67	20.60	1.86	8.0	6.24	18.10	D 16-32	45.0
200.0	23.80	23.73	0.88	22.9	7.45	17.24	D 16-32	42.9
300.0	30.01	26.48	3.85	40.6	8.64	19.32	D 16-32	48.1
400.0	37.26	34.76	5.73	76.4	9.73	21.38	D 16-32	53.2
450.0	40.50	38.47	6.52	106.7	10.21	22.50	D 16-32	56.0
475.0	41.94	40.10	6.87	126.5	10.42	23.00	D 16-32	57.2
500.0	43.18	41.48	6.99	151.8	10.58	23.36	D 16-32	58.1
525.0	44.35	42.78	7.01	185.1	10.74	23.72	D 16-32	59.0
550.0	45.39	43.96	7.06	231.9	10.88	24.03	D 16-32	59.8
600.0	47.24	46.02	7.22	389.2	11.12	24.55	D 16-32	61.1

GRLWEAP: Wave Equation Analysis of Pile Foundations

Blake Road Pedestrian Bridge + HP12x53 9/28/2022
HDR ENGINEERING GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

SOIL PROFILE

Depth	Soil Type	Spec. Wt	Su	Phi	Unit Rs	Unit Rt
ft	-	lb/ft³	ksf	°	ksf	ksf
0.0	Sand	101.9	0.0	0.0	0.00	0.00
69.9	Sand	101.9	0.0	0.0	0.67	49.85
69.9	Rock	101.9	0.0	0.0	5.00	300.00
110.4	Rock	101.9	0.0	0.0	5.00	300.00

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	70.000	Pile Penetration: (ft)	70.000
Pile Size: (ft)	1.00	Toe Area: (in²)	15.50

Pile Profile

Lb Top	X-Area	E-Modulus	Spec. Wt	Perim.	Crit. Index
ft	in²	ksi	lb/ft³	ft	-
0.0	15.5	30,457.9	493.4	4.0	0
70.0	15.5	30,457.9	493.4	4.0	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED
ID	5	Made By:	DELMAG
Model	D 16-32	Type:	OED

Hammer Data

ID	Ram Wt	Ram L.	Ram Ar.	Rtd. Stk	Effic.	Rtd. Energy
-	kips	in	in²	ft	-	kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2
5	3.520	113.4	124.7	11.4	0.80	40.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type	X-Area	E-Modulus	Thickness	COR	Round-out	Stiffness
-	in²	ksi	in	-	in	kips/in
Hammer C.	415.000	530.000	2.000	0.800	0.120	109976.014
Helmet Wt.	3.200	kips				

DRIVE SYSTEM FOR DELMAG D 16-32-OED

Type	X-Area	E-Modulus	Thickness	COR	Round-out	Stiffness
-	in²	ksi	in	-	in	kips/in

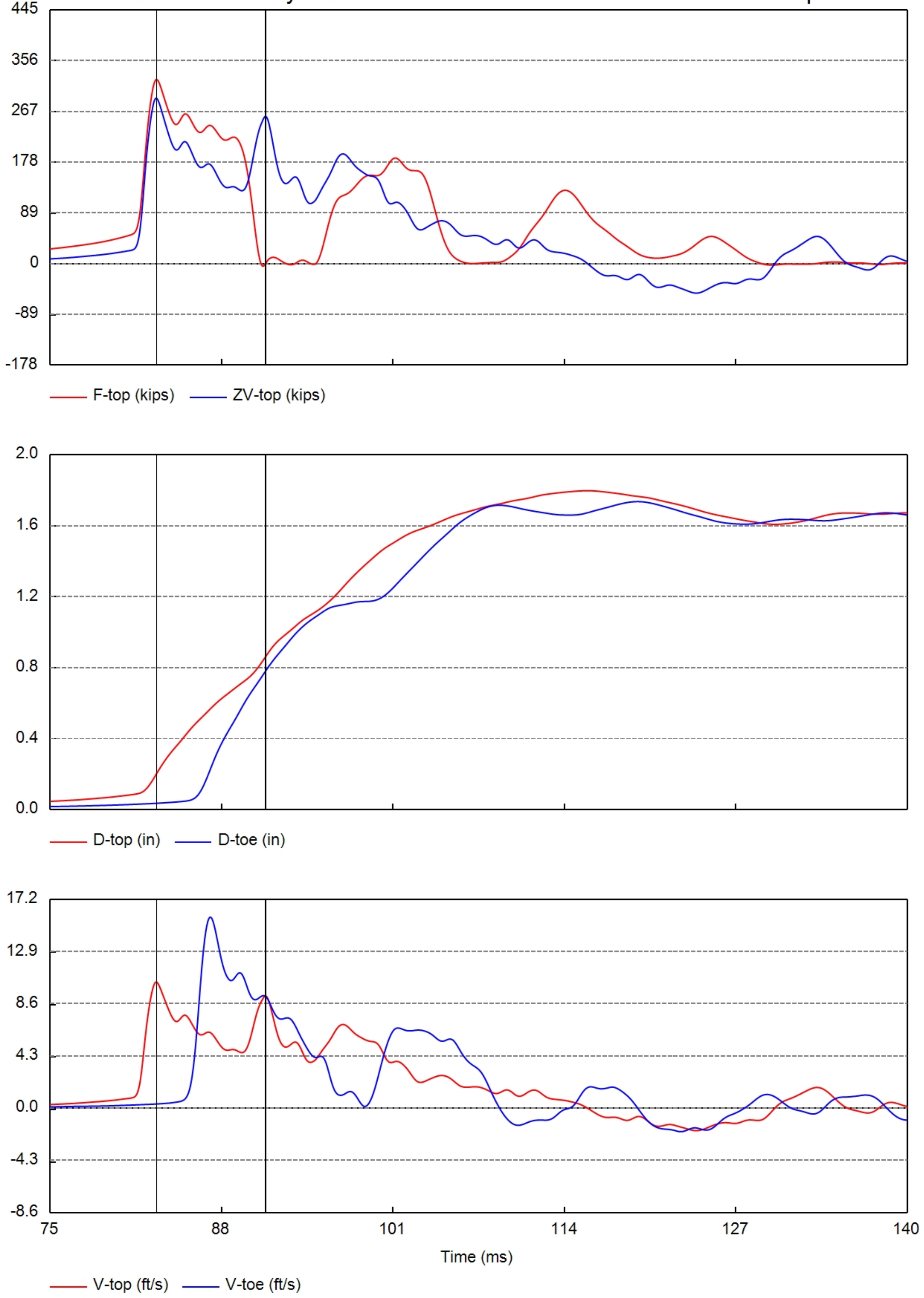
Hammer C.	415.000	530.000	2.000	0.800	0.120	109976.014
Helmet Wt.	3.200	kips				

SOIL RESISTANCE DISTRIBUTION

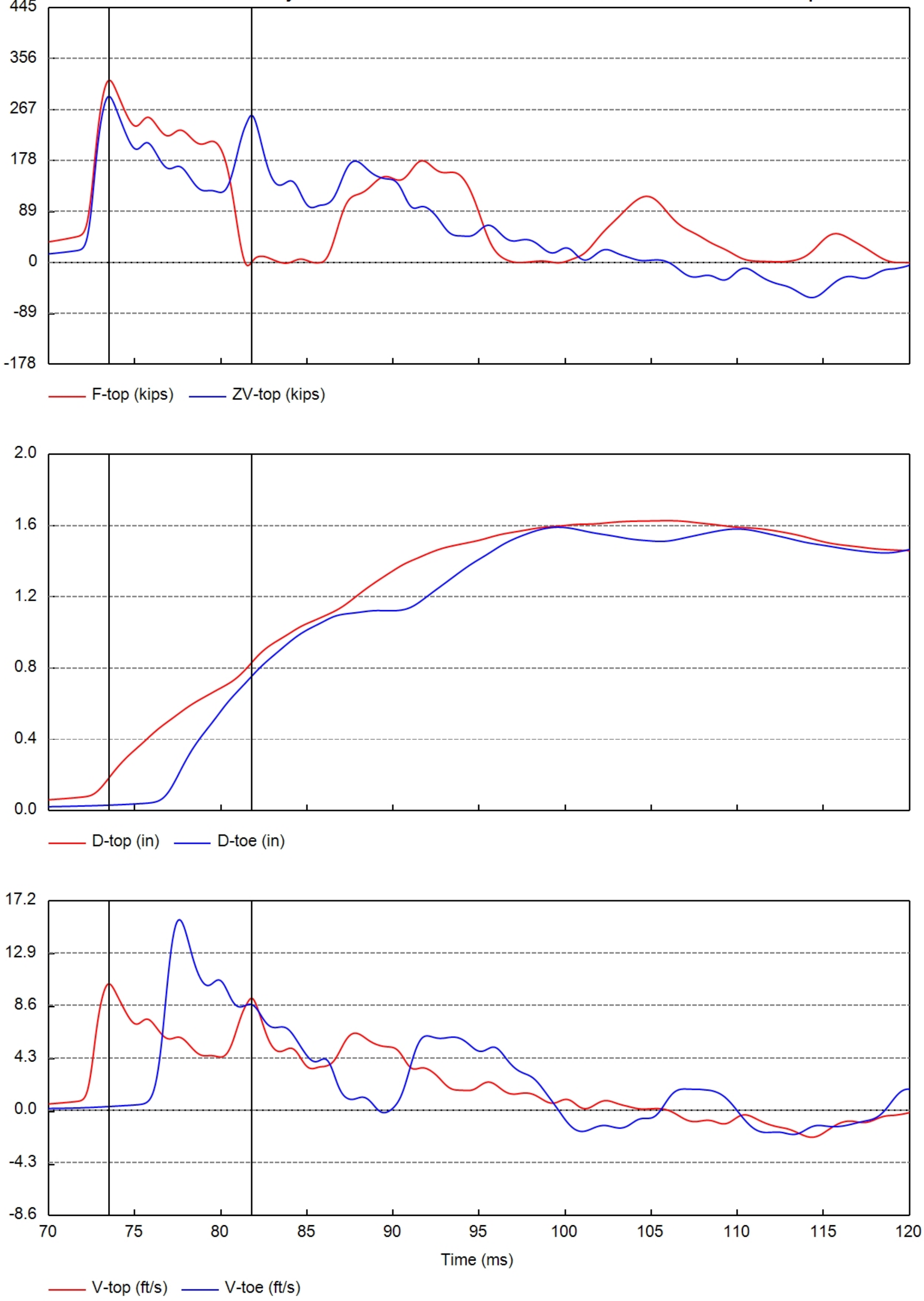
Depth (ft)	Relative Resistance
0.000	0.000
1.664	0.016
3.329	0.032
4.993	0.048
6.657	0.063
8.321	0.079
9.986	0.095
11.650	0.111
13.314	0.127
14.979	0.143
16.643	0.159
18.307	0.175
19.971	0.190
21.636	0.206
23.300	0.222
24.964	0.238
26.629	0.254
28.293	0.270
29.957	0.286
31.621	0.302
33.286	0.317
34.950	0.333
36.614	0.349
38.279	0.365
39.943	0.381
41.607	0.397
43.271	0.413
44.936	0.429
46.600	0.444
48.264	0.460
49.929	0.476
51.593	0.492
53.257	0.508
54.921	0.524
56.586	0.540

58.250	0.555
59.914	0.571
61.578	0.587
63.243	0.603
64.907	0.619
66.571	0.635
68.236	0.651
69.900	0.667
69.900	5.000
110.400	5.000

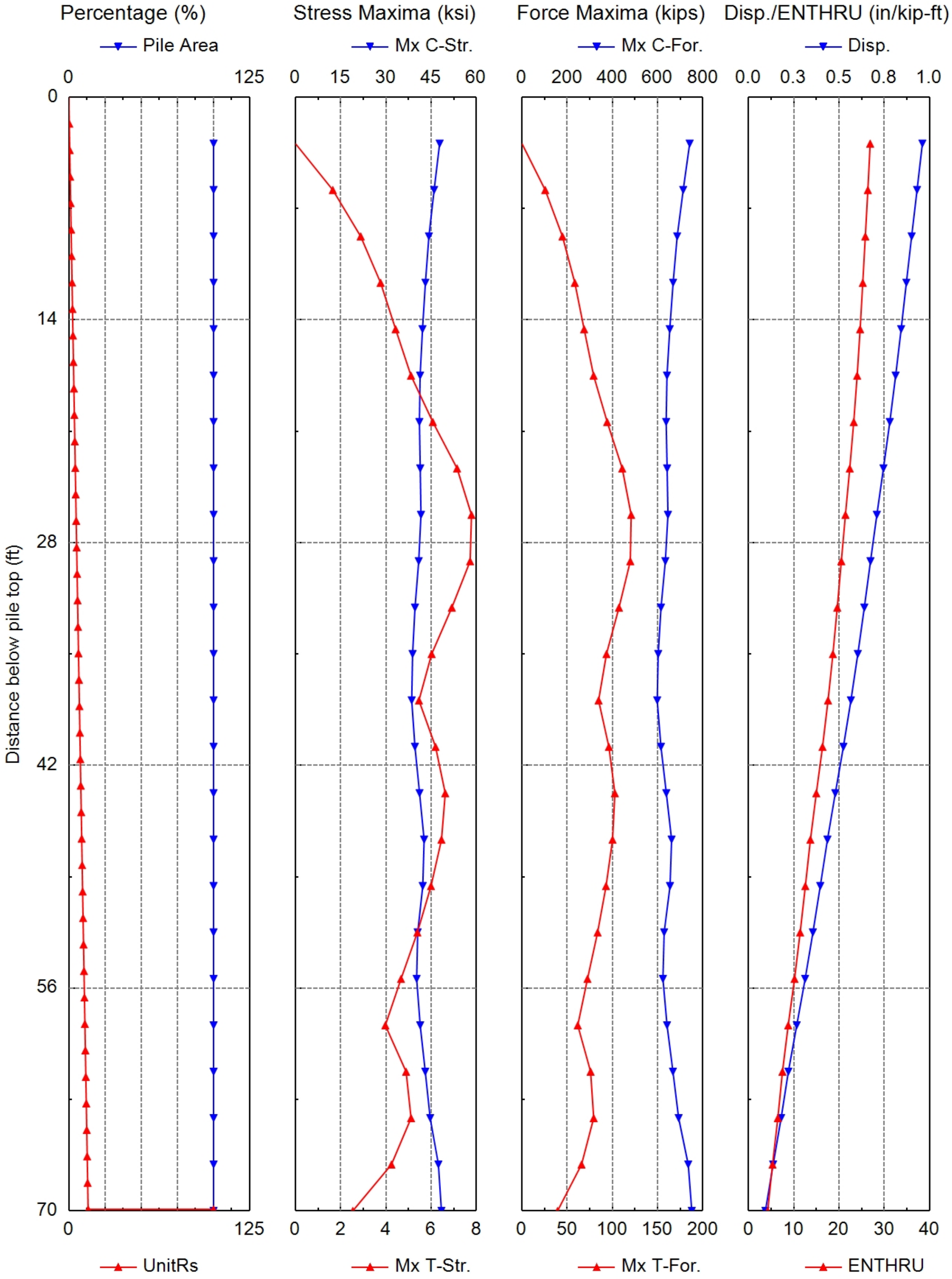
Variable Time Hisotry for DELMAG D 19-42 at Resistance = 100.0kips



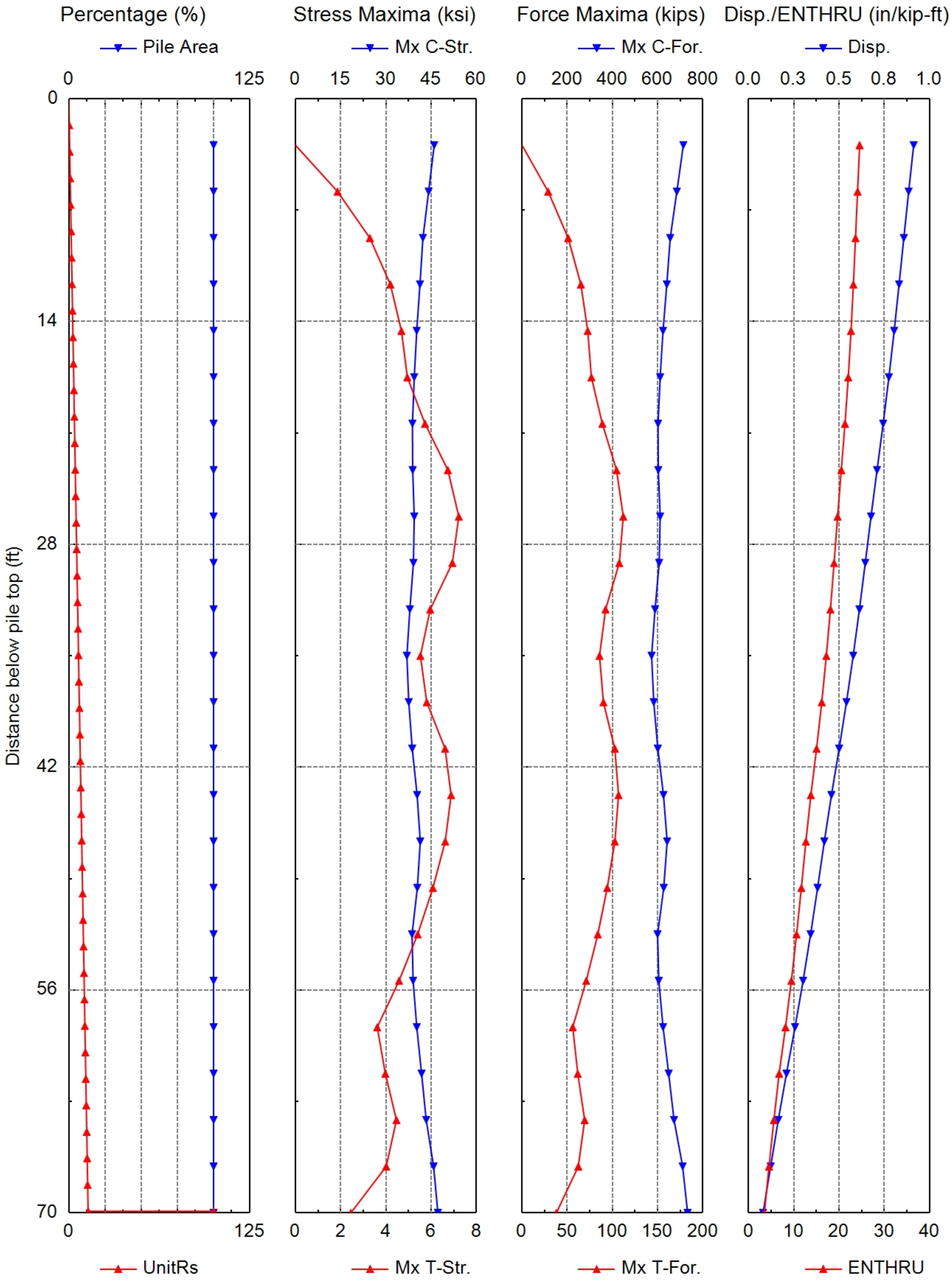
Variable Time Hisotry for DELMAG D 16-32 at Resistance = 100.0kips



Extrema Results for DELMAG D 19-42



Extrema Results for DELMAG D 16-32



GRLWEAP: Wave Equation Analysis of Pile Foundations

Blake Road Pedestrian Bridge + HP12x53 9/28/2022
HDR ENGINEERING GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

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Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

HAMMER DATA

Hammer Model:	D 19-42	Made By:	DELMAG
Hammer ID:	41	Hammer Type:	OED
Hammer Database Type:	PDI		
Hammer Database Name:			PDIHammer.gwh

Hammer and Drive System Segment Data

Segment -	Weight kips	Stiffness kips/in	COR -	C-Slack in	Damping kips/ft/s
1	0.800	140,084.4	1.000	0.000	
2	0.800	140,084.4	1.000	0.000	
3	0.800	140,084.4	1.000	0.000	
4	0.800	140,084.4	1.000	0.000	
5	0.800	70,754.7	0.900	0.120	
Imp Block	0.753	109,976.0	0.800	0.120	
Helmet	3.200				5.3

Ram Weight: (kips)	4.00	Ram Length: (ft)	10.76
Ram Area: (in²)	124.69		
Maximum (Eq) Stroke: (ft)	10.81	Actual (Eq) Stroke: (ft)	10.81
Efficiency:	0.800	Rated Energy: (kip-ft)	43.24
Maximum Pressure: (psi)	1,600.00	Actual Pressure: (psi)	1,600.00
Combustion Delay: (ms)	2.00	Ignition Duration: (ms)	2.00
Expansion Exponent:	1.25		

Hammer Cushion		Pile Cushion	
Cross Sect. Area: (in²)	415.00	Cross Sect. Area: (in²)	0.00
Elastic Modulus: (ksi)	530.0	Elastic Modulus: (ksi)	0.0
Thickness: (in)	2.00	Thickness: (in)	0.00
Coeff. of Restitution:	0.800	Coeff. of Restitution:	0.500
Stiffness: (kips/in)	109,976.0	Stiffness: (kips/in)	0.0

PILE DATA

Uniform Pile		Pile Type:	HPile
Pile Length: (ft)	70.000	Pile Penetration: (ft)	70.000
Pile Inclination: (deg)	0.0	Wave Travel Time 2L/c (ms):	8.279
Pile Size: (ft)	1.00	Toe Area: (in²)	15.50

Pile Profile

Lb Top ft	X-Area in²	E-Mod ksi	Spec. Wt lb/ft³	Perim. ft	C-Index -	Wave Sp ft/s	Impedance kips/ft/s
0.00	15.5	30,458	493.36	3.971	0	16,910.9	27.9
70.00	15.5	30,458	493.36	3.971	0	16,910.9	27.9

Pile and Soil Model Total Capacity Rut (kips): 100.000

Seg. -	Weight kips	Stiffn. kips/in	C-Slk in	T-Slk in	COR -	Ru kips	Js/Jt s/ft	Qs/Qt in	LbTop ft	Perim. ft	X-Area in²
1	0.15	13,489	0.12	0.00	0.85	0.2	0.050	0.10	2.92	3.97	15.5
2	0.15	13,489	0.00	0.00	1.00	0.5	0.050	0.10	5.83	3.97	15.5
3	0.15	13,489	0.00	0.00	1.00	0.8	0.050	0.10	8.75	3.97	15.5
4	0.15	13,489	0.00	0.00	1.00	1.1	0.050	0.10	11.67	3.97	15.5
5	0.15	13,489	0.00	0.00	1.00	1.4	0.050	0.10	14.58	3.97	15.5
6	0.15	13,489	0.00	0.00	1.00	1.7	0.050	0.10	17.50	3.97	15.5
7	0.15	13,489	0.00	0.00	1.00	2.0	0.050	0.10	20.42	3.97	15.5
8	0.15	13,489	0.00	0.00	1.00	2.3	0.050	0.10	23.33	3.97	15.5
9	0.15	13,489	0.00	0.00	1.00	2.6	0.050	0.10	26.25	3.97	15.5
10	0.15	13,489	0.00	0.00	1.00	2.9	0.050	0.10	29.17	3.97	15.5
11	0.15	13,489	0.00	0.00	1.00	3.2	0.050	0.10	32.08	3.97	15.5
12	0.15	13,489	0.00	0.00	1.00	3.5	0.050	0.10	35.00	3.97	15.5
13	0.15	13,489	0.00	0.00	1.00	3.8	0.050	0.10	37.92	3.97	15.5
14	0.15	13,489	0.00	0.00	1.00	4.1	0.050	0.10	40.83	3.97	15.5
15	0.15	13,489	0.00	0.00	1.00	4.4	0.050	0.10	43.75	3.97	15.5
16	0.15	13,489	0.00	0.00	1.00	4.8	0.050	0.10	46.67	3.97	15.5
17	0.15	13,489	0.00	0.00	1.00	5.1	0.050	0.10	49.58	3.97	15.5
18	0.15	13,489	0.00	0.00	1.00	5.4	0.050	0.10	52.50	3.97	15.5
19	0.15	13,489	0.00	0.00	1.00	5.7	0.050	0.10	55.42	3.97	15.5
20	0.15	13,489	0.00	0.00	1.00	6.0	0.050	0.10	58.33	3.97	15.5
21	0.15	13,489	0.00	0.00	1.00	6.3	0.050	0.10	61.25	3.97	15.5
22	0.15	13,489	0.00	0.00	1.00	6.6	0.050	0.10	64.17	3.97	15.5
23	0.15	13,489	0.00	0.00	1.00	6.9	0.050	0.10	67.08	3.97	15.5
24	0.15	13,489	0.00	0.00	1.00	8.9	0.050	0.10	70.00	3.97	15.5
Toe						10.0	0.150	0.04	70.00		

3.717 kips total unreduced pile weight (g = 32.169 ft/s²)
3.717 kips total reduced pile weight (g = 32.169 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS

Analysis type:	Bearing Graph	Soil Damping Option:	Smith
Pile Damping (%):	1	Pile Damping Fact.(kips/ft/s):	0.558
Shaft Resistance in %:	90	Constant shaft resistance	
Max No Analysis Iterations:	0	Time Increment/Critical:	160
Residual Stress Analysis:	0	Analysis Time-Input(ms):	0
Output Level:	Normal	Gravitational Acceleration (ft/s²):	32.17
Hammer Gravity (ft/s²):	32.17	Pile Gravity (ft/s²):	32.17

EXTREMA TABLE

Pile: Rut = 100.0 kips Rtoe = 10.0 kips Time Inc. = 0.076 ms

Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	324.0	0.00	20.90	10.39	1.797	19.94
5.8	9.6	325.0	0.62	20.97	10.36	1.790	19.88
8.7	10.3	325.4	0.66	20.99	10.32	1.784	19.78
11.7	14.2	325.4	0.92	20.99	10.27	1.778	19.61
14.6	16.9	325.1	1.09	20.97	10.31	1.772	19.39
17.5	18.5	324.1	1.19	20.91	10.73	1.768	19.12
20.4	19.4	323.1	1.25	20.85	11.01	1.763	18.80
23.3	20.5	321.6	1.32	20.75	11.05	1.759	18.42
26.3	21.9	319.7	1.41	20.62	10.97	1.757	17.99
29.2	23.5	317.7	1.52	20.50	11.15	1.755	17.50
32.1	25.2	315.3	1.63	20.34	11.62	1.753	16.95
35.0	26.5	312.4	1.71	20.15	12.04	1.751	16.34
37.9	26.9	309.5	1.74	19.96	12.18	1.749	15.67
40.8	26.2	306.1	1.69	19.75	12.04	1.747	14.94
43.8	24.6	302.4	1.58	19.51	11.98	1.745	14.15
46.7	22.1	298.2	1.43	19.24	12.46	1.743	13.30
49.6	19.4	293.6	1.25	18.94	13.05	1.742	12.38
52.5	17.3	288.5	1.11	18.61	13.29	1.741	11.40
55.4	15.3	282.1	0.99	18.20	13.14	1.740	10.37
58.3	12.9	271.6	0.83	17.52	12.89	1.739	9.28
61.2	9.7	252.0	0.63	16.26	13.33	1.738	8.12
64.2	6.9	218.5	0.44	14.10	14.27	1.737	6.89
67.1	4.2	168.2	0.27	10.85	15.21	1.736	5.60
70.0	1.5	101.8	0.10	6.57	15.73	1.735	4.94

Converged Stroke (ft) 5.75 Fixed Combustion Pressure (psi) 1,600.0

(Eq) Strokes Analyzed and Last Return (ft)

10.81 4.95 6.01 5.69 5.77 5.75

Pile: Rut = 200.0 kips Rtoe = 110.0 kips Time Inc. = 0.076 ms

Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	379.1	0.00	24.46	12.37	0.890	18.69
5.8	5.8	380.1	0.37	24.52	12.33	0.879	18.60
8.7	10.5	380.4	0.68	24.54	12.27	0.867	18.48

11.7	14.0	380.8	0.91	24.57	12.22	0.855	18.34
14.6	16.3	380.2	1.05	24.53	12.14	0.844	18.16
17.5	17.3	379.9	1.11	24.51	12.06	0.832	17.96
20.4	17.2	379.1	1.11	24.45	11.98	0.820	17.74
23.3	16.2	377.6	1.05	24.36	11.88	0.808	17.49
26.3	14.7	376.4	0.95	24.29	11.78	0.797	17.22
29.2	14.0	374.7	0.90	24.17	11.69	0.785	16.94
32.1	14.0	372.4	0.91	24.03	11.58	0.774	16.63
35.0	13.3	370.4	0.86	23.89	11.47	0.763	16.30
37.9	11.4	368.0	0.73	23.74	11.34	0.751	15.95
40.8	8.6	365.2	0.56	23.56	11.22	0.740	15.59
43.8	5.7	362.4	0.37	23.38	11.09	0.729	15.21
46.7	3.4	359.5	0.22	23.19	10.93	0.718	14.81
49.6	0.9	356.2	0.06	22.98	10.78	0.708	14.40
52.5	0.0	352.8	0.00	22.76	10.62	0.697	13.98
55.4	0.0	348.8	0.00	22.50	10.47	0.687	13.54
58.3	0.0	342.4	0.00	22.09	10.44	0.676	13.09
61.2	0.0	332.5	0.00	21.45	10.40	0.666	12.63
64.2	0.0	336.3	0.00	21.70	9.99	0.657	12.16
67.1	0.0	330.3	0.00	21.31	10.50	0.648	11.68
70.0	0.0	300.2	0.00	19.37	10.54	0.639	11.42

Converged Stroke (ft) 7.02 Fixed Combustion Pressure (psi) 1,600.0
(Eq) Strokes Analyzed and Last Return (ft)
10.81 6.56 7.09 7.00 7.02

Pile: Rut = 300.0 kips Rtoe = 210.0 kips Time Inc. = 0.066 ms
Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	420.8	0.00	27.15	13.91	0.871	20.85
5.8	11.4	422.1	0.74	27.23	13.87	0.847	20.51
8.7	21.4	422.7	1.38	27.27	13.83	0.824	20.15
11.7	29.5	422.8	1.91	27.27	13.76	0.800	19.77
14.6	35.5	422.3	2.29	27.24	13.68	0.776	19.36
17.5	39.8	421.7	2.57	27.20	13.59	0.753	18.93
20.4	43.8	420.8	2.83	27.15	13.50	0.730	18.49
23.3	47.9	419.5	3.09	27.06	13.40	0.707	18.04
26.3	51.3	417.7	3.31	26.95	13.29	0.685	17.58
29.2	53.0	416.1	3.42	26.84	13.18	0.662	17.11
32.1	52.9	414.1	3.41	26.72	13.06	0.640	16.63

35.0	51.0	411.6	3.29	26.56	12.94	0.619	16.15
37.9	47.7	409.3	3.08	26.40	12.81	0.597	15.66
40.8	44.3	406.7	2.86	26.24	12.66	0.577	15.18
43.8	39.8	403.8	2.57	26.05	12.52	0.556	14.70
46.7	33.9	419.0	2.18	27.04	12.35	0.536	14.21
49.6	27.4	413.1	1.77	26.65	12.18	0.516	13.74
52.5	21.4	402.2	1.38	25.95	12.00	0.497	13.27
55.4	16.0	392.2	1.03	25.30	11.82	0.478	12.81
58.3	11.0	405.8	0.71	26.18	11.66	0.459	12.36
61.2	7.8	425.9	0.50	27.48	11.31	0.441	11.91
64.2	5.7	458.1	0.37	29.56	10.38	0.423	11.48
67.1	3.9	473.6	0.25	30.56	8.38	0.406	11.07
70.0	2.1	458.3	0.13	29.57	7.57	0.390	10.80

Converged Stroke (ft) 8.04 Fixed Combustion Pressure (psi) 1,600.0

(Eq) Strokes Analyzed and Last Return (ft)

10.81 7.79 8.08 8.04

Pile: Rut = 400.0 kips Rtoe = 310.0 kips Time Inc. = 0.051 ms

Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	556.0	0.00	35.87	15.30	0.900	23.15
5.8	14.9	533.3	0.96	34.41	15.25	0.871	22.58
8.7	28.9	529.9	1.87	34.18	15.20	0.843	22.09
11.7	41.9	515.9	2.70	33.29	15.12	0.814	21.53
14.6	54.2	512.0	3.50	33.03	15.04	0.785	20.96
17.5	65.5	504.2	4.23	32.53	14.94	0.757	20.39
20.4	74.7	504.2	4.82	32.53	14.84	0.728	19.77
23.3	80.5	504.4	5.19	32.54	14.73	0.697	19.06
26.3	82.5	501.8	5.32	32.38	14.62	0.663	18.25
29.2	82.0	493.2	5.29	31.82	14.50	0.628	17.36
32.1	82.4	493.2	5.31	31.82	14.36	0.594	16.51
35.0	84.6	481.6	5.46	31.07	14.23	0.562	15.69
37.9	83.1	477.4	5.36	30.80	14.09	0.528	14.92
40.8	76.7	484.0	4.95	31.22	13.94	0.500	14.26
43.8	65.9	506.0	4.25	32.65	13.78	0.473	13.61
46.7	59.6	524.9	3.85	33.87	13.62	0.446	12.98
49.6	50.9	517.5	3.28	33.39	13.43	0.419	12.35
52.5	47.1	504.0	3.04	32.52	13.24	0.392	11.74
55.4	39.8	488.9	2.57	31.54	13.04	0.367	11.15

58.3	30.4	508.5	1.96	32.81	12.79	0.341	10.58
61.2	31.0	527.6	2.00	34.04	12.24	0.315	10.01
64.2	27.4	559.4	1.77	36.09	10.96	0.288	9.43
67.1	20.4	588.8	1.31	37.99	8.38	0.261	8.85
70.0	11.0	581.2	0.71	37.50	5.72	0.236	8.43

Converged Stroke (ft) 9.14 Fixed Combustion Pressure (psi) 1,600.0
(Eq) Strokes Analyzed and Last Return (ft)
10.81 9.12 9.14

Pile: Rut = 450.0 kips Rtoe = 360.0 kips Time Inc. = 0.046 ms
Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	615.2	0.00	39.69	15.93	0.920	24.35
5.8	17.7	588.9	1.14	37.99	15.89	0.893	23.91
8.7	33.4	580.7	2.16	37.46	15.84	0.864	23.38
11.7	47.2	565.0	3.04	36.45	15.77	0.835	22.82
14.6	59.5	558.0	3.84	36.00	15.69	0.806	22.25
17.5	70.9	548.4	4.57	35.38	15.59	0.777	21.66
20.4	80.9	547.8	5.22	35.34	15.47	0.747	20.99
23.3	88.4	549.3	5.70	35.44	15.35	0.714	20.22
26.3	92.4	548.7	5.96	35.40	15.23	0.680	19.34
29.2	94.5	539.3	6.10	34.79	15.10	0.644	18.44
32.1	96.6	531.2	6.23	34.27	14.97	0.611	17.58
35.0	96.3	523.3	6.21	33.76	14.83	0.577	16.72
37.9	90.1	521.3	5.81	33.63	14.69	0.542	15.78
40.8	77.3	526.9	4.99	34.00	14.54	0.504	14.75
43.8	67.2	550.3	4.34	35.50	14.38	0.463	13.58
46.7	67.7	569.0	4.37	36.71	14.21	0.422	12.54
49.6	68.0	559.9	4.39	36.12	14.02	0.393	11.87
52.5	62.8	544.0	4.05	35.09	13.82	0.365	11.22
55.4	51.7	531.3	3.34	34.28	13.61	0.337	10.58
58.3	39.2	552.0	2.53	35.61	13.33	0.310	9.96
61.2	43.4	572.5	2.80	36.94	12.69	0.281	9.32
64.2	42.4	603.4	2.74	38.93	11.26	0.250	8.62
67.1	34.1	637.3	2.20	41.12	8.41	0.218	7.91
70.0	19.2	635.5	1.24	41.00	5.01	0.188	7.36

Converged Stroke (ft) 9.58 Fixed Combustion Pressure (psi) 1,600.0
(Eq) Strokes Analyzed and Last Return (ft)

10.81 9.63 9.58

Pile: Rut = 475.0 kips Rtoe = 385.0 kips Time Inc. = 0.044 ms
Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	641.7	0.00	41.40	16.18	0.930	24.93
5.8	19.4	614.1	1.25	39.62	16.14	0.902	24.47
8.7	35.7	603.0	2.30	38.90	16.09	0.873	23.94
11.7	50.0	587.0	3.22	37.87	16.02	0.843	23.37
14.6	62.2	578.9	4.02	37.35	15.93	0.815	22.80
17.5	73.3	568.4	4.73	36.67	15.84	0.786	22.20
20.4	83.7	567.5	5.40	36.62	15.73	0.755	21.51
23.3	92.2	569.4	5.95	36.74	15.61	0.722	20.72
26.3	97.9	569.3	6.32	36.73	15.48	0.687	19.82
29.2	101.7	559.2	6.56	36.08	15.35	0.651	18.90
32.1	103.1	548.4	6.65	35.38	15.21	0.617	18.04
35.0	100.3	542.3	6.47	34.99	15.07	0.583	17.16
37.9	91.1	540.7	5.88	34.89	14.93	0.547	16.19
40.8	76.5	545.2	4.93	35.18	14.77	0.509	15.11
43.8	76.1	568.4	4.91	36.67	14.61	0.467	13.89
46.7	77.4	588.0	5.00	37.93	14.44	0.424	12.62
49.6	75.7	579.6	4.88	37.39	14.25	0.384	11.62
52.5	68.1	561.5	4.39	36.23	14.06	0.353	10.94
55.4	56.8	550.5	3.66	35.51	13.84	0.325	10.28
58.3	45.3	570.6	2.92	36.81	13.54	0.296	9.63
61.2	49.1	592.0	3.17	38.20	12.88	0.266	8.95
64.2	49.6	622.1	3.20	40.13	11.36	0.234	8.20
67.1	41.4	658.4	2.67	42.47	8.40	0.199	7.41
70.0	23.6	659.1	1.52	42.52	4.66	0.167	6.79

Converged Stroke (ft) 9.79 Fixed Combustion Pressure (psi) 1,600.0
(Eq) Strokes Analyzed and Last Return (ft)
10.81 9.84 9.79

Pile: Rut = 500.0 kips Rtoe = 410.0 kips Time Inc. = 0.042 ms
Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	666.3	0.00	42.99	16.41	0.939	25.47
5.8	21.1	637.8	1.36	41.15	16.37	0.911	25.01

8.7	37.5	623.7	2.42	40.24	16.32	0.881	24.46
11.7	52.4	607.0	3.38	39.16	16.25	0.852	23.89
14.6	64.1	597.7	4.13	38.56	16.16	0.823	23.32
17.5	75.1	587.0	4.84	37.87	16.06	0.794	22.70
20.4	85.9	585.8	5.54	37.79	15.96	0.763	21.99
23.3	96.0	588.0	6.20	37.94	15.84	0.729	21.18
26.3	103.9	588.4	6.70	37.96	15.71	0.693	20.26
29.2	108.7	577.6	7.02	37.26	15.58	0.658	19.34
32.1	108.9	564.5	7.03	36.42	15.43	0.624	18.47
35.0	102.8	559.5	6.63	36.10	15.29	0.589	17.56
37.9	90.5	557.1	5.84	35.94	15.14	0.553	16.57
40.8	79.3	561.9	5.12	36.25	14.99	0.513	15.46
43.8	84.7	585.1	5.47	37.75	14.83	0.471	14.20
46.7	86.3	606.1	5.57	39.11	14.65	0.427	12.90
49.6	82.2	598.5	5.30	38.61	14.47	0.388	11.80
52.5	72.8	578.3	4.70	37.31	14.27	0.348	10.72
55.4	61.9	568.2	3.99	36.66	14.05	0.315	10.02
58.3	50.6	588.2	3.26	37.95	13.74	0.285	9.34
61.2	54.9	610.4	3.54	39.38	13.03	0.254	8.62
64.2	56.4	639.5	3.64	41.26	11.46	0.219	7.81
67.1	48.3	677.4	3.12	43.70	8.41	0.183	6.94
70.0	27.9	681.0	1.80	43.93	4.33	0.148	6.23

Converged Stroke (ft) 9.97 Fixed Combustion Pressure (psi) 1,600.0

(Eq) Strokes Analyzed and Last Return (ft)

10.81 10.03 9.97

Pile: Rut = 525.0 kips Rtoe = 435.0 kips Time Inc. = 0.040 ms

Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	687.8	0.00	44.37	16.59	0.945	25.87
5.8	22.4	658.8	1.45	42.50	16.55	0.917	25.39
8.7	39.3	641.4	2.54	41.38	16.50	0.887	24.84
11.7	54.0	624.4	3.49	40.28	16.43	0.857	24.27
14.6	65.4	613.7	4.22	39.59	16.34	0.829	23.70
17.5	76.3	602.7	4.92	38.89	16.24	0.799	23.07
20.4	87.6	600.9	5.65	38.77	16.13	0.768	22.35
23.3	99.6	603.6	6.42	38.94	16.02	0.734	21.52
26.3	109.5	604.9	7.06	39.02	15.89	0.698	20.59
29.2	114.1	593.9	7.36	38.31	15.76	0.662	19.66

32.1	111.7	579.3	7.21	37.37	15.62	0.628	18.79
35.0	101.0	573.0	6.51	36.97	15.47	0.593	17.87
37.9	87.5	568.8	5.64	36.69	15.31	0.556	16.85
40.8	84.0	576.7	5.42	37.21	15.16	0.516	15.71
43.8	91.2	600.3	5.89	38.73	15.00	0.473	14.41
46.7	92.1	621.8	5.94	40.11	14.82	0.430	13.12
49.6	85.9	613.8	5.54	39.60	14.63	0.390	12.01
52.5	76.1	592.0	4.91	38.20	14.43	0.350	10.91
55.4	65.6	583.6	4.23	37.65	14.21	0.309	9.78
58.3	53.8	603.1	3.47	38.91	13.89	0.276	9.08
61.2	60.8	626.4	3.92	40.41	13.16	0.244	8.32
64.2	63.4	654.6	4.09	42.23	11.52	0.208	7.45
67.1	54.9	693.9	3.54	44.77	8.39	0.169	6.50
70.0	32.2	700.5	2.08	45.19	4.00	0.132	5.71

Converged Stroke (ft) 10.13 Fixed Combustion Pressure (psi) 1,600.0

(Eq) Strokes Analyzed and Last Return (ft)

10.81 10.19 10.13

Pile: Rut = 550.0 kips Rtoe = 460.0 kips Time Inc. = 0.038 ms

Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	707.1	0.00	45.62	16.75	0.951	26.23
5.8	23.7	678.1	1.53	43.75	16.72	0.922	25.74
8.7	41.0	657.5	2.65	42.42	16.67	0.892	25.19
11.7	55.6	640.2	3.59	41.30	16.59	0.863	24.62
14.6	66.5	627.9	4.29	40.51	16.50	0.834	24.04
17.5	77.0	616.6	4.97	39.78	16.41	0.804	23.40
20.4	89.5	614.5	5.77	39.64	16.29	0.772	22.67
23.3	103.6	617.7	6.69	39.85	16.17	0.738	21.82
26.3	114.3	619.6	7.37	39.98	16.05	0.702	20.88
29.2	117.5	608.7	7.58	39.27	15.92	0.666	19.96
32.1	111.6	592.7	7.20	38.24	15.78	0.632	19.08
35.0	96.9	584.3	6.25	37.69	15.63	0.597	18.14
37.9	86.9	578.7	5.61	37.33	15.47	0.559	17.10
40.8	88.6	590.4	5.71	38.09	15.31	0.519	15.93
43.8	96.3	614.2	6.21	39.62	15.15	0.475	14.61
46.7	95.7	636.2	6.17	41.04	14.97	0.432	13.31
49.6	88.6	628.1	5.71	40.52	14.78	0.392	12.21
52.5	79.1	604.7	5.10	39.01	14.58	0.352	11.09

55.4	68.4	597.9	4.41	38.57	14.36	0.310	9.89
58.3	56.3	617.0	3.63	39.81	14.03	0.268	8.82
61.2	66.3	641.2	4.28	41.37	13.27	0.235	8.02
64.2	69.6	668.5	4.49	43.13	11.58	0.197	7.11
67.1	60.8	709.1	3.92	45.75	8.36	0.157	6.08
70.0	36.0	718.5	2.32	46.35	3.69	0.118	5.20

Converged Stroke (ft) 10.28 Fixed Combustion Pressure (psi) 1,600.0
(Eq) Strokes Analyzed and Last Return (ft)
10.81 10.33 10.28

Pile: Rut = 600.0 kips Rtoe = 510.0 kips Time Inc. = 0.035 ms
Hammer: DELMAG D 19-42 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	741.3	0.00	47.83	17.03	0.961	26.88
5.8	25.6	712.8	1.65	45.99	17.01	0.931	26.37
8.7	44.7	686.2	2.89	44.27	16.95	0.901	25.81
11.7	58.4	668.1	3.77	43.10	16.88	0.872	25.24
14.6	68.7	653.3	4.43	42.15	16.79	0.843	24.66
17.5	79.2	641.0	5.11	41.35	16.69	0.813	24.01
20.4	94.2	637.3	6.08	41.12	16.58	0.780	23.25
23.3	110.8	641.6	7.15	41.39	16.46	0.745	22.37
26.3	120.7	645.3	7.78	41.63	16.33	0.709	21.41
29.2	119.7	633.8	7.72	40.89	16.20	0.674	20.50
32.1	107.2	614.6	6.91	39.65	16.06	0.640	19.61
35.0	93.4	602.3	6.02	38.86	15.91	0.604	18.64
37.9	84.7	597.8	5.46	38.57	15.75	0.565	17.56
40.8	96.0	614.3	6.20	39.63	15.59	0.524	16.34
43.8	102.7	638.1	6.63	41.17	15.42	0.479	14.97
46.7	100.1	661.5	6.46	42.68	15.24	0.436	13.68
49.6	92.9	654.6	5.99	42.23	15.05	0.396	12.56
52.5	83.6	628.5	5.39	40.55	14.85	0.356	11.40
55.4	72.4	623.1	4.67	40.20	14.62	0.313	10.16
58.3	61.6	641.3	3.98	41.38	14.27	0.266	8.76
61.2	75.8	667.4	4.89	43.06	13.46	0.220	7.49
64.2	79.2	692.7	5.11	44.69	11.67	0.180	6.47
67.1	65.8	735.0	4.25	47.42	8.32	0.136	5.29
70.0	39.3	750.6	2.54	48.43	3.48	0.093	4.23

Converged Stroke (ft) 10.55 Fixed Combustion Pressure (psi) 1,600.0

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(Eq) Strokes Analyzed and Last Return  (ft)
   10.81       10.58       10.55
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SUMMARY TABLE; HAMMER: DELMAG D 19-42

Rut kips	Bl Ct b/ft	Stk Dn ft	Stk Up ft	Mx T-Str ksi	LTop ft	Mx C-Str ksi	LTop ft	ENTHRU kip-ft	Bl Rt b/min	ActRes kips
100.0	7.3	5.77	5.75	1.74	35.0	20.99	35.0	19.9	49.0	100.0
200.0	21.0	7.00	7.02	1.11	14.6	24.57	14.6	18.7	44.5	200.0
300.0	36.2	8.08	8.04	3.42	26.3	30.56	26.3	20.8	41.6	300.0
400.0	65.8	9.12	9.14	5.46	32.1	37.99	32.1	23.2	39.1	400.0
450.0	88.2	9.63	9.58	6.23	29.2	41.12	29.2	24.4	38.1	450.0
475.0	103.8	9.84	9.79	6.65	29.2	42.52	29.2	24.9	37.7	475.0
500.0	123.1	10.03	9.97	7.03	29.2	43.93	29.2	25.5	37.4	500.0
525.0	146.1	10.19	10.13	7.36	26.3	45.19	26.3	25.9	37.1	525.0
550.0	176.0	10.33	10.28	7.58	26.3	46.35	26.3	26.2	36.8	550.0
600.0	273.2	10.58	10.55	7.78	23.3	48.43	23.3	26.9	36.4	599.4

HAMMER DATA

Hammer Model:	D 16-32	Made By:	DELMAG
Hammer ID:	5	Hammer Type:	OED
Hammer Database Type:	PDI		
Hammer Database Name:			PDIHammer.gwh

Hammer and Drive System Segment Data

Segment -	Weight kips	Stiffness kips/in	COR -	C-Slack in	Damping kips/ft/s
1	0.880	127,583.0	1.000	0.000	
2	0.880	127,583.0	1.000	0.000	
3	0.880	127,583.0	1.000	0.000	
4	0.880	67,443.2	0.900	0.120	
Imp Block	0.750	109,976.0	0.800	0.120	
Helmet	3.200				5.3

Ram Weight: (kips)	3.52	Ram Length: (ft)	9.45
Ram Area: (in²)	124.69		
Maximum (Eq) Stroke: (ft)	11.42	Actual (Eq) Stroke: (ft)	11.42
Efficiency:	0.800	Rated Energy: (kip-ft)	40.20
Maximum Pressure: (psi)	1,500.00	Actual Pressure: (psi)	1,500.00
Combustion Delay: (ms)	2.00	Ignition Duration: (ms)	2.00
Expansion Exponent:	1.25		

Hammer Cushion		Pile Cushion	
Cross Sect. Area: (in²)	415.00	Cross Sect. Area: (in²)	0.00
Elastic Modulus: (ksi)	530.0	Elastic Modulus: (ksi)	0.0
Thickness: (in)	2.00	Thickness: (in)	0.00
Coeff. of Restitution:	0.800	Coeff. of Restitution:	0.500
Stiffness: (kips/in)	109,976.0	Stiffness: (kips/in)	0.0

PILE DATA

Uniform Pile		Pile Type:	HPile
Pile Length: (ft)	70.000	Pile Penetration: (ft)	70.000
Pile Inclination: (deg)	0.0	Wave Travel Time 2L/c (ms):	8.279
Pile Size: (ft)	1.00	Toe Area: (in²)	15.50

Pile Profile

Lb Top ft	X-Area in²	E-Mod ksi	Spec. Wt lb/ft³	Perim. ft	C-Index -	Wave Sp ft/s	Impedance kips/ft/s
0.00	15.5	30,458	493.36	3.971	0	16,910.9	27.9
70.00	15.5	30,458	493.36	3.971	0	16,910.9	27.9

Pile and Soil Model

Total Capacity Rut (kips): 100.000

Seg. -	Weight kips	Stiffn. kips/in	C-Slk in	T-Slk in	COR -	Ru kips	Js/Jt s/ft	Qs/Qt in	LbTop ft	Perim. ft	X-Area in²
1	0.15	13,489	0.12	0.00	0.85	0.2	0.050	0.10	2.92	3.97	15.5
2	0.15	13,489	0.00	0.00	1.00	0.5	0.050	0.10	5.83	3.97	15.5
3	0.15	13,489	0.00	0.00	1.00	0.8	0.050	0.10	8.75	3.97	15.5
4	0.15	13,489	0.00	0.00	1.00	1.1	0.050	0.10	11.67	3.97	15.5
5	0.15	13,489	0.00	0.00	1.00	1.4	0.050	0.10	14.58	3.97	15.5
6	0.15	13,489	0.00	0.00	1.00	1.7	0.050	0.10	17.50	3.97	15.5
7	0.15	13,489	0.00	0.00	1.00	2.0	0.050	0.10	20.42	3.97	15.5
8	0.15	13,489	0.00	0.00	1.00	2.3	0.050	0.10	23.33	3.97	15.5
9	0.15	13,489	0.00	0.00	1.00	2.6	0.050	0.10	26.25	3.97	15.5
10	0.15	13,489	0.00	0.00	1.00	2.9	0.050	0.10	29.17	3.97	15.5
11	0.15	13,489	0.00	0.00	1.00	3.2	0.050	0.10	32.08	3.97	15.5
12	0.15	13,489	0.00	0.00	1.00	3.5	0.050	0.10	35.00	3.97	15.5
13	0.15	13,489	0.00	0.00	1.00	3.8	0.050	0.10	37.92	3.97	15.5
14	0.15	13,489	0.00	0.00	1.00	4.1	0.050	0.10	40.83	3.97	15.5
15	0.15	13,489	0.00	0.00	1.00	4.4	0.050	0.10	43.75	3.97	15.5
16	0.15	13,489	0.00	0.00	1.00	4.8	0.050	0.10	46.67	3.97	15.5
17	0.15	13,489	0.00	0.00	1.00	5.1	0.050	0.10	49.58	3.97	15.5
18	0.15	13,489	0.00	0.00	1.00	5.4	0.050	0.10	52.50	3.97	15.5
19	0.15	13,489	0.00	0.00	1.00	5.7	0.050	0.10	55.42	3.97	15.5
20	0.15	13,489	0.00	0.00	1.00	6.0	0.050	0.10	58.33	3.97	15.5
21	0.15	13,489	0.00	0.00	1.00	6.3	0.050	0.10	61.25	3.97	15.5
22	0.15	13,489	0.00	0.00	1.00	6.6	0.050	0.10	64.17	3.97	15.5
23	0.15	13,489	0.00	0.00	1.00	6.9	0.050	0.10	67.08	3.97	15.5
24	0.15	13,489	0.00	0.00	1.00	8.9	0.050	0.10	70.00	3.97	15.5
Toe						10.0	0.150	0.04	70.00		

3.717 kips total unreduced pile weight (g = 32.169 ft/s²)
3.717 kips total reduced pile weight (g = 32.169 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS

Analysis type:	Bearing Graph	Soil Damping Option:	Smith
Pile Damping (%):	1	Pile Damping Fact.(kips/ft/s):	0.558
Shaft Resistance in %:	90	Constant shaft resistance	
Max No Analysis Iterations:	0	Time Increment/Critical:	160
Residual Stress Analysis:	0	Analysis Time-Input(ms):	0
Output Level:	Normal	Gravitational Acceleration (ft/s²):	32.17
Hammer Gravity (ft/s²):	32.17	Pile Gravity (ft/s²):	32.17

EXTREMA TABLE

Pile: Rut = 100.0 kips Rtoe = 10.0 kips Time Inc. = 0.084 ms

Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	319.3	0.00	20.60	10.38	1.627	18.10
5.8	12.2	320.1	0.79	20.65	10.35	1.621	18.05
8.7	11.9	320.3	0.77	20.67	10.31	1.615	17.95
11.7	16.3	320.1	1.05	20.65	10.26	1.609	17.80
14.6	19.3	319.7	1.25	20.62	10.20	1.604	17.60
17.5	21.1	319.0	1.36	20.58	10.50	1.600	17.35
20.4	22.3	317.9	1.44	20.51	10.67	1.599	17.06
23.3	23.3	316.5	1.50	20.42	10.65	1.598	16.71
26.3	24.6	314.8	1.59	20.31	10.64	1.597	16.32
29.2	26.1	312.7	1.68	20.18	10.93	1.596	15.87
32.1	27.4	310.4	1.77	20.02	11.40	1.595	15.38
35.0	28.3	307.7	1.82	19.85	11.75	1.594	14.83
37.9	28.7	304.8	1.85	19.66	11.81	1.593	14.23
40.8	28.8	301.6	1.86	19.46	11.68	1.592	13.57
43.8	28.2	298.0	1.82	19.23	11.78	1.591	12.85
46.7	26.6	294.2	1.72	18.98	12.32	1.591	12.08
49.6	26.6	290.1	1.72	18.72	12.83	1.591	11.26
52.5	26.5	285.7	1.71	18.43	13.00	1.591	10.38
55.4	25.4	280.0	1.64	18.06	12.84	1.592	9.45
58.3	23.2	270.8	1.50	17.47	12.76	1.592	8.46
61.2	19.7	252.9	1.27	16.32	13.27	1.592	7.41
64.2	15.3	220.7	0.98	14.24	14.18	1.591	6.30
67.1	9.9	171.6	0.64	11.07	15.12	1.591	5.13
70.0	3.9	104.3	0.25	6.73	15.64	1.590	4.52

Converged Stroke (ft) 6.22 Fixed Combustion Pressure (psi) 1,500.0

(Eq) Strokes Analyzed and Last Return (ft)

11.42	5.31	6.47	6.16	6.24	6.22

Pile: Rut = 200.0 kips Rtoe = 110.0 kips Time Inc. = 0.084 ms

Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	367.9	0.00	23.73	12.10	0.843	17.24
5.8	3.7	368.7	0.24	23.79	12.07	0.831	17.15
8.7	6.6	369.0	0.42	23.80	12.02	0.819	17.03

11.7	9.0	368.7	0.58	23.79	11.96	0.808	16.88
14.6	10.9	368.3	0.70	23.76	11.89	0.796	16.72
17.5	12.4	367.7	0.80	23.73	11.81	0.784	16.53
20.4	13.4	366.9	0.86	23.67	11.73	0.773	16.31
23.3	13.6	365.9	0.88	23.61	11.65	0.761	16.07
26.3	13.5	364.6	0.87	23.52	11.56	0.749	15.81
29.2	13.2	363.1	0.85	23.43	11.47	0.737	15.53
32.1	12.0	361.3	0.78	23.31	11.37	0.726	15.24
35.0	10.4	359.3	0.67	23.18	11.26	0.715	14.92
37.9	8.6	356.9	0.55	23.03	11.15	0.703	14.60
40.8	6.8	354.3	0.44	22.86	11.03	0.692	14.25
43.8	5.3	351.5	0.34	22.67	10.90	0.681	13.89
46.7	4.0	348.5	0.26	22.48	10.76	0.670	13.51
49.6	2.8	345.2	0.18	22.27	10.62	0.659	13.13
52.5	1.3	341.7	0.09	22.04	10.47	0.648	12.74
55.4	0.2	337.5	0.02	21.78	10.33	0.638	12.33
58.3	0.0	331.4	0.00	21.38	10.28	0.628	11.91
61.2	0.0	321.6	0.00	20.75	10.33	0.618	11.48
64.2	0.0	321.5	0.00	20.74	10.08	0.608	11.04
67.1	0.0	322.9	0.00	20.83	10.17	0.599	10.60
70.0	0.0	299.5	0.00	19.32	10.30	0.590	10.36

Converged Stroke (ft) 7.46 Fixed Combustion Pressure (psi) 1,500.0

(Eq) Strokes Analyzed and Last Return (ft)

11.42 7.00 7.54 7.45 7.46

Pile: Rut = 300.0 kips Rtoe = 210.0 kips Time Inc. = 0.066 ms

Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	410.4	0.00	26.48	13.66	0.832	19.32
5.8	11.1	411.6	0.72	26.55	13.62	0.808	18.99
8.7	21.7	412.0	1.40	26.58	13.57	0.785	18.64
11.7	32.0	411.8	2.07	26.57	13.51	0.761	18.26
14.6	41.0	411.1	2.65	26.52	13.43	0.738	17.86
17.5	47.7	410.5	3.08	26.49	13.36	0.715	17.44
20.4	51.9	409.5	3.35	26.42	13.27	0.692	17.01
23.3	54.1	408.1	3.49	26.33	13.18	0.669	16.58
26.3	55.4	406.8	3.58	26.25	13.08	0.647	16.13
29.2	57.6	405.2	3.71	26.14	12.98	0.625	15.67
32.1	59.5	403.1	3.84	26.01	12.88	0.603	15.21

35.0	59.6	401.1	3.85	25.88	12.77	0.581	14.74
37.9	57.0	398.7	3.68	25.72	12.65	0.560	14.27
40.8	52.3	396.2	3.38	25.56	12.51	0.540	13.81
43.8	46.6	393.9	3.00	25.41	12.36	0.519	13.35
46.7	39.7	408.0	2.56	26.32	12.21	0.499	12.89
49.6	31.8	401.6	2.05	25.91	12.04	0.480	12.43
52.5	23.7	389.5	1.53	25.13	11.87	0.460	11.99
55.4	17.5	381.2	1.13	24.59	11.70	0.442	11.55
58.3	13.5	396.5	0.87	25.58	11.54	0.423	11.12
61.2	9.7	415.6	0.62	26.81	11.32	0.405	10.70
64.2	6.5	444.7	0.42	28.69	10.58	0.387	10.29
67.1	3.4	465.2	0.22	30.01	8.63	0.370	9.91
70.0	1.0	456.6	0.06	29.46	7.54	0.354	9.65

Converged Stroke (ft) 8.61 Fixed Combustion Pressure (psi) 1,500.0

(Eq) Strokes Analyzed and Last Return (ft)

11.42 8.35 8.64 8.61

Pile: Rut = 400.0 kips Rtoe = 310.0 kips Time Inc. = 0.051 ms

Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	538.7	0.00	34.76	14.96	0.860	21.38
5.8	16.6	513.2	1.07	33.11	14.93	0.835	21.00
8.7	30.8	510.6	1.99	32.94	14.87	0.808	20.55
11.7	42.7	497.3	2.75	32.08	14.80	0.781	20.06
14.6	53.4	492.9	3.45	31.80	14.71	0.755	19.58
17.5	64.5	484.7	4.16	31.27	14.63	0.729	19.06
20.4	75.6	484.6	4.88	31.26	14.53	0.701	18.48
23.3	84.4	484.9	5.45	31.28	14.43	0.670	17.81
26.3	88.7	483.2	5.73	31.18	14.33	0.638	17.05
29.2	88.8	476.8	5.73	30.76	14.23	0.605	16.26
32.1	86.2	476.3	5.56	30.73	14.11	0.574	15.51
35.0	84.7	463.6	5.47	29.91	14.00	0.543	14.76
37.9	80.9	462.0	5.22	29.81	13.88	0.510	13.95
40.8	71.9	475.4	4.64	30.67	13.74	0.476	13.05
43.8	67.9	497.4	4.38	32.09	13.59	0.439	12.21
46.7	63.5	512.2	4.09	33.04	13.44	0.414	11.63
49.6	61.3	501.0	3.95	32.32	13.27	0.388	11.06
52.5	54.9	485.7	3.54	31.33	13.08	0.363	10.50
55.4	43.5	478.7	2.81	30.89	12.90	0.339	9.96

58.3	31.5	498.3	2.03	32.15	12.69	0.314	9.44
61.2	26.6	517.3	1.71	33.37	12.28	0.289	8.91
64.2	26.2	545.8	1.69	35.22	11.15	0.263	8.35
67.1	20.4	576.1	1.32	37.17	8.60	0.236	7.81
70.0	11.6	577.5	0.75	37.26	5.64	0.211	7.40

Converged Stroke (ft) 9.74 Fixed Combustion Pressure (psi) 1,500.0

(Eq) Strokes Analyzed and Last Return (ft)

11.42 9.73 9.74

Pile: Rut = 450.0 kips Rtoe = 360.0 kips Time Inc. = 0.046 ms

Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	596.3	0.00	38.47	15.52	0.880	22.50
5.8	20.4	566.7	1.32	36.56	15.48	0.853	22.10
8.7	36.4	558.5	2.35	36.03	15.42	0.826	21.63
11.7	49.7	544.4	3.21	35.12	15.35	0.799	21.15
14.6	59.7	537.0	3.85	34.65	15.26	0.773	20.66
17.5	69.8	527.3	4.50	34.02	15.16	0.746	20.12
20.4	80.6	526.1	5.20	33.94	15.07	0.717	19.49
23.3	90.7	527.0	5.85	34.00	14.97	0.685	18.77
26.3	97.7	527.4	6.30	34.02	14.86	0.652	17.97
29.2	101.1	519.1	6.52	33.49	14.75	0.619	17.18
32.1	100.5	511.9	6.49	33.03	14.64	0.588	16.42
35.0	95.2	502.6	6.14	32.43	14.52	0.556	15.62
37.9	84.6	501.5	5.46	32.36	14.39	0.522	14.74
40.8	84.2	516.3	5.43	33.31	14.26	0.485	13.76
43.8	86.7	539.7	5.59	34.82	14.11	0.445	12.65
46.7	85.0	554.6	5.48	35.78	13.96	0.405	11.53
49.6	78.6	541.7	5.07	34.95	13.78	0.368	10.56
52.5	68.5	522.9	4.42	33.73	13.60	0.336	9.92
55.4	57.3	519.6	3.70	33.52	13.40	0.310	9.34
58.3	46.6	539.2	3.01	34.79	13.16	0.284	8.77
61.2	36.2	559.9	2.34	36.12	12.69	0.256	8.17
64.2	38.7	587.3	2.50	37.89	11.42	0.226	7.53
67.1	33.7	621.0	2.17	40.06	8.61	0.194	6.85
70.0	19.5	627.8	1.26	40.50	4.88	0.164	6.31

Converged Stroke (ft) 10.17 Fixed Combustion Pressure (psi) 1,500.0

(Eq) Strokes Analyzed and Last Return (ft)

11.42 10.21 10.17

Pile: Rut = 475.0 kips Rtoe = 385.0 kips Time Inc. = 0.044 ms
Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	621.5	0.00	40.10	15.73	0.888	23.00
5.8	22.0	590.8	1.42	38.12	15.70	0.862	22.59
8.7	38.6	579.4	2.49	37.38	15.65	0.834	22.12
11.7	52.3	565.0	3.37	36.45	15.57	0.807	21.64
14.6	62.1	556.1	4.01	35.88	15.48	0.781	21.14
17.5	71.4	546.0	4.61	35.22	15.39	0.753	20.58
20.4	82.2	544.3	5.30	35.12	15.29	0.724	19.94
23.3	93.8	545.7	6.05	35.21	15.19	0.692	19.20
26.3	102.6	546.7	6.62	35.27	15.08	0.658	18.38
29.2	106.5	538.0	6.87	34.71	14.97	0.626	17.59
32.1	104.4	528.0	6.74	34.06	14.85	0.594	16.82
35.0	95.0	519.7	6.13	33.53	14.73	0.562	16.00
37.9	82.2	518.6	5.31	33.46	14.61	0.527	15.09
40.8	90.5	534.2	5.84	34.46	14.47	0.489	14.07
43.8	94.5	557.6	6.10	35.97	14.32	0.449	12.93
46.7	91.9	573.3	5.93	36.99	14.16	0.408	11.79
49.6	83.6	560.4	5.39	36.16	13.99	0.371	10.81
52.5	73.3	539.4	4.73	34.80	13.80	0.335	9.85
55.4	62.9	537.5	4.06	34.68	13.60	0.300	9.10
58.3	51.4	557.1	3.32	35.94	13.36	0.273	8.50
61.2	40.6	578.5	2.62	37.32	12.85	0.244	7.87
64.2	44.7	605.4	2.88	39.05	11.51	0.212	7.17
67.1	39.7	640.5	2.56	41.32	8.59	0.178	6.42
70.0	23.8	650.1	1.54	41.94	4.51	0.146	5.81

Converged Stroke (ft) 10.35 Fixed Combustion Pressure (psi) 1,500.0
(Eq) Strokes Analyzed and Last Return (ft)
11.42 10.42 10.35

Pile: Rut = 500.0 kips Rtoe = 410.0 kips Time Inc. = 0.042 ms
Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	642.9	0.00	41.48	15.91	0.894	23.36
5.8	23.4	611.9	1.51	39.47	15.88	0.867	22.93

8.7	40.9	596.8	2.64	38.51	15.82	0.840	22.46
11.7	54.5	582.1	3.52	37.56	15.74	0.813	21.99
14.6	63.6	571.7	4.10	36.88	15.66	0.787	21.49
17.5	72.1	561.3	4.65	36.21	15.56	0.759	20.92
20.4	83.1	559.0	5.36	36.06	15.46	0.728	20.26
23.3	96.0	560.4	6.19	36.16	15.36	0.696	19.49
26.3	105.6	562.7	6.81	36.30	15.25	0.662	18.67
29.2	108.4	554.1	6.99	35.75	15.14	0.630	17.89
32.1	103.1	541.0	6.65	34.91	15.02	0.599	17.11
35.0	90.6	532.7	5.85	34.37	14.90	0.566	16.28
37.9	84.0	533.7	5.42	34.43	14.77	0.530	15.34
40.8	93.8	549.9	6.05	35.48	14.63	0.492	14.29
43.8	97.8	573.9	6.31	37.02	14.48	0.451	13.11
46.7	94.0	589.2	6.06	38.02	14.32	0.410	11.99
49.6	85.6	575.2	5.52	37.11	14.15	0.374	11.01
52.5	75.9	552.8	4.89	35.66	13.97	0.336	10.03
55.4	65.5	553.2	4.22	35.69	13.77	0.297	8.97
58.3	53.0	573.0	3.42	36.97	13.51	0.263	8.23
61.2	45.3	595.1	2.92	38.39	12.97	0.233	7.56
64.2	50.3	621.4	3.24	40.09	11.56	0.200	6.81
67.1	44.9	657.2	2.90	42.40	8.56	0.164	5.99
70.0	27.3	669.2	1.76	43.18	4.15	0.130	5.30

Converged Stroke (ft) 10.52 Fixed Combustion Pressure (psi) 1,500.0

(Eq) Strokes Analyzed and Last Return (ft)

11.42 10.58 10.52

Pile: Rut = 525.0 kips Rtoe = 435.0 kips Time Inc. = 0.040 ms

Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
2.9	0.0	663.1	0.00	42.78	16.08	0.900	23.72
5.8	24.8	632.1	1.60	40.78	16.04	0.872	23.28
8.7	43.2	613.3	2.79	39.57	15.98	0.845	22.81
11.7	56.6	598.6	3.65	38.62	15.91	0.819	22.34
14.6	65.3	586.3	4.21	37.83	15.82	0.792	21.84
17.5	72.6	575.7	4.68	37.14	15.73	0.764	21.25
20.4	84.3	572.7	5.44	36.95	15.62	0.733	20.58
23.3	98.5	574.6	6.36	37.07	15.52	0.700	19.80
26.3	107.7	577.7	6.95	37.27	15.41	0.667	18.97
29.2	108.7	569.5	7.01	36.74	15.30	0.635	18.19

32.1	100.3	554.5	6.47	35.77	15.18	0.603	17.41
35.0	87.7	544.8	5.66	35.15	15.06	0.569	16.55
37.9	85.9	547.6	5.54	35.33	14.93	0.533	15.60
40.8	96.6	564.5	6.23	36.42	14.79	0.495	14.51
43.8	100.0	588.6	6.45	37.98	14.64	0.453	13.31
46.7	95.7	604.4	6.17	38.99	14.48	0.413	12.18
49.6	87.4	590.0	5.64	38.06	14.31	0.376	11.21
52.5	77.9	565.7	5.02	36.49	14.12	0.338	10.20
55.4	66.9	568.0	4.32	36.65	13.91	0.298	9.11
58.3	53.3	587.7	3.44	37.91	13.65	0.255	7.98
61.2	49.9	610.5	3.22	39.39	13.08	0.224	7.27
64.2	55.7	635.9	3.60	41.03	11.62	0.189	6.47
67.1	50.3	672.8	3.25	43.40	8.53	0.151	5.58
70.0	30.8	687.4	1.99	44.35	3.85	0.115	4.81

Converged Stroke (ft) 10.67 Fixed Combustion Pressure (psi) 1,500.0
(Eq) Strokes Analyzed and Last Return (ft)
11.42 10.74 10.67

Pile: Rut = 550.0 kips Rtoe = 460.0 kips Time Inc. = 0.038 ms
Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top	Mx.T-For.	Mx.C-For	Mx.T-Str.	Mx.C-Str.	Mx Vel.	Mx Dis.	ENTHRU
ft	kips	kips	ksi	ksi	ft/s	in	kip-ft
2.9	0.0	681.4	0.00	43.96	16.23	0.904	24.03
5.8	26.0	650.8	1.67	41.99	16.19	0.877	23.58
8.7	45.4	628.3	2.93	40.54	16.12	0.850	23.12
11.7	58.9	613.7	3.80	39.59	16.04	0.824	22.65
14.6	66.8	599.7	4.31	38.69	15.96	0.797	22.14
17.5	73.2	588.8	4.72	37.99	15.86	0.768	21.55
20.4	85.9	584.9	5.54	37.74	15.76	0.737	20.85
23.3	101.0	587.5	6.52	37.90	15.65	0.704	20.06
26.3	109.4	591.3	7.06	38.15	15.55	0.670	19.23
29.2	108.2	583.0	6.98	37.61	15.43	0.638	18.45
32.1	96.7	566.9	6.24	36.58	15.31	0.607	17.66
35.0	86.3	554.9	5.57	35.80	15.19	0.573	16.79
37.9	87.8	560.3	5.67	36.15	15.06	0.536	15.81
40.8	99.1	577.5	6.39	37.26	14.92	0.497	14.71
43.8	102.1	602.0	6.59	38.84	14.77	0.455	13.48
46.7	97.7	618.1	6.30	39.88	14.61	0.415	12.36
49.6	89.4	603.7	5.77	38.95	14.43	0.378	11.37
52.5	79.6	577.5	5.14	37.26	14.25	0.340	10.35

55.4	68.0	581.5	4.39	37.51	14.04	0.299	9.23
58.3	53.1	600.7	3.43	38.75	13.77	0.256	7.99
61.2	54.4	624.3	3.51	40.28	13.18	0.215	6.98
64.2	61.1	649.2	3.94	41.88	11.66	0.179	6.14
67.1	54.9	686.3	3.54	44.28	8.49	0.140	5.18
70.0	33.8	703.6	2.18	45.39	3.73	0.102	4.33

Converged Stroke (ft) 10.82 Fixed Combustion Pressure (psi) 1,500.0
(Eq) Strokes Analyzed and Last Return (ft)
11.42 10.88 10.82

Pile: Rut = 600.0 kips Rtoe = 510.0 kips Time Inc. = 0.035 ms
Hammer: DELMAG D 16-32 Efficiency: 0.800

Lb Top	Mx.T-For.	Mx.C-For	Mx.T-Str.	Mx.C-Str.	Mx Vel.	Mx Dis.	ENTHRU
ft	kips	kips	ksi	ksi	ft/s	in	kip-ft
2.9	0.0	713.3	0.00	46.02	16.50	0.912	24.55
5.8	28.9	684.7	1.86	44.17	16.45	0.885	24.10
8.7	51.0	655.3	3.29	42.28	16.38	0.858	23.64
11.7	65.1	640.2	4.20	41.30	16.30	0.832	23.17
14.6	72.7	623.5	4.69	40.23	16.21	0.805	22.65
17.5	76.7	610.8	4.95	39.41	16.12	0.775	22.04
20.4	88.8	601.6	5.73	38.81	16.01	0.744	21.31
23.3	104.5	602.8	6.74	38.89	15.90	0.710	20.50
26.3	112.0	610.8	7.22	39.41	15.79	0.677	19.68
29.2	107.6	606.5	6.94	39.13	15.68	0.645	18.90
32.1	92.4	588.3	5.96	37.96	15.56	0.613	18.09
35.0	85.7	572.9	5.53	36.96	15.43	0.578	17.19
37.9	90.0	582.6	5.81	37.58	15.30	0.541	16.18
40.8	102.6	600.4	6.62	38.74	15.16	0.501	15.03
43.8	106.7	625.5	6.88	40.35	15.01	0.458	13.77
46.7	102.7	641.8	6.62	41.41	14.85	0.419	12.67
49.6	94.2	626.7	6.08	40.43	14.68	0.381	11.67
52.5	83.8	599.5	5.41	38.68	14.49	0.343	10.61
55.4	71.0	604.8	4.58	39.02	14.28	0.301	9.46
58.3	56.1	623.7	3.62	40.24	13.99	0.257	8.16
61.2	61.6	648.5	3.98	41.84	13.35	0.209	6.76
64.2	69.2	672.3	4.47	43.37	11.74	0.164	5.59
67.1	62.2	710.2	4.02	45.82	8.43	0.122	4.52
70.0	38.0	732.3	2.45	47.24	3.53	0.080	3.49

Converged Stroke (ft) 11.08 Fixed Combustion Pressure (psi) 1,500.0

```
(Eq) Strokes Analyzed and Last Return  (ft)
   11.42        11.12        11.08
```

SUMMARY TABLE; HAMMER: DELMAG D 16-32

Rut kips	Bl Ct b/ft	Stk Dn ft	Stk Up ft	Mx T-Str ksi	LTop ft	Mx C-Str ksi	LTop ft	ENTHRU kip-ft	Bl Rt b/min	ActRes kips
100.0	8.0	6.24	6.22	1.86	37.9	20.67	37.9	18.1	47.3	100.0
200.0	22.9	7.45	7.46	0.88	20.4	23.80	20.4	17.2	43.3	200.0
300.0	40.6	8.64	8.61	3.85	32.1	30.01	32.1	19.3	40.3	300.0
400.0	76.4	9.73	9.74	5.73	26.3	37.26	26.3	21.4	37.9	400.0
450.0	106.7	10.21	10.17	6.52	26.3	40.50	26.3	22.5	37.1	450.0
475.0	126.5	10.42	10.35	6.87	26.3	41.94	26.3	23.0	36.7	475.0
500.0	151.8	10.58	10.52	6.99	26.3	43.18	26.3	23.4	36.5	500.0
525.0	185.1	10.74	10.67	7.01	26.3	44.35	26.3	23.7	36.2	525.0
550.0	231.9	10.88	10.82	7.06	23.3	45.39	23.3	24.0	36.0	550.0
600.0	389.2	11.12	11.08	7.22	23.3	47.24	23.3	24.5	35.6	598.2

Attachment F

Outlet Structure: Bearing Capacity and Settlement Analysis

Assess allowable bearing capacity along base of based on spread footing.

Project Number: 10268112
Project Name: Blake Road Stormwa
Station: Outlet Structure

Date: 9/26/2022
Calculations by: KB
Reviewed/QC: MS

Soil Conditions					
	Material Type	γ (pcf)	ϕ' (degrees)	c' (psf)	
Upper Foundation Soil	Sand	123	30	0	
Lower Foundation Soil					
Groundwater Depth below base		-4	ft-depth below centerline of foundation		
Two Layered System	No				
Distance to	0	feet below level of foundation			
Slope at toe of wall	1	:V	1000	:H (if no slope, set :H to 1000)	

Bearing Capacity Factors*		
$N_{q,1}$ =	18.40	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Equation 10.6.3.1.2c-1
$N_{c,1}$=	30.14	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
$N_{\gamma,1}$=	22.40	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
$N_{q,2}$=	1.00	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Equation 10.6.3.1.2c-1
$N_{c,2}$=	5.14	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
$N_{\gamma,2}$=	0.00	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
*If on slope, check bearing capacity factor with AAHSTO Figures 10.6.3.1.2c-1 and 10.6.3.1.2c-2		

Geometry and Loading Conditions of Spread Footing					
	Parameter				
D_f=	4	feet (depth of embedment)			
L=	40	ft			
B=	10.0	ft			
e_B=	0	ft (eccentricity along base of foundation)			
e_L=	0	ft (eccentricity along length of foundation)			
Vertical Load=	400000	lbs (factored vertical load)			
Horizontal Load=	0	lbs (factored horizontal load)			
ϕ_r=	1	N/A for FOS design			

Calculated Bearing Pressure					
	Inclination factor	No Inclination factor			
Allowable Capacity	**11949**	**11949**	psf		
Required Pressure	**1000**	**1000**	psf		
FOS	**11.9**	**11.9**			

Calculated by:
Checked by:

Assess allowable bearing capacity along base of based on spread footing.

Project Number: 10268112 Date: 9/26/2022
Project Name: Blake Road Stormwa Calculations by: KB
Station: Outlet Structure Reviewed/QC: MS

Assumptions: -Wall will bear on Sand with a footing width of 10 ft.
-Embedment depth is 4 feet.
-This analysis does not address Global Stability, as a 1000H:1V slope exists at the toe of the wall.

Resources: [1]AASHTO LRFD Bridge Design Specifications. 4th edition with 2008 and 2009 Interims.
[2]NCHRP Report 651: LRFD Design and Constructionof Shallow Foundations for Highway Bridge Structures

Bearing Capacity Equation: $\phi_r q_u = \phi_r(cN_c s_c i_c + \gamma D C_{wq} N_q s_q i_q d_q + 0.5\gamma C_{w\gamma} B N_\gamma s_\gamma i_\gamma)$[1]

where: ϕ_r= Resistance factor[1]

$N_q = e^{\pi \tan\phi'}\tan^2(45+\phi'/2)$ (assumes construction on flat ground; modified if constructed on slope)[1]

$N_c=(N_q-1)\cot\phi'$ (assumes construction on flat ground; modified if constructed on slope)[1]

$N_\gamma=2(N_q+1)\tan(\phi')$ (assumes construction on flat ground; modified if constructed on slope)[1]

$s_c = 1+(N_q/N_c)(B/L)$ where B is width of foundation and L is length[1]

$s_q = 1+\tan(\phi)(B/L)$ for $\phi'>10$ degrees, or 1 for $\phi'=0$ degrees[1]

$s_\gamma = 1-0.4(B/L)$ for $\phi'>10$ degrees, or 1 for $\phi'=0$ degrees[1]

$d_q = 1+2\tan(\phi')(1-\sin\phi')^2(D/B)$ for $\phi'>10$ degrees or 1 for $\phi'=0$ degrees[1]

i_c = load inclination factor (calculated from factored vertical and horizontal loads-deviation from AASHTO)[1]

i_q = load inclination factor (calculated from factored vertical and horizontal loads-deviation from AASHTO)[1]

i_γ = load inclination factor (calculated from factored vertical and horizontal loads-deviation from AASHTO)[1]

$C_{w\gamma}$, C_{wq} = correction factors for location of water table[1]

e=eccentricity of wall[1]

B= footing width (ft)[1]

Calculated by:
Checked by:

Assess allowable bearing capacity along base of based on spread footing.

Project Number: 10268112
Date: 9/26/2022
Project Name: Blake Road Stormwa
Calculations by: KB
Station: Outlet Structure
Reviewed/QC: MS

Solution:	**Inclination factor**	**No Inclination factor**	
$N_{q,1}$ =	18.40	18.40	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Equation 10.6.3.1.2c-1
$N_{c,1}$=	30.14	30.14	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
$N_{\gamma,1}$=	22.40	22.40	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
$s_{c,1}$ =	1.15	1.15	Shape correction factor- AASHTO Table 10.6.3.1.2a-3
$s_{q,1}$ =	1.14	1.14	Shape correction factor- AASHTO Table 10.6.3.1.2a-3
$s_{\gamma,1}$ =	0.90	0.90	Shape correction factor- AASHTO Table 10.6.3.1.2a-3
$d_{q,1}$ =	1.11	1.11	Depth correction factor- AASHTO Table 10.6.3.1.2a-3
$i_{c,1}$ =	1.00	1.00	Inclination factor-AASHTO Eq. 10.6.3.1.2a-5,6
$i_{q,1}$ =	1.00	1.00	Inclination factor-AASHTO Eq. 10.6.3.1.2a-7
$i_{\gamma,1}$ =	1.00	1.00	Inclination factor-AASHTO Eq. 10.6.3.1.2a-8
$C_{w\gamma,1}$	0.50	0.50	Correction for elevation of water table-AASHTO Table 10.6.3.1.2a-2
$C_{wq,1}$	0.50	0.50	Correction for elevation of water table-AASHTO Table 10.6.3.1.2a-2
$q_{t,1}$	11949	11949	psf (ultimate bearing capacity)
$N_{q,2}$ =	1.00	1.00	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Equation 10.6.3.1.2c-1
$N_{c,2}$=	5.14	5.14	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
$N_{\gamma,2}$=	0.00	0.00	Bearing capacity factor- AASHTO Table 10.6.3.1.2a-1 and Figure 10.6.3.1.2c-1 and 10.6.3.1.2c-2
$s_{c,2}$ =	1.05	1.05	Shape correction factor- AASHTO Table 10.6.3.1.2a-3
$s_{q,2}$ =	1.00	1.00	Shape correction factor- AASHTO Table 10.6.3.1.2a-3
$s_{\gamma,2}$ =	1.00	1.00	Shape correction factor- AASHTO Table 10.6.3.1.2a-3
$d_{q,2}$ =	1.00	1.00	Depth correction factor- AASHTO Table 10.6.3.1.2a-3
$i_{c,2}$ =	#DIV/0!	#DIV/0!	Inclination factor-AASHTO Eq. 10.6.3.1.2a-5,6
$i_{q,2}$=	1.00	1.00	Inclination factor-AASHTO Eq. 10.6.3.1.2a-7
$i_{\gamma,2}$ =	1.00	1.00	Inclination factor-AASHTO Eq. 10.6.3.1.2a-8
$C_{w\gamma,2}$	0.50	0.50	Correction for elevation of water table-AASHTO Table 10.6.3.1.2a-2
$C_{wq,2}$	0.50	0.50	Correction for elevation of water table-AASHTO Table 10.6.3.1.2a-2
q_2 / q_1	0.0	0.00	Ratio of Upper to Lower Ultimate bearing capacity assuming homogenous beds
K_s	1	1.00	Punching shear coefficient
c_a	0	0.00	Adhesion Coefficient
$q_{b,2}$	11949	11949	psf (ultimate bearing capacity of lower soil)
q_u	11949	11949	psf (ultimate bearing capacity of 2-layered system)
q_r	11949	11949	psf (Factored bearing pressure-capacity)
σ_v	1000	1000	psf (Bearing pressure from foundation-demand)
FOS	11.9	11.9	

Calculated by:
Checked by:

HDR Engineering, Inc.

COMBINED SETTLEMENT ANALYSIS FOR CLAYS AND SANDS

INPUT PARAMETERS

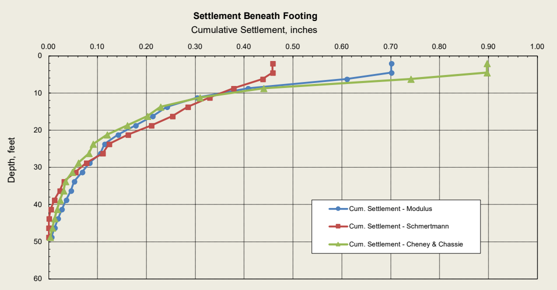
Project Number: 10268112
Project Name: Blake Road Stormwater
Location: Minnesota
Calculations By: KB Review/QC: MS
Date: 9/26/22

Depth to groundwater: 0.0 feet
Depth to bottom of footing: 4.0 feet
Foundation bearing pressure: 1,000 psf
Footing width, b: 10.0 feet
Footing length, l: 40.0 feet
Foundation Load: 10 kips or klf
Settlement Location: Rectangle - Center

Time of interest, t: 50.0 years (for Schmertmann, t > 0.1)
Footing Shape: Continuous Square or Continuous (for Schmertmann)
Depth for Izp: 14 ft
Izp: 0.61
C1: 0.88 depth factor
C2: 1.54 secondary creep factor
C3: 0.73 shape factor
SPT Hammer Type: Automatic
N-value Corrections: Hammer Energy & Overburden Pressure

RESULTS OF ANALYSIS

Settlement Component	Modulus w/ Bousinesq	Cheney & Chassie Compressibility	Schmertmann
Sand	0.701	0.897	0.458
Clay	0.000	0.000	0.000
Total (inches)	**0.701**	**0.897**	**0.458**


Settlement Beneath Footing

Layer	El. Top of Layer feet	El. Bottom of Layer feet	El. Midpoint of Layer feet	Layer Thickness feet	Depth to Bottom of Soil Layer feet	Material Type for Modulus	Material Type for Cheney & Chassie	SPT N-Value (Field) bpf	Soil Unit Weight pcf	Compression Ratio (CR)	Recompression Ratio (RR)	p'c psf	Existing Effective Stress psf	Corrected SPT N-Value bpf	Young's Modulus tsf	Cheney and Chassie Compressibility
1	894	890	892	4	4	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	9	123				121	21	102	0.011
2	890	889	889.5	1	5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	4	123				273	8	66	0.019
3	889	886.5	887.75	2.5	7.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	5	123				379	9	72	0.018
4	886.5	884	885.25	2.5	10	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	12	123				530	21	120	0.011
5	884	881.5	882.75	2.5	12.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	15	123				682	25	164	0.009
6	881.5	879	880.25	2.5	15	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	32	123				833	50	284	0.004
7	879	876.5	877.75	2.5	17.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	19	123				985	28	194	0.008
8	876.5	874	875.25	2.5	20	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	14	123				1136	20	158	0.011
9	874	871.5	872.75	2.5	22.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	17	123				1288	23	176	0.010
10	871.5	869	870.25	2.5	25	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	85	123				1439	70	476	0.004
11	869	866.5	867.75	2.5	27.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	14	123				1591	18	158	0.012
12	866.5	864	865.25	2.5	30	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	21	123				1742	26	206	0.009
13	864	861.5	862.75	2.5	32.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	15	123				1894	18	164	0.012
14	861.5	859	860.25	2.5	35	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	41	123				2045	49	350	0.004
15	859	856.5	857.75	2.5	37.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	22	123				2197	26	212	0.009
16	856.5	854	855.25	2.5	40	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	22	123				2348	25	212	0.009
17	854	851.5	852.75	2.5	42.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	22	123				2500	24	212	0.009
18	851.5	849	850.25	2.5	45	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	22	123				2651	24	212	0.009
19	849	846.5	847.75	2.5	47.5	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	22	123				2803	23	212	0.010
20	846.5	844	845.25	2.5	50	Gravelly Sand and Gravel	Well Graded Silty Sand and Gravel	22	123				2954	23	212	0.010

Attachment G

Weir Wall: Pile Analysis

Project:	Blake Road	Computed:	SJO	Date:	7/18/22
Subject:	Sheet Pile Weir	Checked:	MS	Date:	7/18/22
Task:	Axial Analysis - PZ 27, A 572 Grade 50 (Factored)	Page:		of:	
Job #:	10268112	No:			

Location

Station/Structure		Weir					
Boring Number		B-5					completed 1/26/2022
Embankment/Mudline Elevation (GL)		890.00	ft				estimated
Boring Surface Elevation		907.31	ft				from boring log
Bottom of Footing Elevation (BoF)		889.00	ft				from bridge Eng
Water Elevation		897.00	ft				from boring log (B-5)

Pile Properties

Size		PZ 27					
Area of Steel (A_s)		7.94	in^2				
Height (h)		12.00	in				
Flange Width (w)		18.00	in				
Flange Thickness (t_f)		0.375	in				
Web Thickness (t_w)		0.375	in				
Yield Strength of Steel (F_y)		50	ksi				A 572 Grade 50
Section Modulus (elastic)		30.20	in^3				
Section Modulus (plastic)		36.49	in^3				
Modulus of Elasticity - steel (E_s)		29000	ksi				
Unit Weight of Steel (W_s)		0.490	kcf	=	0.284	pci	
Area of Pile Tip (A_t), if soil plug	=	h x w		=	216	in^2	
Assume soil plug is developed (Y or N)		N					
Tip area = A_t (plug) or A_s (no plug)	=	7.94	in^2	=	0.055	ft^2	
Assume both sides (Y or N)		N					
Perimeter = P_b (both) or P_f (single side)	=	53.76	in	=	4.48	ft	

Pile Load

Dead Load (Q_D)		6	kips				unfactored permanent load (i.e., R_R)
Resistance Factor (φ)		0.33					equivalent to FS = 3.0
Nominal Bearing Resistance (R_n)	=	R_R / φ		=	**18**	**kips**	

Project:	Blake Road	Computed:	SJO	Date:	7/18/22
Subject:	Sheet Pile Weir	Checked:		Date:	
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Pile Side Resistance (R_s) = Σ L x σ'$_v$ x β

Pile Top Depth / Elev		Layer Thickness (L) - ft	Unit Weight	Vertical Effective Stress (σ'$_v$)	Effective Perimeter (P_b or P_f)	Soil Beta β	Friction Resistance (Q_N)	Unfactored Load - Q_T (Q_D + Q_N)	Resistance R_T (R_U - Q_N)	Neutral Plane (R_T - Q_T)	Downdrag Load (DD) 1/2 (R_T - Q_T)	
894 ft		----	water pcf	0	4.48	----	----	6 kips	25 kips	19 kips	**10 kips**	
		0.00	NA	0	4.48	0.00	0.000	6	25	19		
18.31	889	17.31	B-5	0	4.48	0.00	0.000	6	25	19		Symbols
21	887	2.5	123	152	4.48	0.35	0.297	6	25	19		Water
23	884	2.5	123	303	4.48	0.35	0.891	7	24	17		Fill
26	882	2.5	123	455	4.48	0.35	1.485	9	23	14		m dense SP
28	879	2.5	123	606	4.48	0.35	2.079	11	21	10		Gravelly SM
31	877	2.5	125	763	4.48	0.50	3.832	15	17	2		SM/SC Till
33	874	2.5	125	919	4.48	0.50	4.708	19	12	-7		weathered LS
36	872	2.5	125	1076	4.48	0.50	5.585	25	6	-18		Limestome
38	869	2.5	125	1232	4.48	0.50	6.461	31	0	-31		
38	869		125	1232	4.48	0.50	0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		130	1232	4.48		0.000	31	0	-31		
38	869		135	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38.3	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		
38	869		140	1232	4.48		0.000	31	0	-31		

Pile Penetration = 20.0 ft   1232   Total R_s = 25 kips

Pile Length (L_p) = 25.0 ft

Tip Elevation = 869 ft

H Pile weight = 0.68 kips

total side resistance - 100% of total

Pile weight

Pile Tip Resistance (R_p) = ϕ_c x F_y x A_p

Tip Resistance Factor (N_t) = 0

R_p = A_p x N_t x σ'$_z$ = 0 kips

0 ksf = 0 ksi

Ultimate Resitance (R_u)

R_u = R_s + R_p = 25 kips

proportionality coefficient

toe resistance

v dense granular modulus - 20 ksi

estimated toe yield = 0 inch

total resistance

Ok, > Factored Load

Project:	Blake Road	Computed:	SJO	Date:	7/18/22
Subject:	Sheet Pile Weir	Checked:		Date:	
Task:	Axial Analysis - PZ 27, A 572 Grade 50 (Factored)	Page:		of:	
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Plot of Load and Resistance

Project:	Blake Road	Computed:	SJO	Date:	7/18/22
Subject:	Sheet Pile Weir	Checked:		Date:	
Task:	Axial Analysis - PZ 27, A 572 Grade 50 (Factored)	Page:		of:	
Job #:	10268112	No:			

Analysis Results

Origin of Chart is EL 907.31 feet (ground surface at boring B-5)	
Curves begin at BOFE = ~889 feet	
Neutral Plane is near bottom of pile within the very dense Gravelly Silty Sand (SM)	N = 111 to 50 bpf at toe
Estimated pile settlement is ~0.1 inch, if able to advance to EL 869 feet	minimal (zero ksi) toe pressure
Obstruction may occur near surface of v dense SM at ~ EL 877 feet	N = 111 bpf at toe
Estimated settlement is less tha 0.1 inch	minimal (zero ksi) pressure at toe

AMERICAN ENGINEERING TESTING	**Stormwater and Greenway Project** **325 Blake Rd N, Hopkins, Minnesota**		AET Project No. P-0006986
	Boring Location Map		
	Scale: Shown	Drawn by: TE	Reviewed by: JB	**Date: February 2, 2022**

SUBSURFACE BORING LOG

AET JOB NO: **P-0006986**

LOG OF BORING NO. **B-5 (p. 1 of 1)**

PROJECT: **Stormwater and Greenway Project, 325 Blake Rd N; Hopkins, MN**

SURFACE ELEVATION: **907.3** LATITUDE: **44.930157** LONGITUDE: **-93.382573**

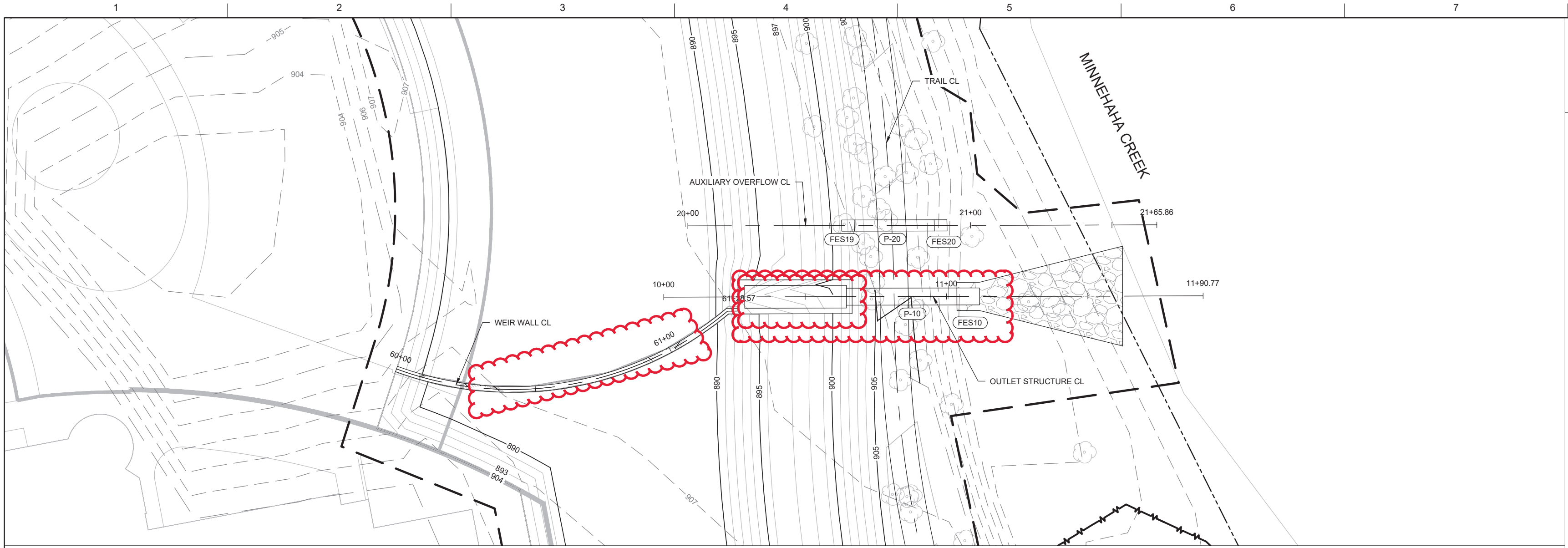
DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS				
							WC	DEN	LL	PL	%-#200
1	FILL, mostly silty sand, with gravel, brown, frozen	FILL		F	SU						
2	FILL, mostly silty sand, a little gravel, brown										
3			13	M	SS	4					
4											
5			5	M	SS	6					
6											
7	FILL, mixture of clayey sand with organic fines and silty sand, black and brown										
8			15	M	SS	12	19		Weir Cap at EL 897 ft		
9											
10	SILTY SAND WITH GRAVEL, brown, moist, medium dense (SM)	COARSE ALLUVIUM	19	▼ M	SS	12			Water Level ~EL 897 ft		12
11											
12	SAND WITH SILT AND GRAVEL, fine to medium grained, brown, waterbearing, medium dense (SP-SM)										
13			11	W	SS	13					7
14											
15			16	W	SS	4					
16									Weir Cap at EL 889 ft		
17	SAND, a little gravel, fine to medium grained, brown, waterbearing, medium dense (SP)										
18			26	W	SS	3					
19											
20			19	W	SS	10					
21											
22											
23			24	W	SS	10					
24											
25			23	W	SS	10					
26											
27											
28			26	W	SS	12					
29	SAND WITH SILT AND GRAVEL, fine to medium grained, brown, wet, very dense to dense (SP-SM)										
30			111	W	SS	10					8
31											
32											
33			74	W	SS	16					
34											
35			50	W	SS	10					
36	**END OF BORING**										

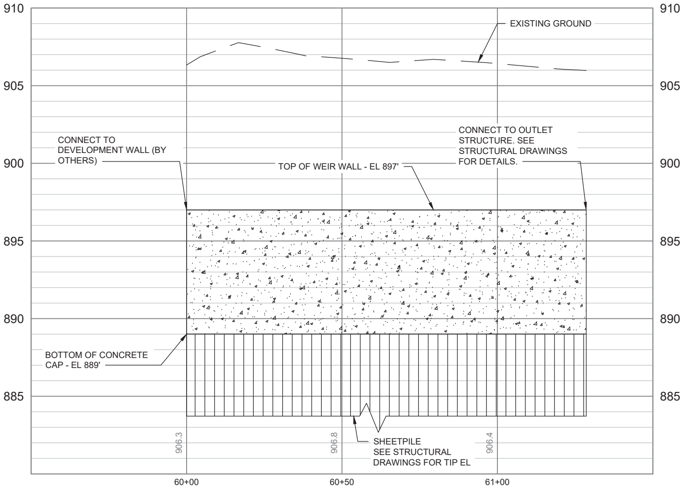
DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS						
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14'	**3.25" HSA**							
14-34½'	**RD w/DM**	**1/25/22**	**10:40**	**13.5**	**12.0**	**11.8**		**10.6**
		1/25/22	**10:50**	**13.5**	**12.0**	**11.7**		**10.5**

BORING COMPLETED: **1/26/22**

DR: **SG** LG: **SB** Rig: **41**

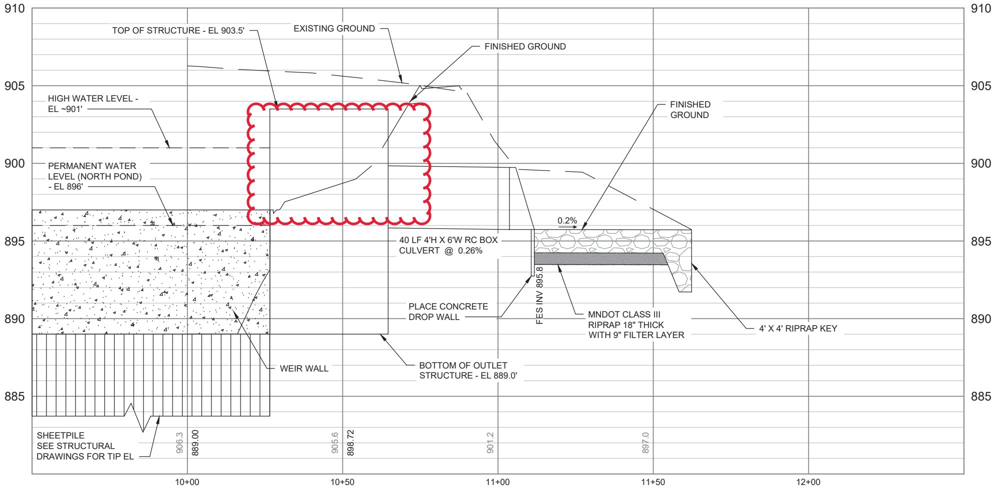
NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG





WEIR WALL PROFILE

H: 1"=20', V: 1"=4'



OUTLET STRUCTURE PROFILE

H: 1"=20', V: 1"=4'

MINNEHAHA CREEK WATERSHED DISTRICT

ISSUE	DATE	DESCRIPTION
-	-	-

PROJECT MANAGER ANDREW F. JUDD

PROJECT NUMBER 10268112

60% DRAFT SUBMITTAL FOR CLIENT REVIEW

325 BLAKE RD REGIONAL STORMWATER AND GREENWAY

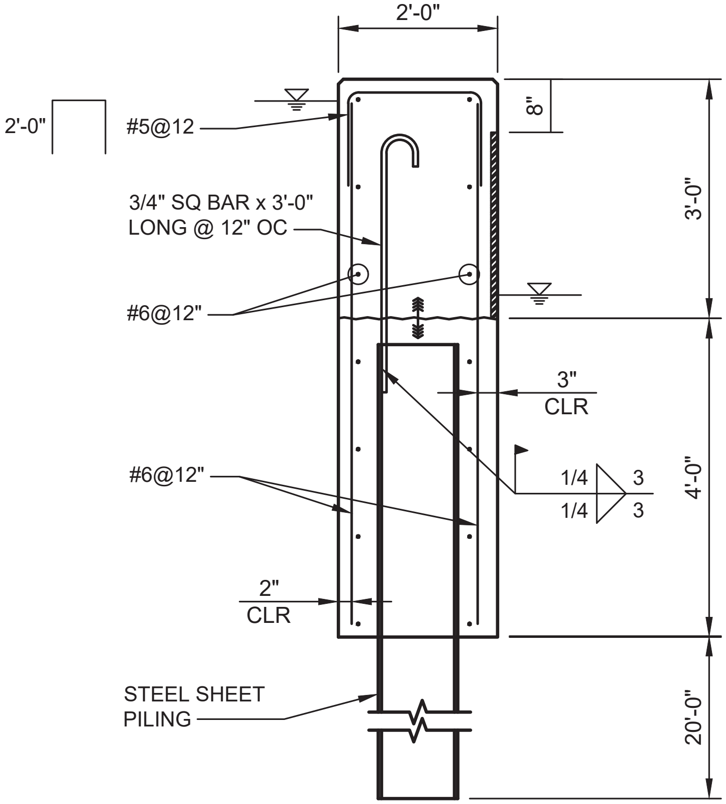
MINNEHAHA CREEK WATERSHED DISTRICT
325 BLAKE RD
HOPKINS, MN 55343

STORMWATER PLAN & PROFILE

FILENAME CP101-104.DWG

SCALE 1" = 20'

SHEET CP103



WEIR WALL DETAIL

1" = 1'-0"

1
-

Appendix E

Cost Estimate

3/31/2023

325 BLAKE ROAD PROJECT

Bid Item #	Item	Unit	Quantity	Base Bid		Engineers Estimate	
				Unit Price	Extension	Unit Price	Extension
GENERAL CONDITIONS							
1	MOBILIZATION AND DEMOBILIZATION	LS	1			$ 486,946	$ 486,946
2	ENGINEERING AND ADMINISTRATION	LS	1			$ 97,389	$ 97,389
3	CONSTRUCTION SURVEY	LS	1			$ 73,042	$ 73,042
4	INDEPENDENT TESTING	LS	1			$ 48,695	$ 48,695
5	EROSION AND SEDIMENT CONTROL	LS	1			$ 121,737	$ 121,737
DEMOLITION							
6	SAWCUT BITUMINOUS PAVEMENT	LF	54			$ 3.45	$ 186
7	REMOVE BITUMINOUS PAVEMENT	SY	12			$ 4.60	$ 55
8	SAWCUT CONCRETE WALK	LF	32			$ 5.75	$ 184
9	REMOVE CONCRETE WALK	SY	133			$ 3.45	$ 459
10	REMOVE CURB AND GUTTER	LF	90			$ 5.29	$ 476
11	REMOVE UTILITY PIPING (SMALL DIA)	LF	221			$ 19.55	$ 4,321
12	REMOVE UTILITY PIPING (LARGE DIA)	LF	30			$ 32.20	$ 966
13	BULKHEAD/FILL/ABANDON STORM SEWER PIPE	EA	5			$ 2,070	$ 10,350
14	REMOVE, STOCKPILE, AND RELOCATE SIGNAGE	EA	4			$ 345	$ 1,380
15	MANHOLE REMOVAL	EA	2			$ 920	$ 1,840
16	SAMPLING WELL STANDPIPE REMOVAL	EA	5			$ 2,415	$ 12,075
17	MISCELLANEOUS REMOVAL	TN	10			$ 58	$ 575
18	CLEARING AND GRUBBING	AC	0.5			$ 13,800	$ 6,900
19	TREE REMOVAL (SMALL DIA)	EA	57			$ 506	$ 28,842
20	TREE REMOVAL (LARGE DIA)	EA	20			$ 748	$ 14,950
21	TREE PROTECTION	LS	1			$ 57,500	$ 57,500
EARTHWORK							
22	FIELD SET WORK	DAY	5			$ 1,380	$ 6,900
23	STRIP, STOCKPILE, AND REUSE TOPSOIL	CY	528			$ 21.85	$ 11,537
24	DEWATERING AND DIVERSION	LS	1			$ 103,500	$ 103,500
25	EXCAVATE, STOCKPILE, AND ONSITE RE-USE	CY	1064			$ 17.3	$ 18,354
26	EXCAVATE, STOCKPILE, HAUL AND WASTE	CY	35095			$ 26.5	$ 928,263
27	EXCAVATE, STOCKPILE, HAUL AND LANDFILL	CY	590			$ 48.3	$ 28,497
28	SUPPLY, PLACE, AND COMPACT LANDING MIX	CY	70			$ 74.8	$ 5,233
29	SUPPLY, PLACE, AND COMPACT COARSE FILTER MATERIAL	CY	140			$ 71.3	$ 9,982
30	SUPPLY, PLACE, AND COMPACT BIORENTENTION SOIL	CY	186			$ 63.3	$ 11,765
31	AIR SPADE BELOW EXISTING TREES	SF	6060			$ 4.6	$ 27,876
32	MNDOT CLASS II RIPRAP	CY	90			$ 77.1	$ 6,935
33	IMPORTED TOPSOIL	CY	1025			$ 57.5	$ 58,938
34	SOIL AMENDMENT	SF	7777			$ 4.6	$ 35,774
35	TURF REINFORCEMENT MAT 76HP-TRM	SY	36			$ 28.8	$ 1,035
UTILITIES							
36	36" RCP FLARED END SECTION	EA	1			$ 2,007	$ 2,007
37	42" RCP FLARED END SECTION	EA	1			$ 2,498	$ 2,498
38	4'H X 6'W RC BOX END SECTION	EA	1			$ 10,389	$ 10,389
39	1.5'H X 4'W RC BOX END SECTION	EA	2			$ 5,195	$ 10,389
40	4'H X 6'W BOX CULVERT	LF	40			$ 910	$ 36,409
41	1.5'H X 4'W BOX CULVERT	LF	37			$ 455	$ 16,837
42	36" RCP - CLASS III	LF	62			$ 205	$ 12,691
43	36" RCP - CLASS V	LF	40			$ 205	$ 8,188
44	42" RCP - CLASS III	LF	496			$ 165	$ 81,909
45	42" RCP - CLASS V	LF	14			$ 426	$ 5,957
46	EXISTING PIPE/MH CONNECTION	EA	2			$ 1,524	$ 3,048
47	60" DIA RCP MANHOLE	EA	1			$ 20,069	$ 20,069
48	66" DIA RCP MANHOLE	EA	1			$ 21,073	$ 21,073
49	72" DIA RCP MANHOLE	EA	2			$ 22,126	$ 44,252
50	78" DIA RCP MANHOLE	EA	1			$ 23,233	$ 23,233
51	84" DIA RCP MANHOLE	EA	2			$ 24,394	$ 48,788
52	6'W x 12'L NUTRIENT SEPERATING BAFFLE BOX	EA	1			$ 40,250	$ 40,250
53	8'W x 16'L NUTRIENT SEPERATING BAFFLE BOX	EA	1			$ 46,000	$ 46,000
54	6" PVC SUBDRAIN/FRENCH DRAIN	LF	600			$ 39.10	$ 23,460
55	STILLING WELL	EA	1			$ 1,047	$ 1,047
56	STILLING WELL PIPE	LF	40			$ 46.00	$ 1,840
STRUCTURES							
57	SHEETPILE	SF	3900			$ 69.00	$ 269,100
58	WEIR WALL CAP	LF	130			$ 1,472	$ 191,360
59	OUTLET STRUCTURE	LS	1			$ 306,176	$ 306,176
60	PRE-FABRICATED PEDESTRIAN BRIDGE	LS	1			$ 345,000	$ 345,000
61	PEDESTRIAN BRIDGE CONCRETE ABUTMENTS	EA	2			$ 14,996	$ 29,992
62	PEDESTRAIN BRIDGE ABUTMENT H-PILE	LF	390			$ 201.25	$ 78,488

3/31/2023

325 BLAKE ROAD PROJECT

Bid Item #	Item	Unit	Quantity	Base Bid		Engineers Estimate	
				Unit Price	Extension	Unit Price	Extension
ELECTRICAL							
63	ELECTRICAL	LS	1			$ 201,960	$ 201,960
SURFACING							
64	ASPHALT TRAIL	SF	13158			$ 6.90	$ 90,790
65	PAVING TYPE 02 - PERMEABLE UNIT PAVERS	SF	1919			$ 28.75	$ 55,171
66	PAVING TYPE 03 - CONCRETE PAVING	SF	540			$ 23.00	$ 12,420
67	PAVING TYPE 04A - CRUSHED STONE SURFACING	SF	1477			$ 9.20	$ 13,588
68	PAVING TYPE 07 - DECORATIVE CONCRETE PAVING	SF	336			$ 51.75	$ 17,388
69	PAVING TYPE 09A - WOOD FIBER SURFACING (EWF) 9" DEPTH	SF	1717			$ 4.60	$ 7,898
70	PAVING TYPE 09B - WOOD FIBER SURFACING (EWF) 4" DEPTH	SF	1057			$ 3.45	$ 3,647
71	PAVING TYPE 11 - HARDWOOD MULCH PATH	SF	1001			$ 4.60	$ 4,605
72	PAVING TYPE 12 - ENGRAVED GRANITE PAVERS	SF	654			$ 161.00	$ 105,294
73	MINERAL MULCH TYPE 1 - 6-9" TRAP ROCK	SF	188			$ 9.20	$ 1,730
CURBING							
74	CURB TYPE 01 - 8" CIP CONCRETE PLANTER CURB	LF	210			$ 173	$ 36,225
75	CURB TYPE 02 - 8" CIP CONCRETE RIBBON CURB	LF	236			$ 46.00	$ 10,856
76	CURB TYPE 03 - 12" CIP CONCRETE PLAY AREA CURB	LF	158			$ 57.50	$ 9,085
77	CURB TYPE 04 - 12" CIP CONCRETE PLANTER CURB	LF	91			$ 207.00	$ 18,837
EDGING							
78	EDGING TYPE 01 - STONE EDGING	LF	254			$ 28.75	$ 7,303
79	EDGING TYPE 02 - STEEL EDGING	LF	136			$ 5.75	$ 782
FENCING							
80	GUARDRAIL TYPE 01A - WALL MOUNT GUARDRAIL	LF	84			$ 115.00	$ 9,660
81	GUARDRAIL TYPE 01B - PLATE MOUNT GUARDRAIL	LF	27			$ 230.00	$ 6,210
82	FENCE TYPE 02 - WOOD POST & ROPE FENCE	LF	82			$ 86.25	$ 7,073
83	GATE TYPE 01 - PLAY AREA TIMBER GATE	EA	2			$ 1,150.00	$ 2,300
SIGNAGE							
84	SIGN TYPE 01 - DIRECTIONAL	EA	3			$ 2,875	$ 8,625
85	SIGN TYPE 02A - WAYFINDING KIOSK	EA	1			$ 28,750	$ 28,750
86	SIGN TYPE 02B - WAYFINDING KIOSK	EA	1			$ 28,750	$ 28,750
87	SIGN TYPE 03 - STOP SIGN	EA	3			$ 230	$ 690
88	SIGN TYPE 04 - TRAIL & REGULATION	EA	6			$ 2,875	$ 17,250
89	SIGNTYPE 05A - INTERPRETIVE SIGN	EA	1			$ 2,875	$ 2,875
90	SIGN TYPE 05B - INTERPRETIVE SIGN	EA	2			$ 2,875	$ 5,750
91	SIGN TYPE 06 - THREE RIVERS DIRECTIONAL	EA	1			$ 1,150	$ 1,150
92	SIGN TYPE 07 - THREE RIVERS TRAIL KIOSK	EA	1			$ 1,150	$ 1,150
93	SIGN TYPE 08 - THREE RIVERS SYSTEM KIOSK	EA	1			$ 1,150	$ 1,150
AMENITIES							
94	AMENITY TYPE 02 - PERGOLA	EA	1			$ 224,250	$ 224,250
95	AMENITY TYPE 03 - KAYAK RACK	EA	1			$ 11,500	$ 11,500
96	AMENITY TYPE 04 - FIRE PIT	EA	1			$ 5,750	$ 5,750
97	AMENITY TYPE 05 - BAT ROCKET BOX	EA	1			$ 2,300	$ 2,300
98	AMENITY TYPE 06 - BLUEBIRD HOUSE	EA	3			$ 173	$ 518
99	AMENITY TYPE 07 - WOOD DUCK BOX	EA	3			$ 173	$ 518
100	AMENITY TYPE 08 - WOOD ENGRAVING	EA	6			$ 4,600	$ 27,600
101	AMENITY TYPE 09 - STONE ENGRAVING	EA	4			$ 4,600	$ 18,400
102	AMENITY TYPE 10 - CONCRETE ENGRAVING	EA	1			$ 4,600	$ 4,600
103	AMENITY TYPE 11 - STAFF GAUGE	EA	2			$ 5,750	$ 11,500
104	ROCK TYPE 01 - LANDSCAPE BOULDER	EA	88			$ 575	$ 50,600
PLAY EQUIPMENT							
105	PLAY EQUIPMENT TYPE 01 - LOG STACK	EA	1			$ 17,250	$ 17,250
106	PLAY EQUIPMENT TYPE 02 - PLAY MOUND	EA	1			$ 23,000	$ 23,000
107	PLAY EQUIPMENT TYPE 03 - PRECAST CONCRETE ACORN	EA	3			$ 11,500	$ 34,500

3/31/2023

325 BLAKE ROAD PROJECT

Bid Item #	**Item**	**Unit**	**Quantity**	**Base Bid**		**Engineers Estimate**	
				Unit Price	**Extension**	**Unit Price**	**Extension**
FURNISHINGS							
108	SITE FURNITURE TYPE 01A - CANTILEVER BENCH	EA	2			$ 3,450	$ 6,900
109	SITE FURNITURE TYPE 01B - BACKED BENCH	EA	1			$ 2,875	$ 2,875
110	SITE FURNITURE TYPE 02 - HAMMOCK POLE	EA	4			$ 575	$ 2,300
111	SITE FURNITURE TYPE 03 - ROLLING BIKE RACK	EA	3			$ 920	$ 2,760
112	SITE FURNITURE TYPE 04 - HOOP BIKE RACK	EA	11			$ 748	$ 8,223
113	SITE FURNITURE TYPE 05 - TIMBER BENCH	EA	2			$ 2,300	$ 4,600
114	SITE FURNITURE TYPE 06 - PICNIC TABLE	EA	2			$ 4,600	$ 9,200
115	SITE FURNITURE TYPE 07 - WASTE RECEPTACLE	EA	3			$ 575	$ 1,725
116	SITE FURNITURE TYPE 08 - BACKED BENCH	EA	4			$ 1,380	$ 5,520
117	SITE FURNITURE TYPE 09A - LIMESTONE BLOCK ON AGGREGATE SPLIT FACE	EA	12			$ 1,725	$ 20,700
118	SITE FURNITURE TYPE 09B - LIMESTONE BLOCK ON PAVEMENT SPLIT FACE	EA	2			$ 1,725	$ 3,450
119	SITE FURNITURE TYPE 09C - LIMESTONE BLOCK ON AGGREGATE SAWN FACE	EA	6			$ 1,725	$ 10,350
120	SITE FURNITURE TYPE 10 - SWING BENCH	EA	2			$ 8,625	$ 17,250
121	SITE FURNITURE TYPE 11 - BIKE FIX-IT STATION	EA	1			$ 2,875	$ 2,875
122	SITE FURNITURE TYPE 12 - DRINKING FOUNTAIN	EA	1			$ 11,500	$ 11,500
WALLS AND STAIRS							
123	WALL TYPE 01 - LIMESTONE SEATWALL @ TRAILHEAD	LF	110			$ 288	$ 31,625
124	WALL TYPE 02 - LIMESTONE SEATWALL @ PLAY AREA	LF	130			$ 115	$ 14,950
125	WALL TYPE 03 - LIMESTONE SEATWALL @ PICNIC AREA	LF	50			$ 483	$ 24,150
126	WALL TYPE 04 - CIP CONCRETE WALL	LF	140			$ 460	$ 64,400
127	WALL TYPE 05 - CIP CONCRETE SEATWALL WITH STONE MASONRY VENEER	LF	90			$ 690	$ 62,100
128	STAIR TYPE 01 - STONE STEPPER	EA	18			$ 230	$ 4,140
VEGETATION							
129	3.5" CAL DECIDOUS CANOPY TREE	EA	3			$ 1,380	$ 4,140
130	3" CAL DECIDOUS CANOPY TREE	EA	1			$ 1,150	$ 1,150
131	2.5" CAL DECIDOUS CANOPY TREE	EA	54			$ 920	$ 49,680
132	2" CAL DECIDOUS CANOPY TREE	EA	15			$ 690	$ 10,350
133	8' HGT ORNAMENTAL TREE	EA	25			$ 920	$ 23,000
134	#15 SHRUB	EA	11			$ 173	$ 1,898
135	#10 SHRUB	EA	3			$ 115	$ 345
136	#5 SHRUB	EA	193			$ 80.50	$ 15,537
137	#2 SHRUB	EA	2227			$ 57.50	$ 128,053
138	#1 SHRUB	EA	52			$ 23.00	$ 1,196
139	1 GAL PERENNIAL	EA	2454			$ 18.40	$ 45,154
140	PLUGS	EA	2623			$ 5.75	$ 15,082
141	NATIVE SEED	SF	34,898			$ 0.23	$ 8,027
142	TURF SEED	SF	3409			$ 1.15	$ 3,920
143	IRRIGATION	LS	1			$ 23,000	$ 23,000
ALTERNATE							
144	ALTERNATE 1 - PAVING BELOW PERGOLA	SF	654			$ (115)	$ (75,210)
145	ALTERNATE 2 - ONE YEAR EXTENDED PLANT ESTABLISHMENT AND WARRANTY	LS	1			$ 23,000	$ 23,000
				TOTAL		**$ 5,697,273**	

Appendix F

Storm Sewer Diversion Field and Document Review

This document provides an overview of the design team's understanding of the Lake Street and Powell Road diversions based on a review of drawings and field visits.

Lake Street Diversion

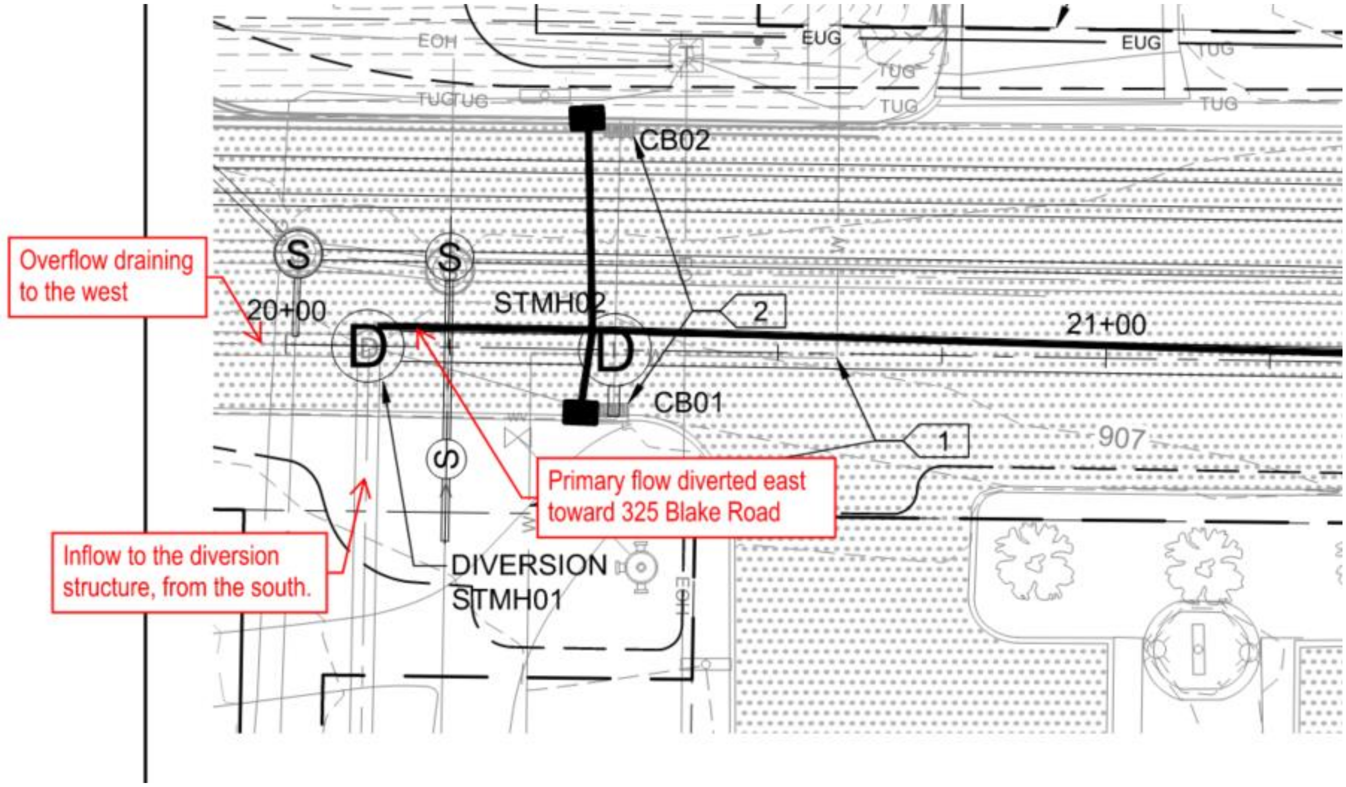


Exhibit A: Image from Lift Station L27 Record Drawings, with red text added by HDR. This exhibit shows the plan view for the diversion structure which is located approximately 700 feet west of the Blake Road and Lake Street intersection.

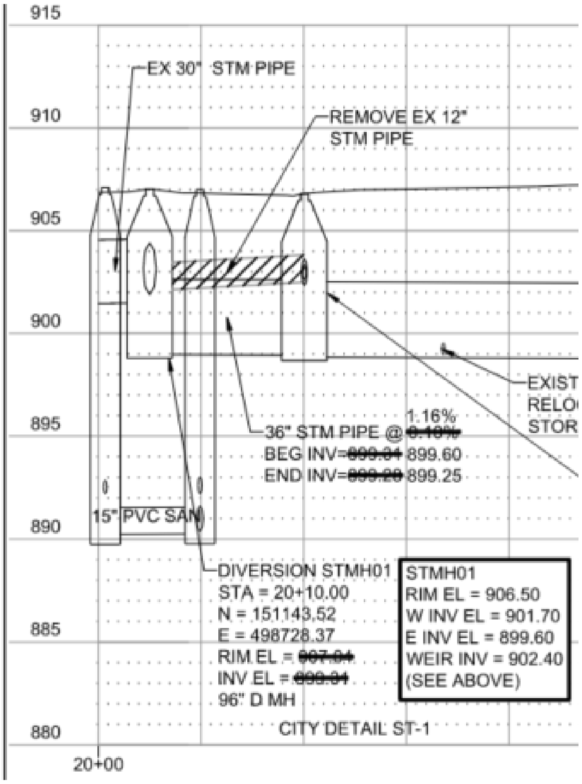


Exhibit B: The profile view at the diversion is consistent with the plan view in Exhibit A.

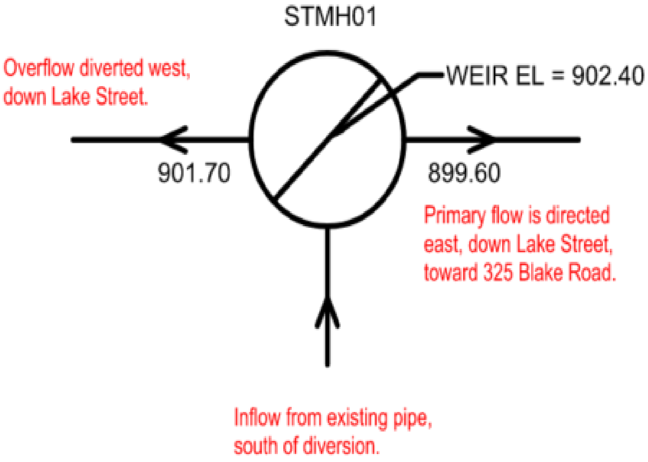


Exhibit C: Record drawings include a schematic, indicating that stormwater inflow from the south is diverted by a concrete weir. Primary flow drains east toward 325 Blake Road, until the weir is overtopped and overflow drains west. Red text has been added by HDR to supplement the detail. This schematic is consistent with the plan and profile views in Exhibits A and B.

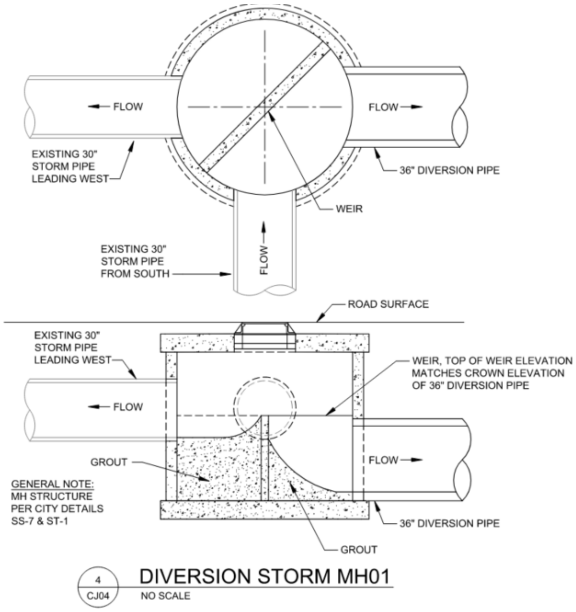
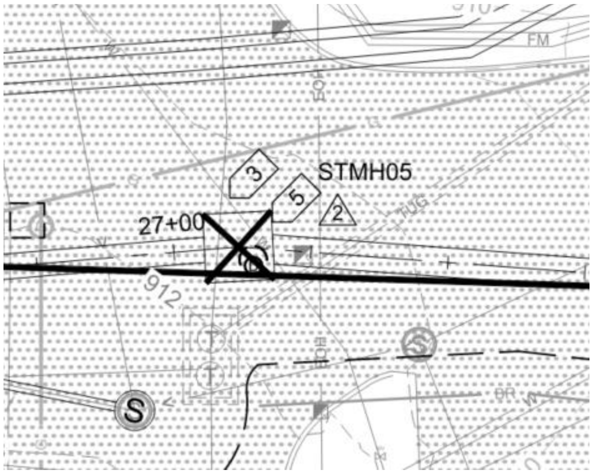


Exhibit D: Record drawings include a detail further confirming the Lake Street diversion plan, profile, and schematic discussed above. A permanent concrete weir structure controls primary and secondary stormwater flows



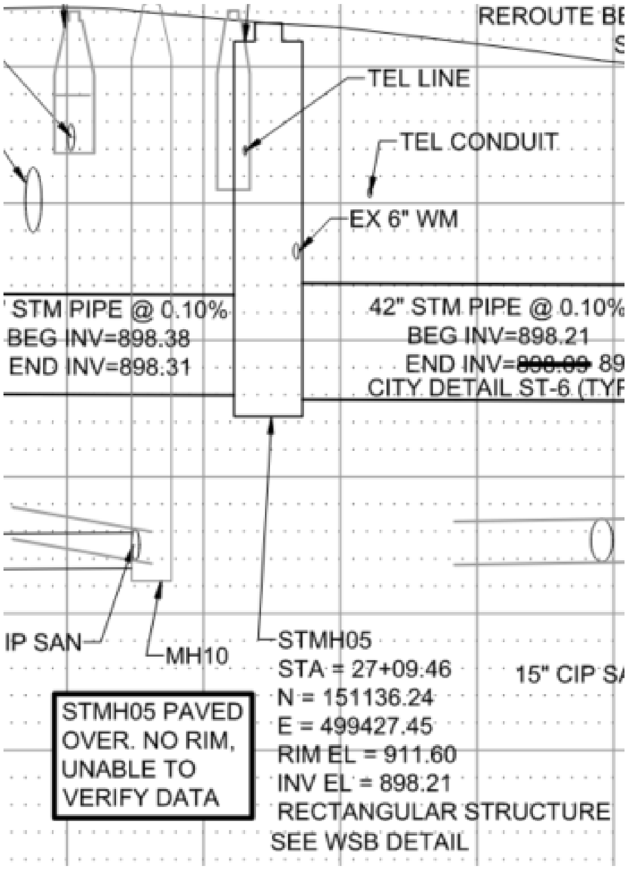


Exhibit E (above) and Exhibit F (right): Record drawings indicate a second diversion structure at the intersection of Lake Street and Blake Road. According to the drawings, this diversion is paved over and additional detail is missing from surveys, plans, and studies, to confirm the existence or mechanics of a storm sewer diversion in this area. There are no storm sewer pipes shown draining in any directions different from the main storm sewer line.

Conclusion: Stormwater diversion occurs in a Lake Street MH near Oakes Park and the stormwater baseflow is conveyed east towards the Blake Road site and overflow conveyed west.

Powell Road Diversion

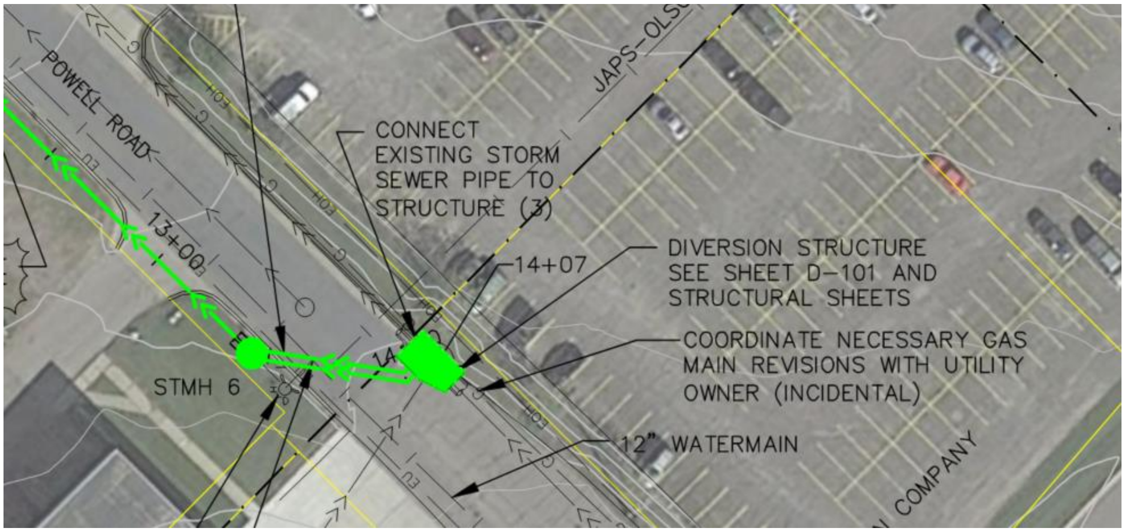


Exhibit A: Image from Powell Road Diversion Record Drawings. The Powell Road diversion is located adjacent to the Japs-Olson Company parking lot.

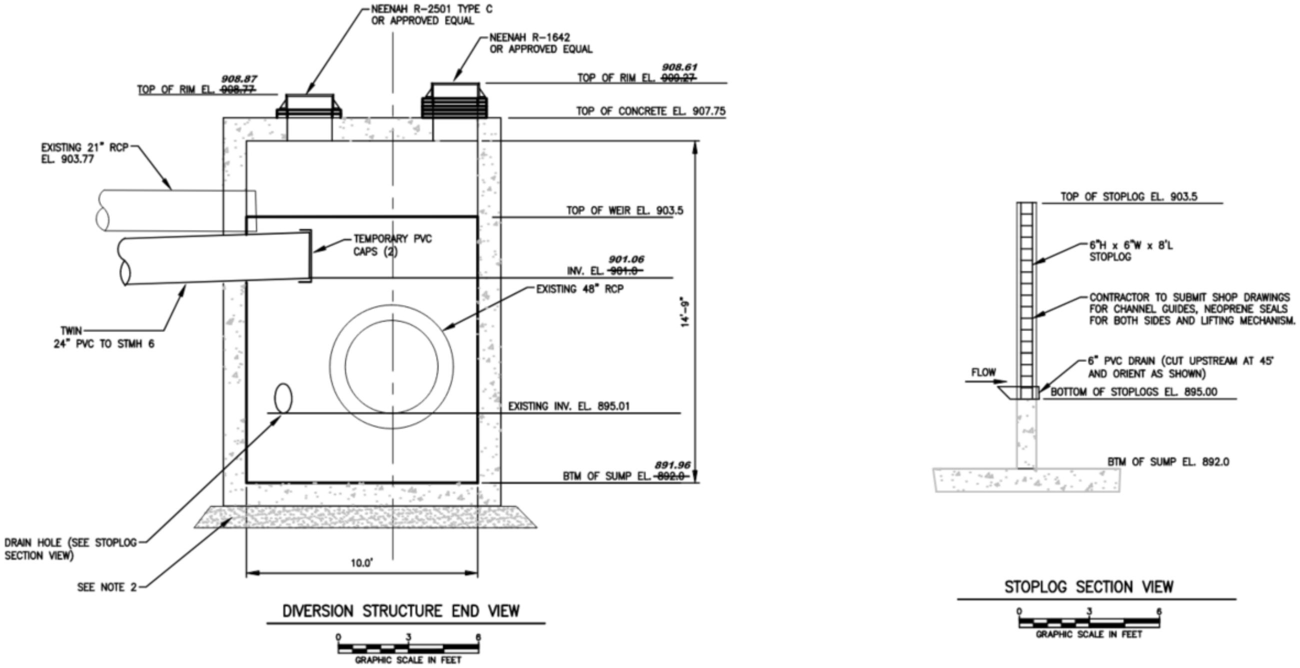


Exhibit B: This Powell Road Diversion detail indicates flow coming into the structure through a 48" RCP, and using a stop log weir to divert runoff toward 325 Blake Road. Diverted flow drains through two 24" PVC pipes. Flow that exceeds the diversion capacity will overtop the stop log weir or drain through a weep hole, draining through a 48" RCP toward Minnehaha Creek, downstream of the Blake Road site.

Appendix G

Interprative Concepts

325 Blake Road | Greenway Trail

MINNEHAHA CREEK
WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

HDR

DF/ DAMON FARBER LANDSCAPE ARCHITECTS

INTERPRETATION REFINED CONCEPTS

HOPKINS, MN
JANUARY 19, 2023

Themes for Interpretation + Art

1

Local ecology highlighting flora & fauna

Scavenger Hunt

PRECEDENT IMAGERY

2

Minnehaha Creek history

Watershed map at gateway to greenway

3

Stormwater management strategies

Information on pond
Outlet structure function
Cascade function within development

4

Importance of Creek to Native American culture

Dakota language translations

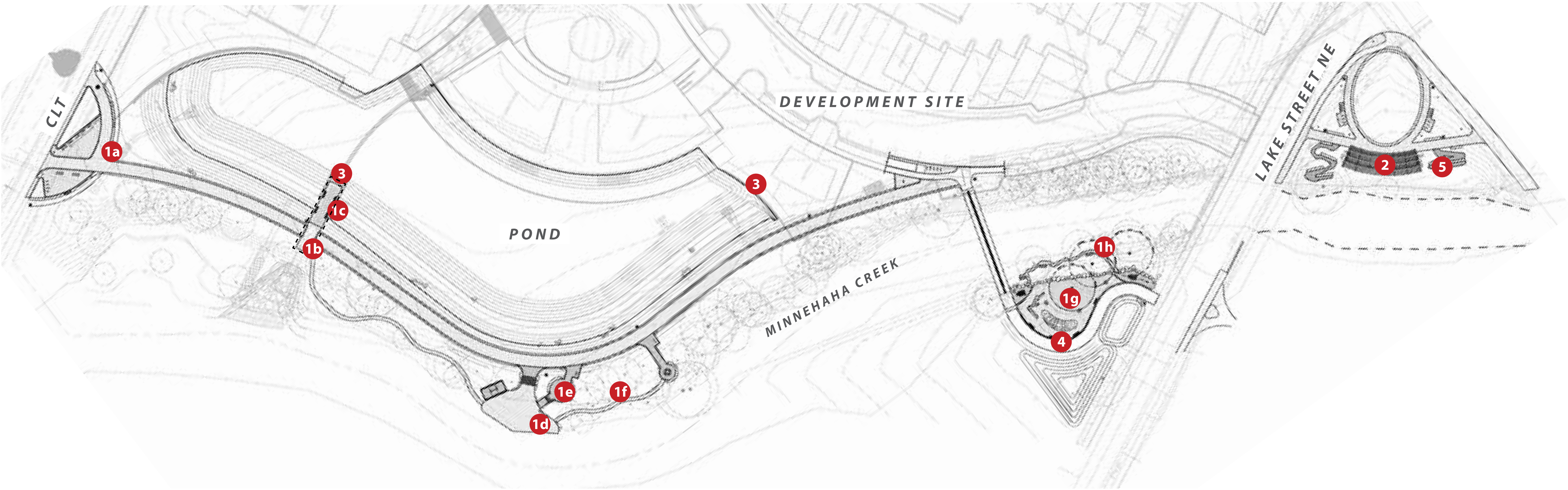
Interpretation + Public Art Opportunities

INTERPRETIVE FEATURES

① Scavenger Hunt
  a. Limestone wall end
  b. Limestone wall end
  c. Wood bench or guard handrail
  d. Wood bench
  e. Picnic table
  f. Fire pit or hammock pole
  g. Precast acorns
  h. Limestone block bench

② Watershed Map
③ Stormwater Strategies
④ Dakota Language Translations

⑤ Craig Churchward Dedication

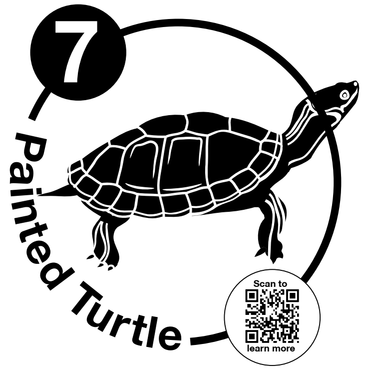


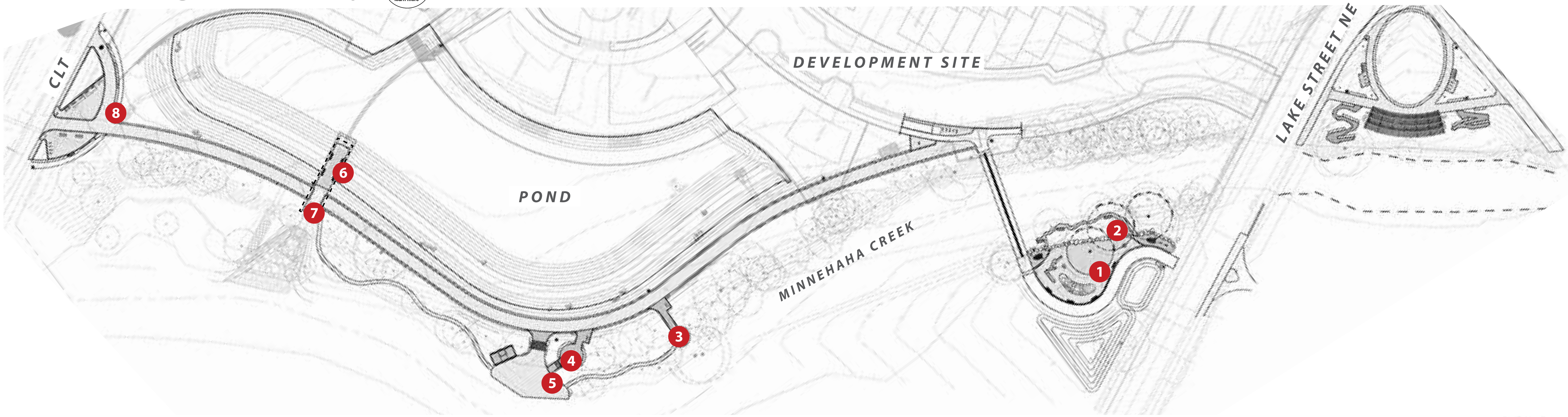
1

Local ecology highlighting flora & fauna

Interpretation + Public Art Opportunities

Scavenger Hunt





Interpretation + Public Art Opportunities

Scavenger Hunt

These Plants and Animal
all live in this area. H
many can you find?

1. Monarch Butte
2. Creek Chub
3. Maple
4. Raccoon
5. Deer
6. Eastern Cottor
7. American Crov

Can You Find These

Nice Work!

You Found a Raccoon!

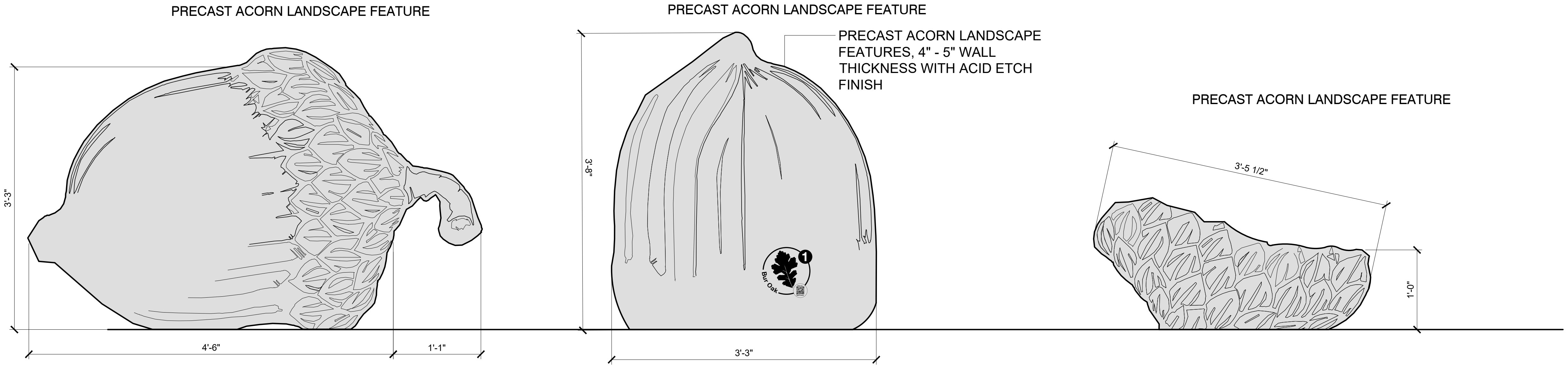
Fun Facts About Raccoons:

- Raccoons can make over 50 sounds
- While raccoons aren't as smart as us, they are considered to be one of the smartest animals, ranking with monkeys and pigs
- Raccoons can run at15 miles per hour

7. American Crow

Interpretation + Public Art Opportunities

Scavenger Hunt



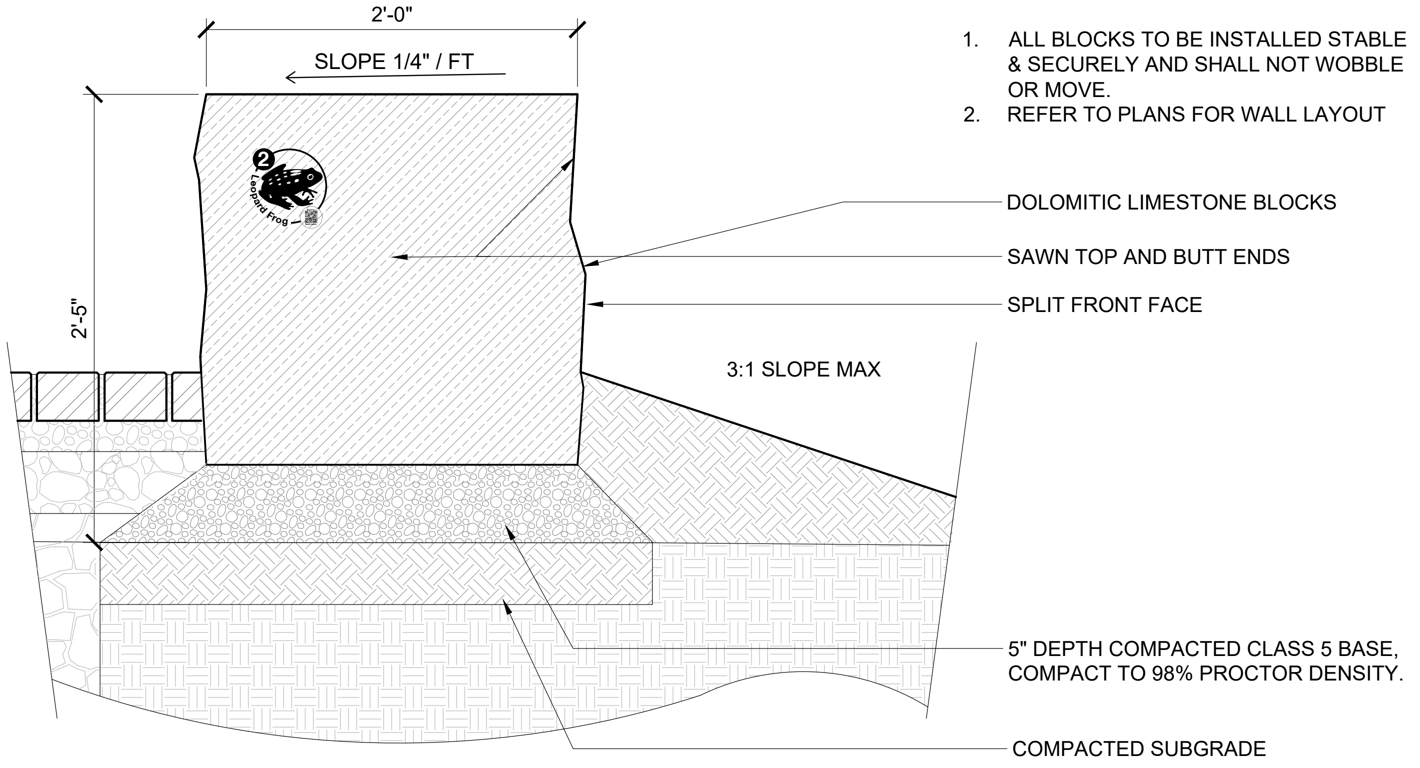
① PRECAST ACORN LANDSCAPE FEATURE

1 1/2" = 1'-0"

P-20.199-147

Interpretation + Public Art Opportunities

Scavenger Hunt

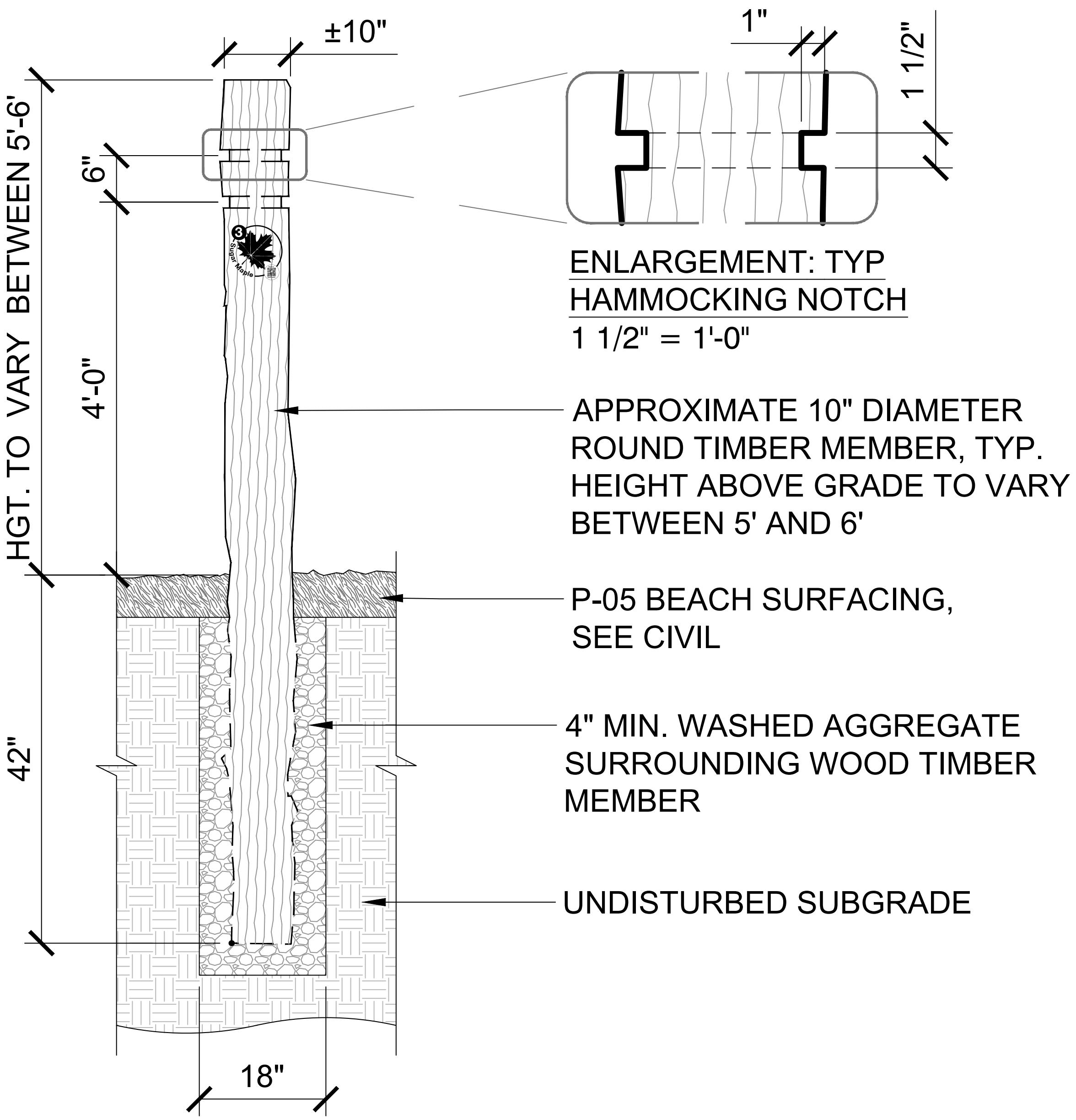


NOTES:

1. ALL BLOCKS TO BE INSTALLED STABLE & SECURELY AND SHALL NOT WOBBLE OR MOVE.
2. REFER TO PLANS FOR WALL LAYOUT

Interpretation + Public Art Opportunities

Scavenger Hunt



ENLARGEMENT: TYP HAMMOCKING NOTCH
1 1/2" = 1'-0"

APPROXIMATE 10" DIAMETER ROUND TIMBER MEMBER, TYP. HEIGHT ABOVE GRADE TO VARY BETWEEN 5' AND 6'

P-05 BEACH SURFACING, SEE CIVIL

4" MIN. WASHED AGGREGATE SURROUNDING WOOD TIMBER MEMBER

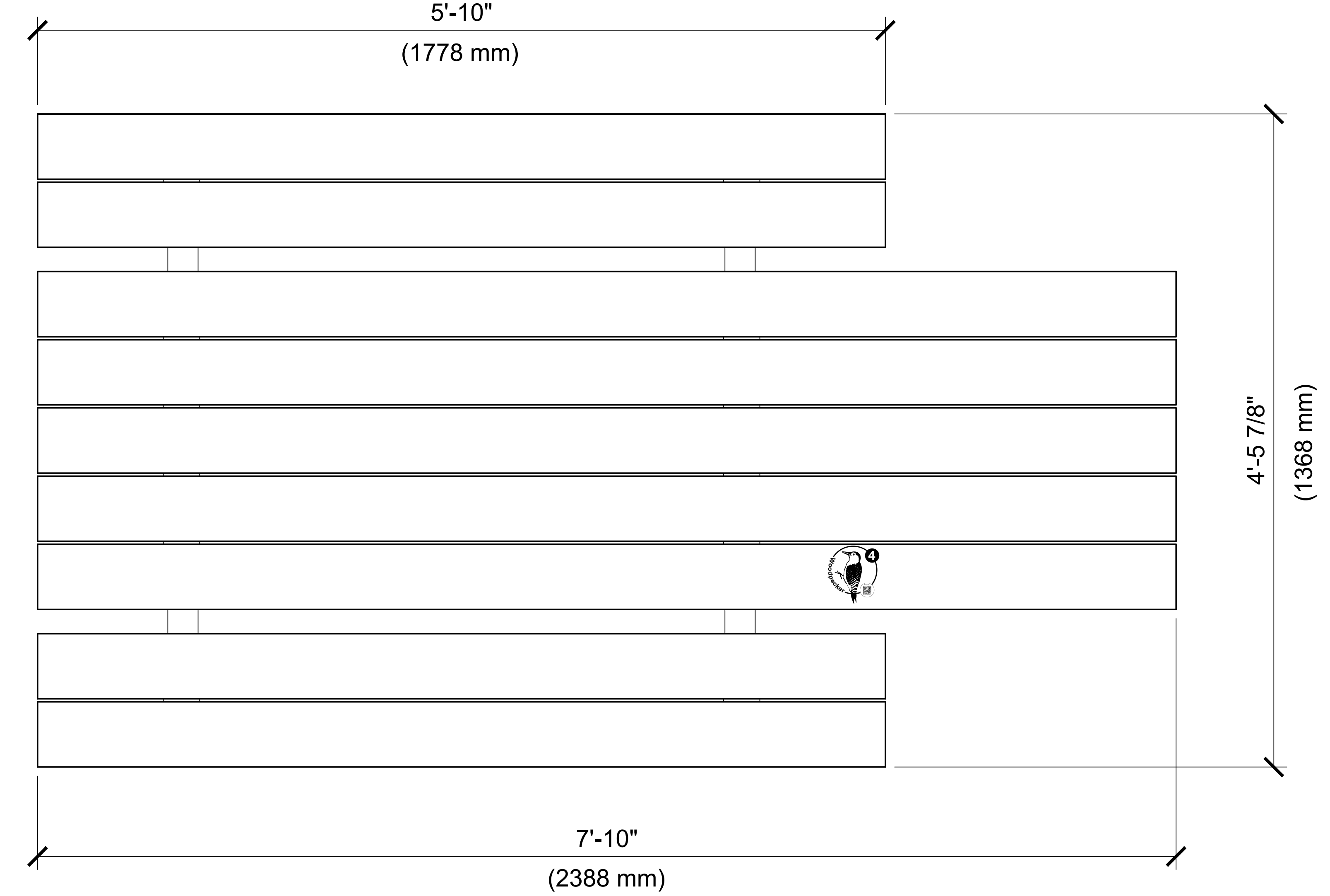
UNDISTURBED SUBGRADE

1 DETAIL - SF-02 HAMMOCK POLE

1/2" = 1'-0"

Interpretation + Public Art Opportunities

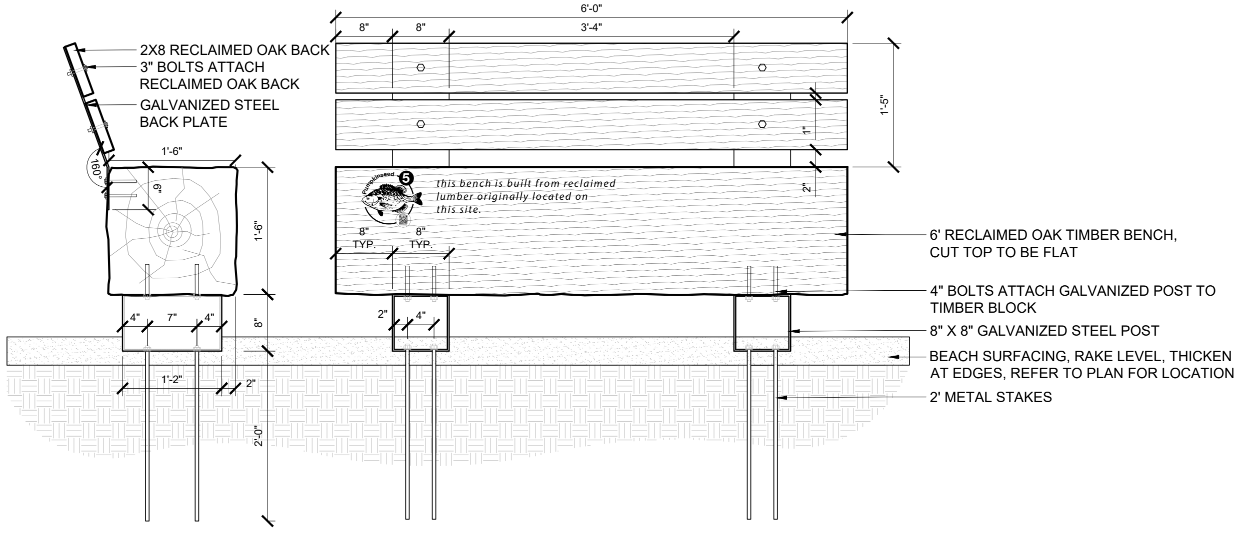
Scavenger Hunt



TOP VIEW

Interpretation + Public Art Opportunities

Scavenger Hunt



2 DETAIL - SF-05 LANDING TIMBER BENCH

1" = 1'-0"

P-20.199-176

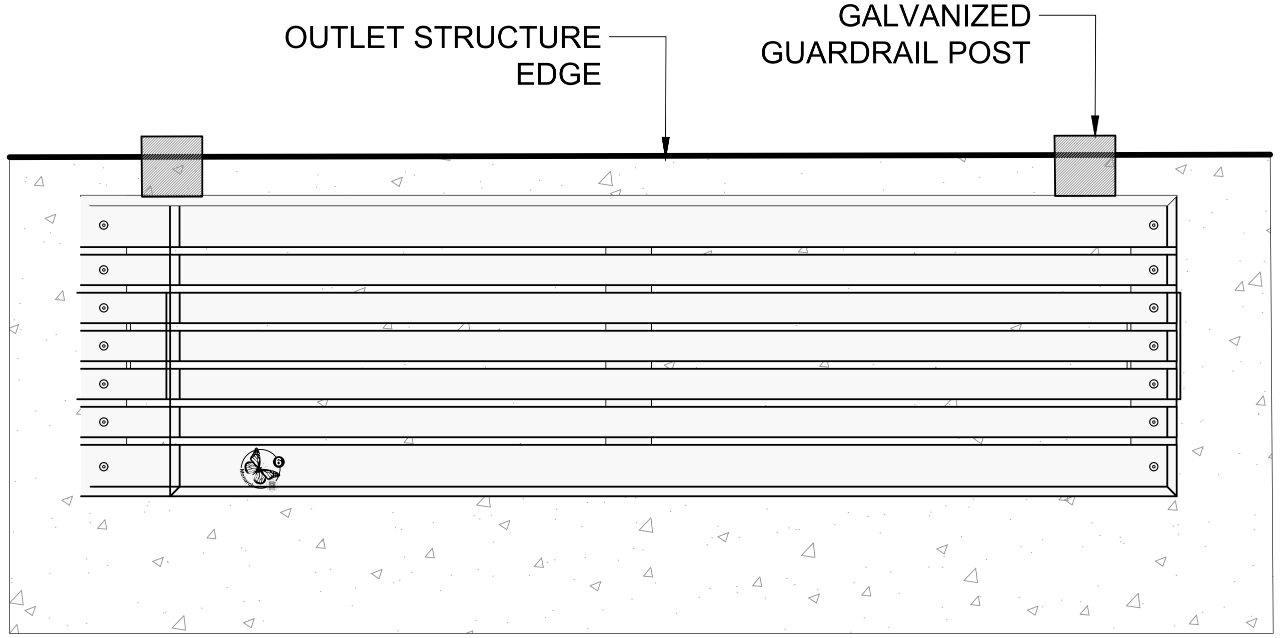
Interpretation + Public Art Opportunities

Scavenger Hunt

PRODUCT OF FORMS + SURFACES

KNIGHT BENCH, BACKLESS, 6' LENGTH,
TOP OF WALL MOUNT, NO ARMS

MOUNT PER MFR RECOMMENDATION



PLAN

3 DETAIL - SF-09 OUTLET STRUCTURE BENCH

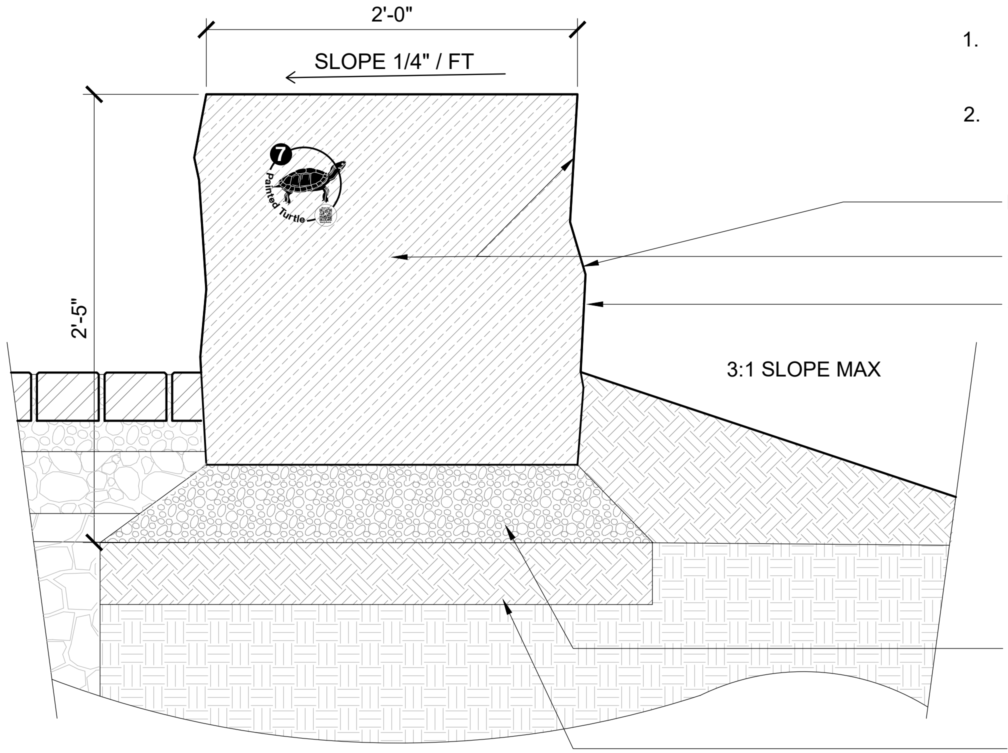
1" = 1'-0"

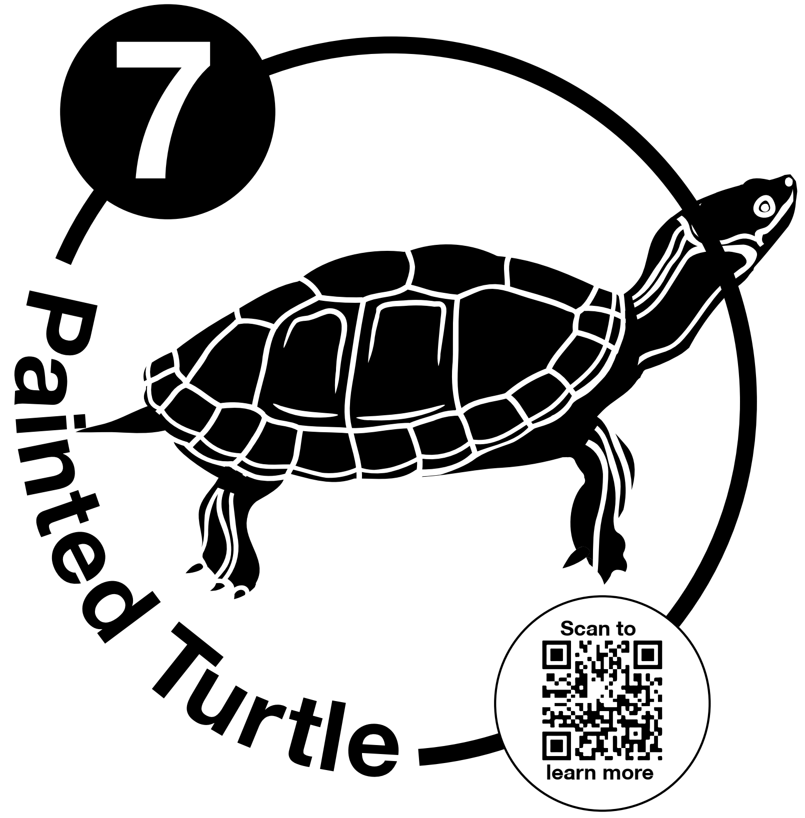
Interpretation + Public Art Opportunities

Scavenger Hunt

NOTES:

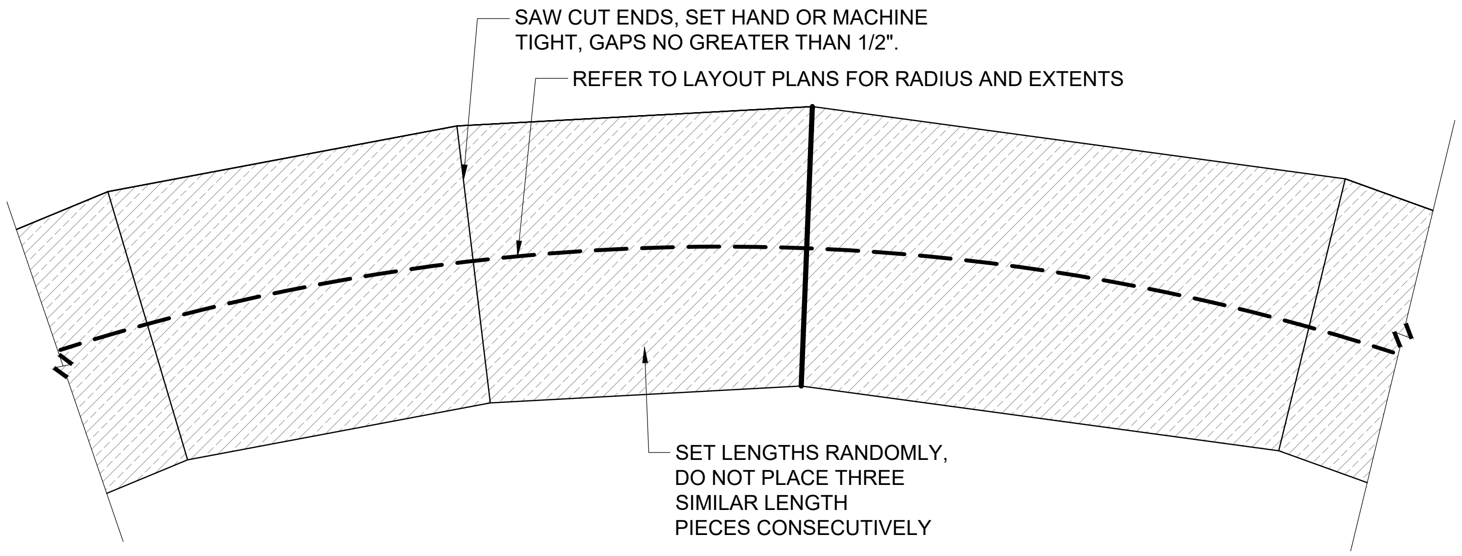
1. ALL BLOCKS TO BE INSTALLED STABLE & SECURELY AND SHALL NOT WOBBLE OR MOVE.
2. REFER TO PLANS FOR WALL LAYOUT



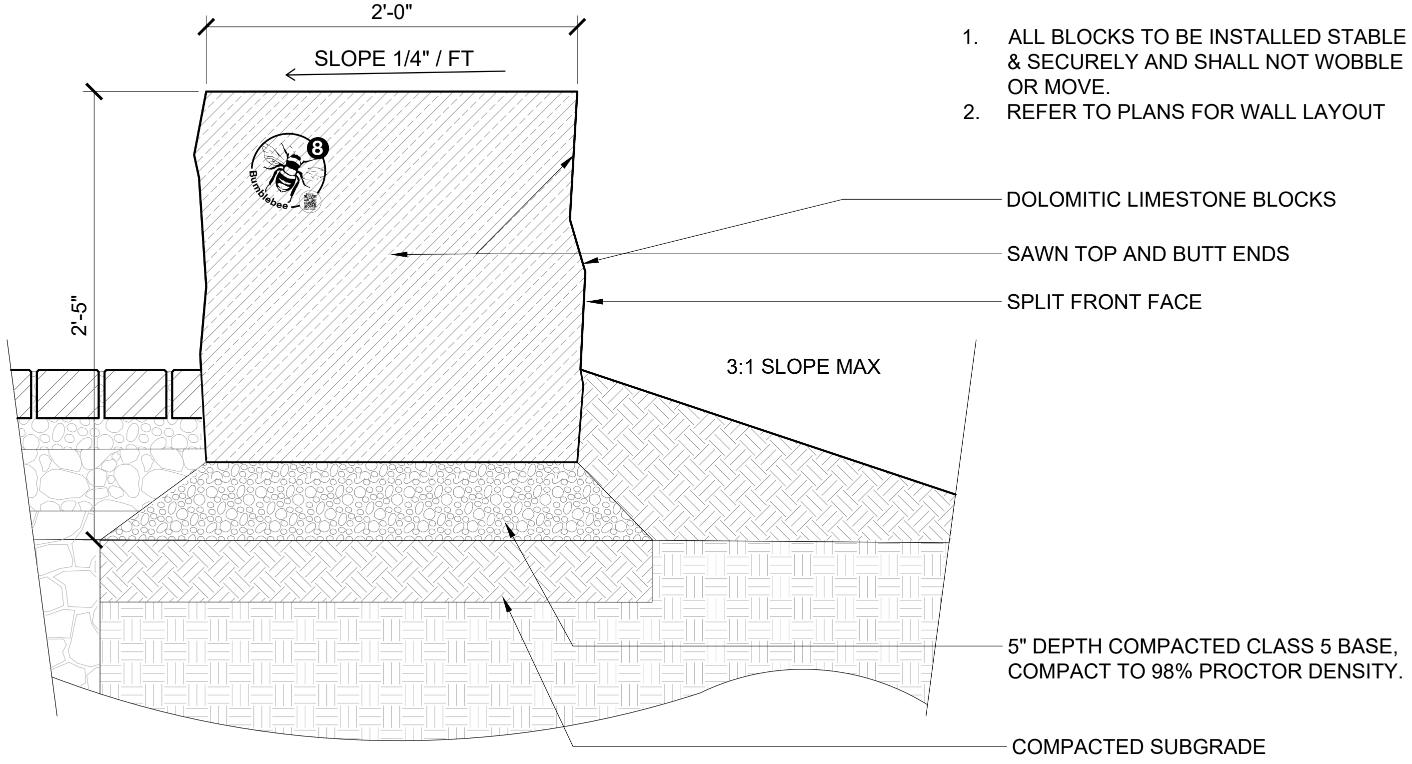


Interpretation + Public Art Opportunities

Scavenger Hunt



PLAN



NOTES:

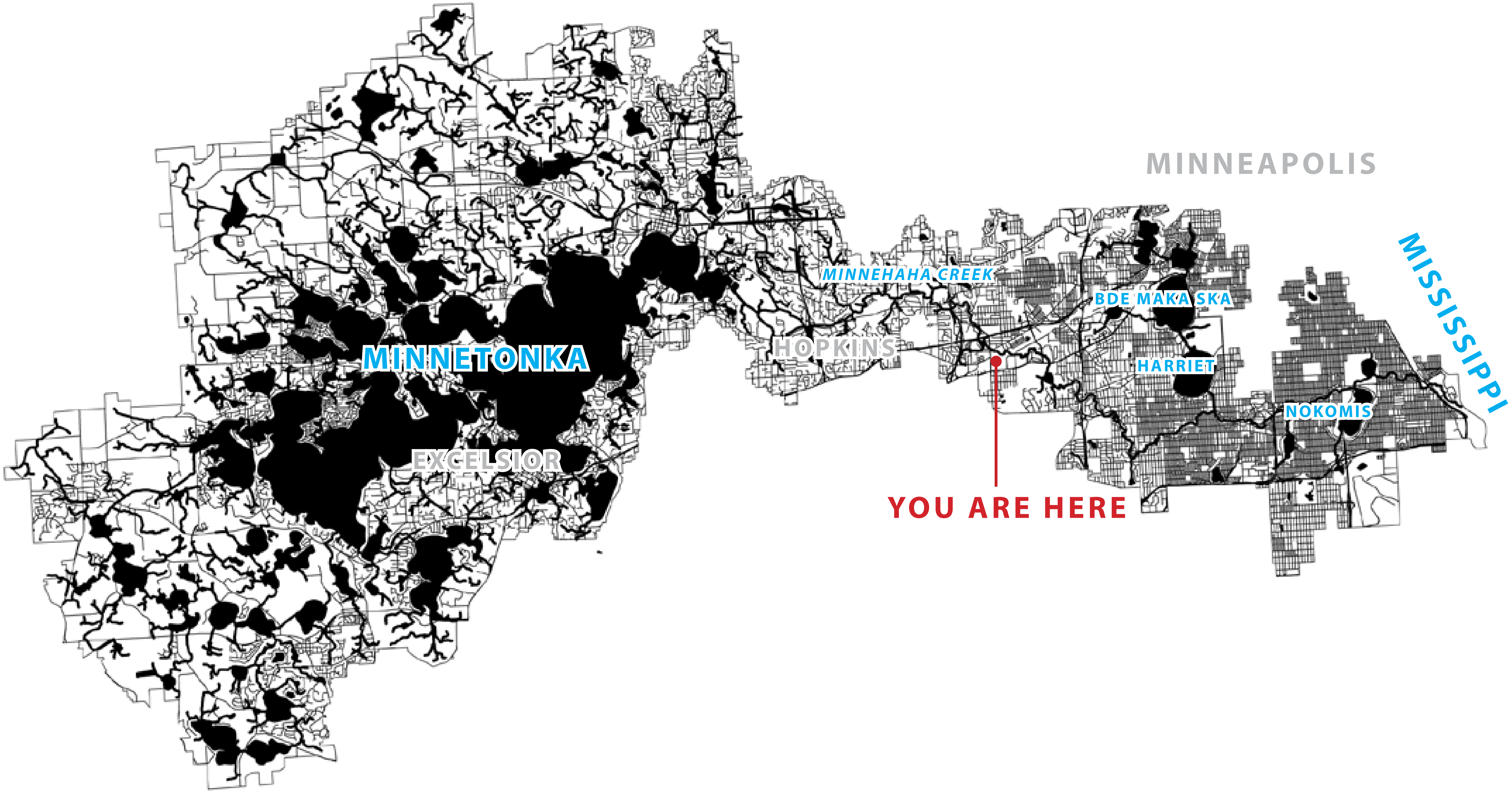
1. ALL BLOCKS TO BE INSTALLED STABLE & SECURELY AND SHALL NOT WOBBLE OR MOVE.
2. REFER TO PLANS FOR WALL LAYOUT

2

Minnehaha Creek and Watershed story

Interpretation + Public Art Opportunities

Minnehaha creek and Watershed Story



Interpretation + Public Art Opportunities

Minnehaha creek and Watershed Story

Sand Blasted Concrete

$ Cost effective, $40-50/SF

Least durable

Highly susceptable to salt damage

Highly difficult to repair

Engraved Precast Pavers

$$ Labor intensive, $80-100/SF

($35,000 add)

More durable than sand blasting

(Higher PSI, can be painted)

Moderatly susceptable to salt damage

Moderatly difficult to repair

Engraved Granite Pavers

$$$ Expensive, $120-160/SF

($75,000 add)

Very Durable

Moderatly difficult to repair

(granite wont fade, but will require re-engraving)

Interpretation + Public Art Opportunities

Minnehaha creek and Watershed Story

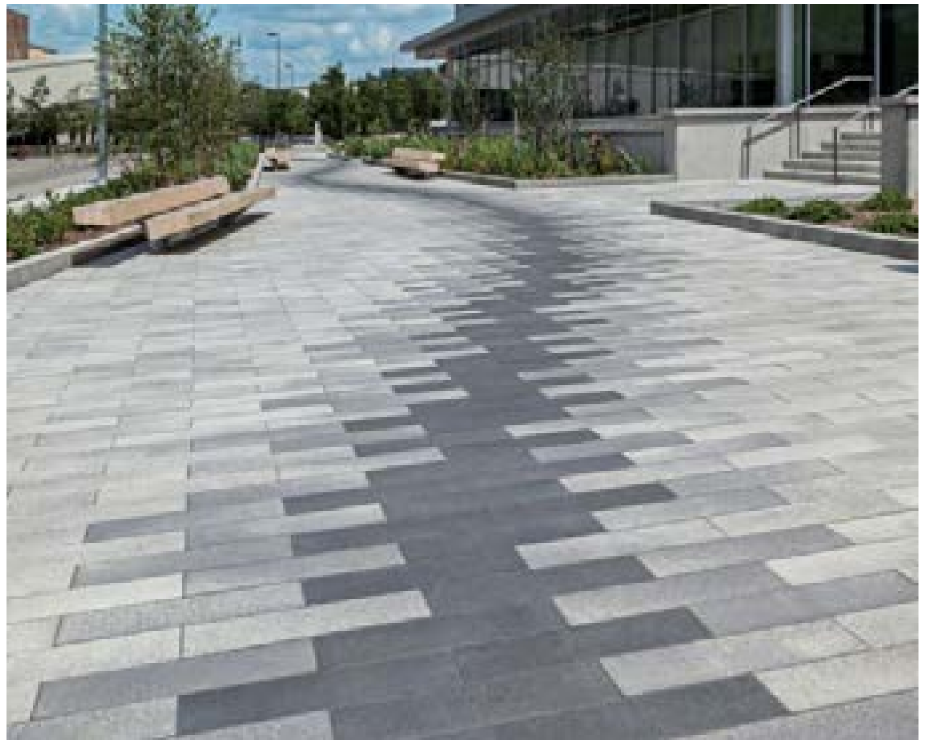
Concrete Pavers River Pattern

$ Cost effective, $45/SF

Highly susceptable to salt damage

Moderatly difficult to repair

(pavers will fade over time)



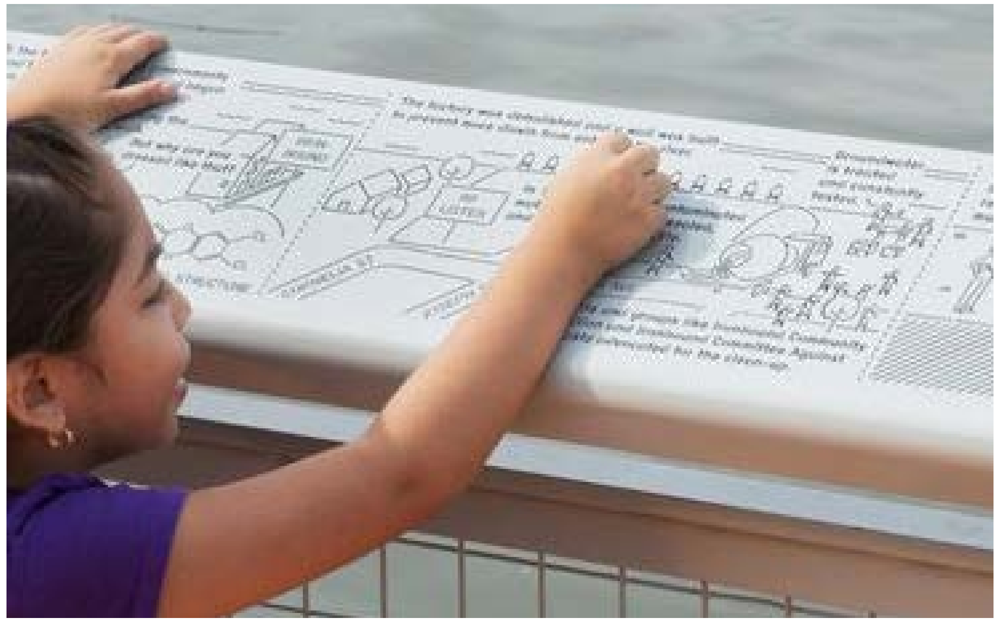
3

Stormwater management strategies and water quality statistics

Interpretation + Public Art Opportunities

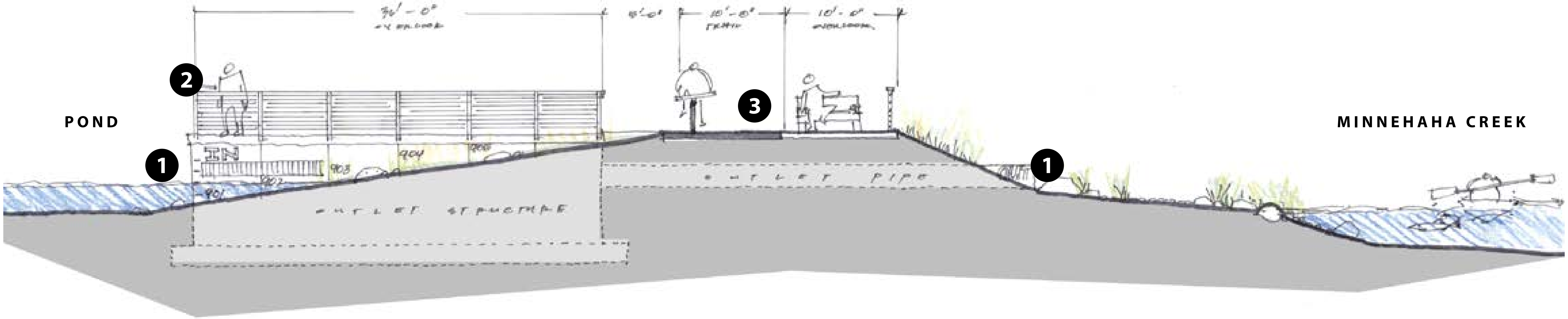
Water Quality Transect

① STAMPED METAL PANEL WITH WATER ELEVATION AND FLOW DIRECTIONS "IN" AND "OUT"



② SIGNAGE WITH SYSTEM COMPONENTS, REFERENCE TO CASCADE IN ALATUS SITE

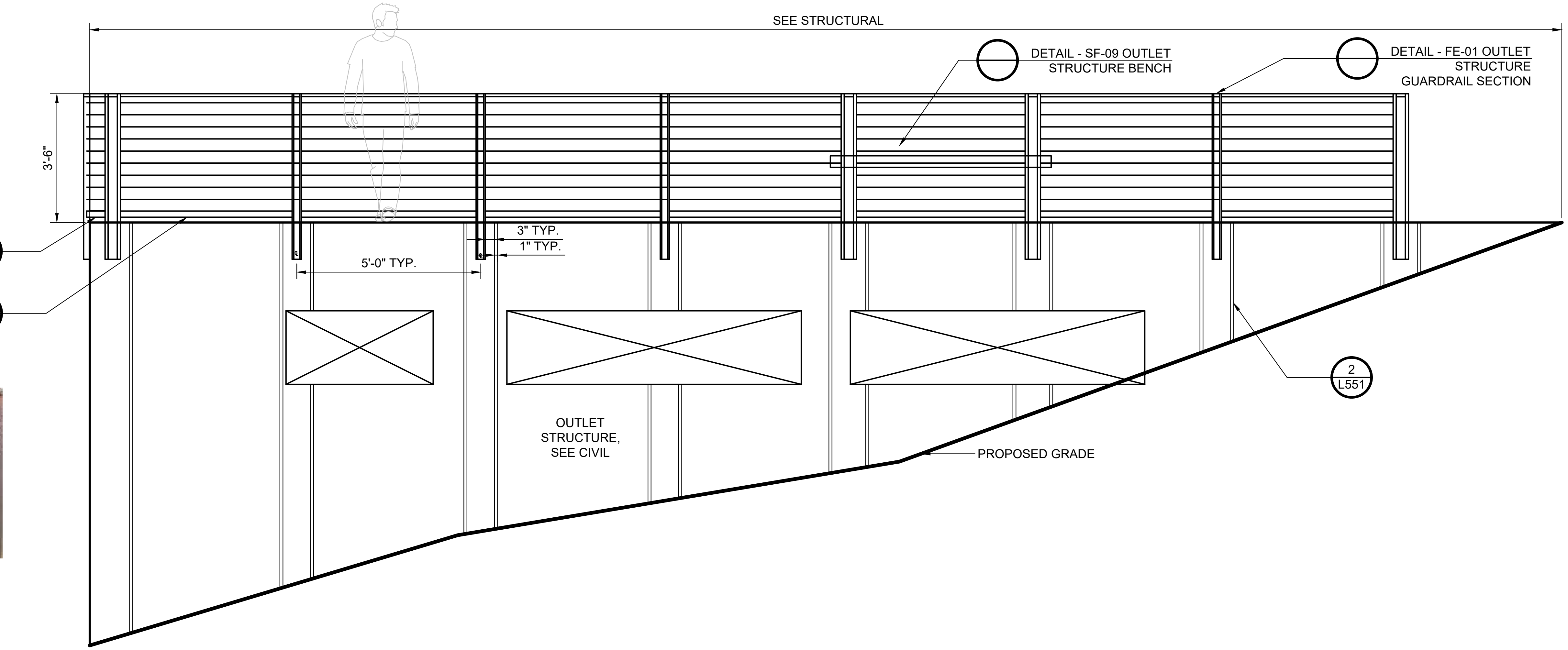
③ PAVEMENT MARKING WITH FLOW ARROWS AND TEXT "TO MINNEHAHA CREEK"



Interpretation + Public Art Opportunities

Water Quality Transect

what elevations will be on outlet structure and how do they relate to storm frequency?



4

Importance of creek to Native American Culture

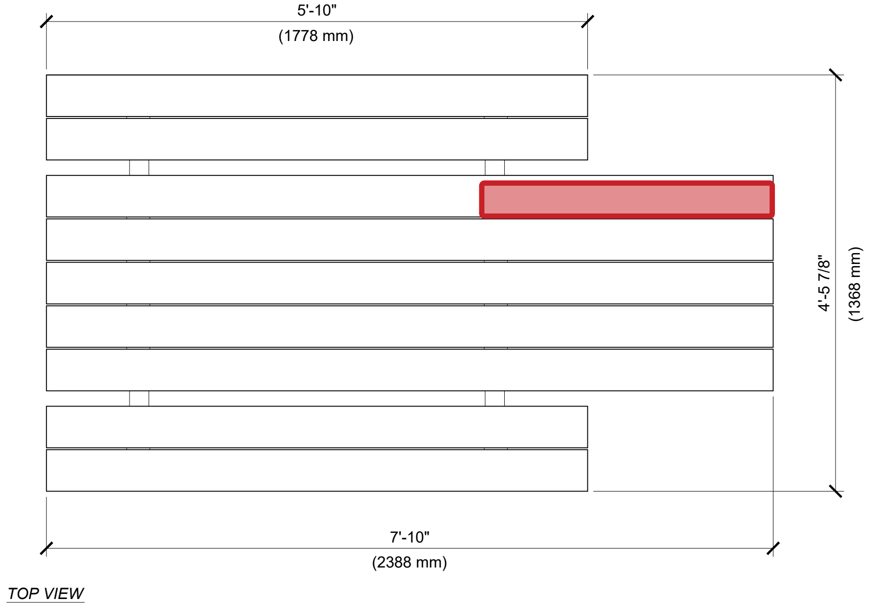
Interpretation + Public Art Opportunities

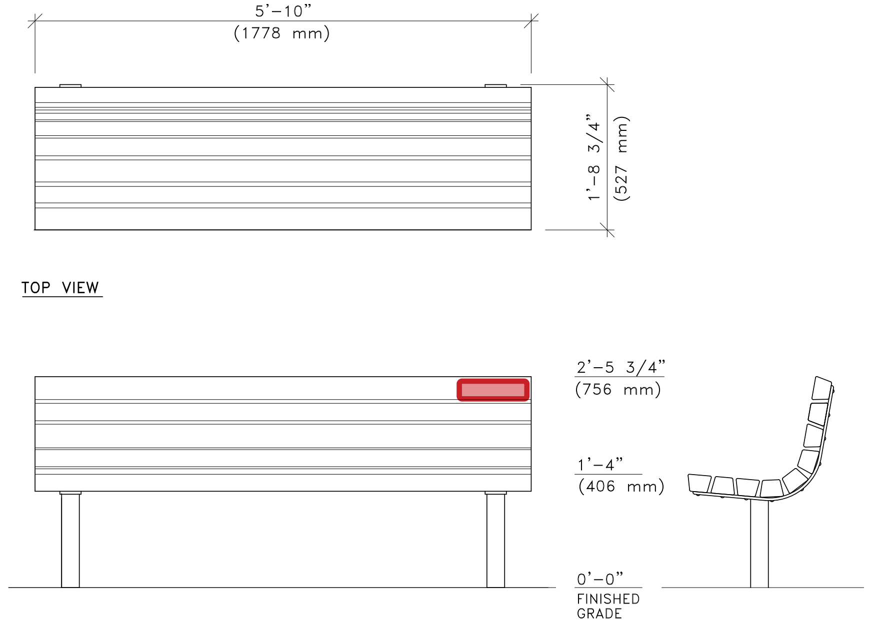
Native American Cultural Connection

“Mnisóta Makhóčhe
Lands where the waters
reflect the skies”

“Mniȟáȟa
~~Waterfall, curling waters”~~

We need to confirm with a translator.





Ecological Enhancement Opportunities

ECOLOGICAL ENHANCEMENTS

① Bat House
② Pollinator Garden
③ Bee House
④ Duck Nesting Area
⑤ Bird House
⑥ Oak Savannah Prairie Plantings

IMAGERY + THEME IDEAS

Sustainable bat houses with informative signage

Natural pollinator plantings to foster native wildlife

Artistic and functional bee houses nestled into the landscape

Duck nesting houses

Bird houses for native and endangered species

Establishment of native oak savanna landscape