Trillium Water Resource Feature Feasibility Study

St. Paul, MN

Design Report

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Prepared for:

Capitol Region Watershed District

Table of Contents

Table of Figures

Table of Tables

1. Executive Summary

A dominant theme in the Capitol Region Watershed District's (CRWD) 2010 Watershed Management Plan is "Bring Water Back to St. Paul." The value of reconnecting the residents of St. Paul with the water resources that flow around them and beneath their streets is reflected in many of the CRWD programs – from education programs that aim to bring water back into the consciousness of people to physical restoration and enhancement initiatives that aim to literally bring streams that have long been buried in storm sewers back to life as flowing streams. Among the specific goals highlighted in the Watershed Management Plan is a goal to "identify opportunities to restore portions of historic streams of the District by providing surface flow where water is currently conveyed through an underground pipe."

The Trillium Nature Sanctuary presents an excellent opportunity to begin realizing this goal and building support for expansion of restoration efforts in the city. This 41 acre site proposed for development into a park space attractive to humans as well as a diverse ecosystem of other species, sits close to the middle of where Trout Brook formerly flowed. Although re-creating the middle reach of a stream can be a challenge, incorporating the new stream as part of a beautiful ecologically rich park will emphasize the value of the vision.

The purposes of the Trillium Site Water Feature Feasibility Study are to determine the best alternatives for bringing water back to the surface at this site and begin to identify and address challenges associated with re-creating a stream in a densely developed watershed. To achieve these purposes, the design team has conducted preliminary analysis and developed preliminary concept drawings of proposed water features to allow the design project to move efficiently into the final park design process.

An important part of the conceptual design process is incorporating input from numerous project partners and interested people. Before the design process began, a workgroup was formed that included representatives from the local neighborhood, City of St. Paul Parks and Recreation and Public Works Departments, Minnesota Department of Transportation, Minnesota Pollution Control Agency, Ramsey County Parks and Recreation, and the Capitol Region Watershed District. An initial kickoff meeting and site visit was held with this workgroup, and four additional meetings were held with the group to discuss project objectives, constraints and alternative designs.

Figure 1.1 – Workgroup Members Visiting the Trillium Site

Some of the challenges associated with daylighting the stream include determining the best source of water to provide flow and determining how to get that water to the site at an elevation that allows it to flow downhill. An analysis of the alternative sources of water was conducted and included several options for routing stormwater runoff from nearby watersheds to the site, options for pumping water from sources at elevations lower than the upstream end of the site, and options for running gravity driven flow through a pipe from sources at higher elevations. Based on this analysis, the project partners concluded that the preferred option is to drain water continuously from Arlington Jackson pond, north of the site, through a pipe that would outlet at the north end of the Trillium site. This water is proposed to be augmented during and after storm events with treated stormwater runoff from the Hatch Agate neighborhood west of the site. If capital funding and/or easements cannot be secured to construct the pipe from Arlington Jackson pond, pumping water from the Trout Brook Storm Sewer Interceptor (TBI) is also a possibility.

Water features proposed on site include a small stream, three stormwater treatment complexes, and an enhanced pond where the Sims Agate stormwater pond is located. The stream will begin at the northern end of the site and is proposed to have a base width on the order of 6 – 7 ft, with a floodplain bench on each side, and options for unpaved footpaths near the stream. Due to site constraints described in detail in this report, the stream will have very mild sinuosity for most of the reach, but will become very sinuous at the lower end of the site before reaching the Sims Agate pond.

Three general areas are proposed to contain stormwater management systems that will be aesthetically subtle and contain diverse treatment elements to maximize pollutant removal. Water will enter the stormwater management systems from the neighborhood west of the site and will pass through a system of settling ponds, filtration systems, and wetlands before entering the stream. Detailed design of these stormwater systems will be conducted during the next stage of site design.

Enhancements at the Sims Agate pond are proposed that will render the pond safer and more attractive for people to recreate near it and make it more attractive to a variety of wildlife. The anticipated result of routing higher quality water from Arlington Jackson pond to this pond and treating stormwater from the Hatch Agate neighborhood prior to entering the Sims Agate pond is greater capacity for ecological function and diversity. Changes to the pond are proposed that will increase habitat quality along with this increased water quality. These enhancements include a broader emergent vegetation zone that will also function as a safety bench to prevent people from accidentally falling into deep areas, greater depth diversity throughout the pond to increase habitat diversity for a variety fish, birds, reptiles, and amphibians.

Concept level construction cost estimates for the most likely source water options and site water feature construction are described, and remaining analysis for the next stage of design is outlined in the later sections of the report.

2. Background Information

The Trillium site is a 41 acre parcel located just north of downtown St. Paul. It is west of Interstate 35 E and bounded by Maryland Avenue to the north, Cayuga Street to the south, the Burlington Northern Santa Fe Railroad to the east, and the Hatch Agate neighborhood to the west. The site is proposed for development into a park space by the City of St. Paul. As part of the park development, re-creation of a daylighted Trout Brook is proposed.

The Inter-Fluve design team gathered and reviewed several documents and data sets describing the history of the Trillium site, plans for natural resource management at the site, contaminated soils, water quality of potential water sources, and state regulations that may affect activities on the site and/or provide context for some of the environmental quality data.

2.1. Site History and Soil Quality

The Trillium site was used as a rail yard for the Northern Pacific Railroad and contained tracks for two major rail routes. To serve these functions, the Trout Brook floodplain valley was filled and terraced. The site was used as a soil storage area from approximately the mid 1990s to 2001 (Braun Intertec, 2003) and there is evidence of uncontrolled dumping on the site. The native sandy soils on the site were covered by several feet of fine to medium grained sand and silt, with asphalt, wood debris, concrete and other materials of unknown origin. On the southern end of the site, a large stormwater pond was constructed which captures stormwater from approximately 150 acres of primarily urban residential land.

Due to the land use history of the site, there are elevated concentrations of some contaminants in the soils on the site. In 2003 and 2004, Phase I and Phase II Environmental Site Assessments were completed (Braun Intertec, 2003 and 2004a). The study reported a depth to bedrock of 150 – 200 ft and depth to water table of approximately 20 ft. The review of potential sources of contamination included identification of 4 hazardous waste activity sites registered under the Resource Conservation and Recovery Act (RCRA) within a mile of the site, 3 MN Voluntary Investigation Cleanup (VIC or SCL) sites within half a mile of the site, 9 Leaking Underground Storage Tank (LUST) sites within half a mile of the site, and 1 Underground Storage Tank (UST) located adjacent to the site.

During the Phase II assessment, 9 borings and 21 test pits that ranged from 8-17 feet deep were dug to evaluate depth and type of fill material and the chemical composition of the soils (see Figure 2.1). The analysis was conducted for a sample taken from the location in the boring with the highest organic vapor content or where staining or odors were encountered. Therefore, the test results are likely biased toward the higher end of the contamination range for each location, and do not reflect an average contaminant content. Samples were analyzed for volatile organic compounds (VOCs), gasoline range organics (GRO), diesel range organics (DRO), metals, polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs). Contaminant concentrations were compared to the MPCA Tier 2 Recreational Human Health Based Soil Reference Values (SRVs).

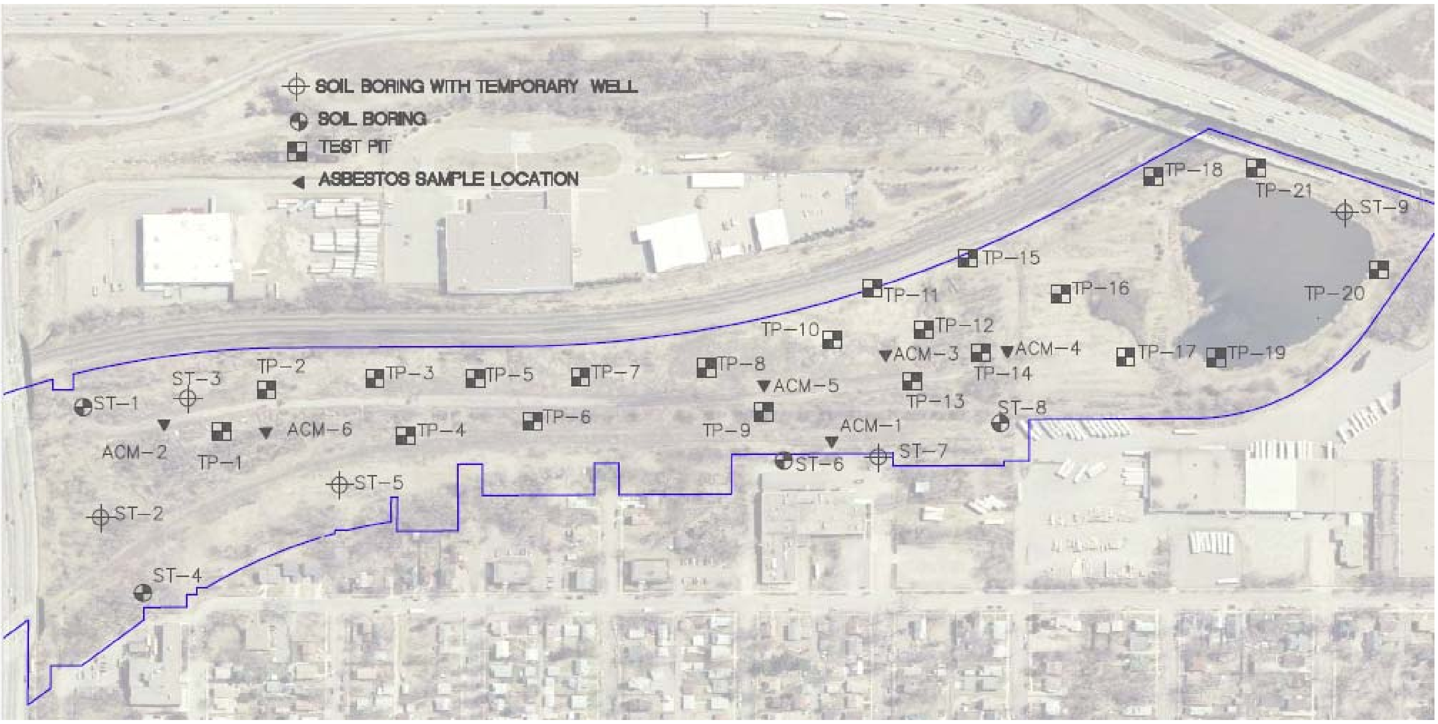


Figure 2.1 – Location of Soil and Well Test Locations.

The results of the analysis showed that samples from three borings and five test pits contained contaminant concentrations that exceeded the SRV for either arsenic or mercury (Table 2.1). No other SRVs were exceeded. Some samples contained detectable levels of gasoline range and diesel range organics, but there are no established SRVs for these contaminant groups.

Table 2.1 – Soil Reference Value (SRV) Exceedances

Sample	Depth of Sample	Contaminant	Concentration (mg/kg)	SRV (mg/kg)
ST-1	10 ft	Arsenic	24	12
ST-3	5 ft	Arsenic	21	12
ST-9	7.5 ft	Arsenic	22	12
TP-3	2 - 3 ft	Arsenic	37	12
TP-13	2 - 5 ft	Arsenic	16	12
TP-16	3 – 8 ft	Arsenic	39	12
TP-18	4 – 7 ft	Mercury	13	1.5
TP-21	0 – 4 ft	Arsenic	17	12

Additionally, DRO and/or GRO levels exceeded 10 mg/kg at ST-1, ST-2, ST-8, TP-3, TP-13, TP-16, TP-17, TP-18, and TP-21. At TP-16 DRO was reported at 110 mg/kg, and at TP-21 DRO was reported at 2200 mg/kg. Although there is no SRV established for these groups of contaminants, the MPCA guidance indicates that material that exceeds 10 mg/kg does not qualify as "unregulated fill" and therefore, reuse of this material off-site would require mixing with and/or capping with clean fill prior to reuse. Soils that have petroleum contamination that exceeds 200 ppm must be disposed or treated at an approved off-site facility.

During the Phase II assessment, six samples of asphalt shingles and tar roofing material found on site were analyzed to determine asbestos content, but no asbestos was detected.

2.2. Trillium Site Natural Resources

In 2004 a Natural Resource Management Plan was developed for the Trillium site (EOR, 2004). Objectives were identified for the site during this planning process and included visitor use, restoration of several different upland communities, construction of a stream that could accommodate a base flow of 1-2 cfs and storm flows from the adjacent neighborhood that are not conveyed by the existing storm sewer network. The plan also included a set of natural resources issues, concerns, and recommendations. These issues were also discussed and refined as part of this feasibility study during the first workgroup meeting, as described in Section 3 of this report. The recommendations identified in the 2004 plan remain very relevant because they are specifically referenced in a conservation easement agreement that dictates activities that may and may not be conducted within the easement, which contains the eastern portion of the site (see Existing Conditions sheet of Appendix G).

The existing vegetation on the Trillium site is described in detail in the Natural Resource Management Plan. Nine vegetation communities/land descriptions were identified on the site, including:

- Lowland Hardwood Forest
- Disturbed Deciduous Woodland
- Old Field
- Old Field/Abandoned Railroad Grade
- Woodland/Old Field
- Cattail Marsh
- Soil Stockpile Site
- Oak Woodland
- Old Field-Brushland

Vegetation and wildlife species lists were also developed for the site with identification of the community types in which each species was found. A list of threatened species and species of concern that may be present on site is also included.

2.3. Water

Capitol Region Watershed District collects water quality and flow data at multiple locations within the Trout Brook watershed and has reported the results of this monitoring effort annually since 2005 (CRWD, 2010 and preceding reports). In 2009, there were 9 sites at which both water quality and flow were monitored, 2 sites at which only flow was monitored, and 4 stormwater ponds at which water levels were monitored. Water quality data collected included nutrients, suspended sediment, metals, and bacteria. Both baseflow and stormflow quality was monitored. The data most relevant to this study is that which represents water quality and available quantity of potential sources for the recreated Trout Brook, including the West Branch of Trout Brook, which is regularly monitored; Sims Agate and Arlington Jackson Ponds, for which data is limited; and runoff from the Hatch Agate neighborhood, for which data from a similar watershed will be used to approximate the quality. The analysis of the quality of these sources of water is presented in Section 4.3 of this report.

Braun Intertec (2004) installed temporary groundwater monitoring wells at five of their soil boring locations – ST-2, ST-3, ST-5, ST-7, and ST-9 (See Figure 2.1). Groundwater was encountered at depths from 6 to 28 ft below the ground surface. Samples from each well were analyzed for VOCs, PAHs, GRO, DRO, and dissolved metals. Some samples contained detectable concentrations of organics and metals, but all concentrations were below the Health Risk Limit (HRL) and EPA's drinking water Maximum Contaminant Level (MCL). DRO was recorded at 110 μg/L.

According to the 1987 Jackson/Magnolia soil boring reports completed by BRAUN, the groundwater elevations at borings closest to the project site were approximately 771 at that time. The Minnesota Well Index for well # 243197 (just northwest of the site at address 45 Maryland Ave. E) shows a static groundwater level of 780 while well # 255721 (just west of Sims/Agate Pond and I-35E at the Advance Corporation) shows a static groundwater level at 785.

2.4. Future Development Plans

In addition to the Natural Resource Management Plan, other information associated with plans for the Trillium site and the surrounding region were reviewed to ensure that proposed water features do not conflict with other needs at the site. The Trout Brook Regional Trail Master Plan (City of Saint Paul Parks and Recreation Design Section, 2009) describes a regional bicycle and walking trail that will extend from Lake McCarrons County Park to the Lower Phalen Creek Valley area. The trail will follow the abandoned Canadian Pacific/Soo Line (CPSL) Railroad right of way south of Arlington Jackson Pond and continue along the path of the abandoned railroad along the western portion of the Trillium site.

This proposed alignment of the regional trail is also reflected in the most recent Trillium Nature Sanctuary Master Plan. The site master plan further shows an unpaved walking loop trail that extends through the eastern portion of the site. Proposed vegetation community zones, overlook points, and connections to the adjacent neighborhood were also developed as part of that site plan. (Figure 2.2)

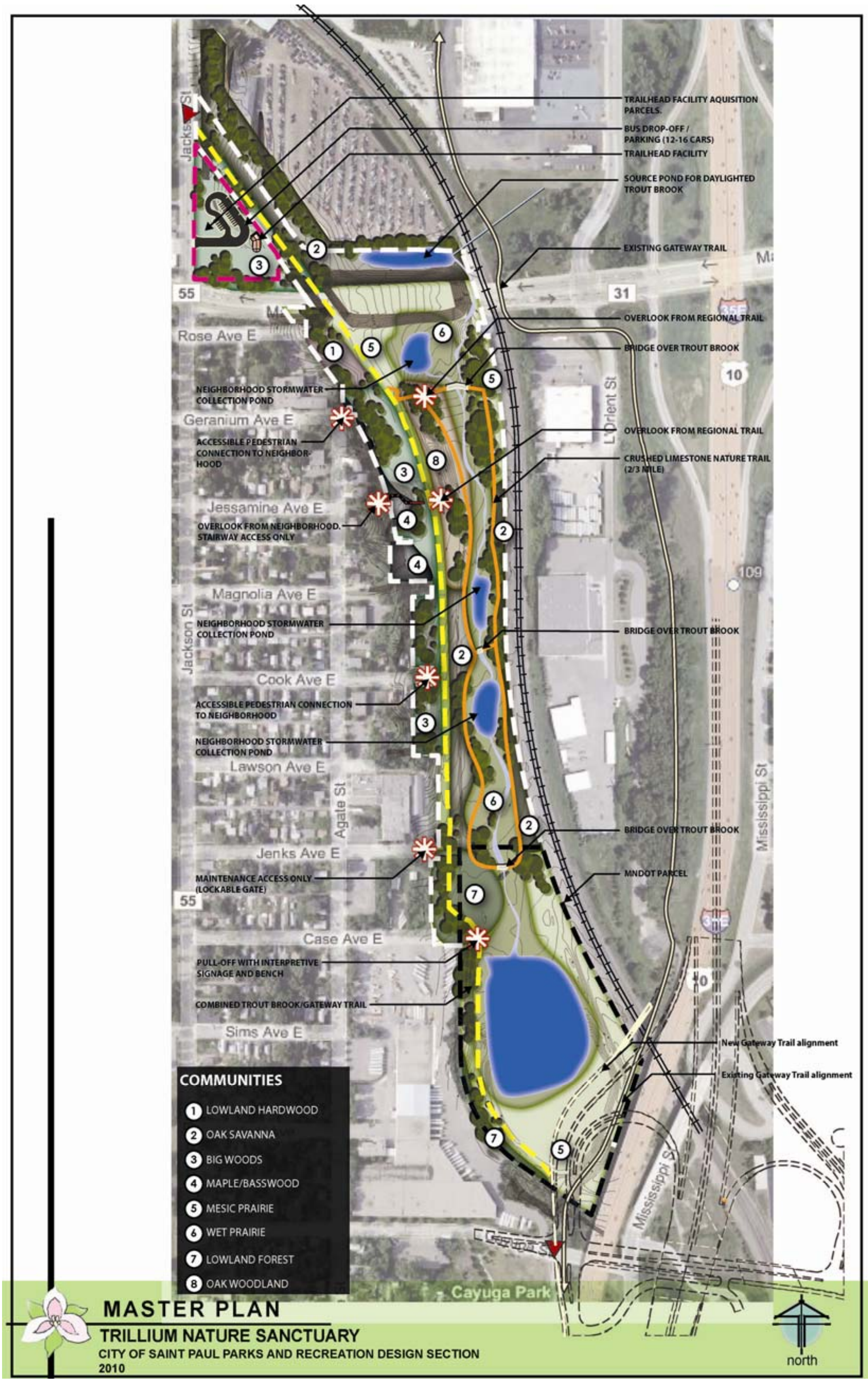


Figure 2.2 – 2010 Trillium Nature Sanctuary Master Plan (courtesy of City of St Paul Parks and Recreation)

3. Design Criteria

To ensure that the design meets the needs and expectations of the project partners, we established a set of design criteria to inform design decisions and review throughout the design process. At the kickoff meeting for this feasibility study, workgroup participants identified objectives for the Trillium site. The project team intentionally did not limit the scope of the discussion to the scope of the Trillium Site Water Feature Feasibility Study to ensure that all objectives for the site were understood. After the meeting, each objective was evaluated to determine the relevance to the scope of the feasibility study. For those objectives that do have implications for the feasibility study, design criteria for the feasibility study and preliminary design were developed. These objectives and design criteria were grouped into issue areas. For those objectives that do not have significant implications for the feasibility study, specific design criteria were not developed at this time.

The objectives and criteria relevant to this study are summarized in Table 3.1. The full set of objectives and criteria discussed with the workgroup are attached as Appendix A.

Table 3.1 – Objectives and Design Criteria

Issue Area	Objective	Criteria
Stream Ecology	1. Create a stream that is as nature-like as possible.	1.1: Stream channel geometry will mimic channel geometry typical for a more natural stream in this region and will be adaptable to variable flow conditions including short term storm flows and long term increases due to expansion of the channel and watershed to ensure nature-like conditions in the future
		1.2: Hydrologic and hydraulic conditions in the channel will be sufficient to support some native fish, macroinvertebrates and wildlife that are appropriate for riverine systems.
	2. Create a stream that supports aquatic life.	2.1: The recommendation regarding water sources will include consideration of water quality.
		2.2: Given the anticipated conditions, including available water quality and quantity and contiguous size of the resource available in the short and long terms, aquatic life communities and species will be identified that can thrive.
	3. Create a stream and riparian corridor connecting Lake McCarrons and the Mississippi River.	3.1: Stream channel geometry (bed elevation, channel shape, planform, etc) through the Trillium site will be consistent with the vision for upstream and downstream expansion.
		3.2: The site plan will allow for increased flows that result from project expansion. The increased flows considered will be consistent with results of analytical results of flow availability.
Stormwater Management	4. Treat stormwater to improve water quality such that it meets criteria for human contact and aquatic life use to the extent achievable given cost constraints and technology limitations.	4.1: Preliminary analysis and design will include stormwater BMPs to treat runoff from the neighborhood located to the west of the site. If feasible, treatment will be sufficient to achieve water quality criteria appropriate for recreation and aquatic life in the stream.
	5. Utilize stormwater runoff as stream flow.	5.1: The preliminary design will include use of stormwater to provide flow to the stream on the site to the extent practical.
		5.2: The preliminary design will ensure that storm flows in excess of flow rates desired for the water feature will remain in existing conveyance system including existing storm sewer pipes and existing overland flow routes.
	6. Control erosion along hillside due to runoff from streets.	6.1: The stormwater treatment and conveyance elements proposed for the site will be preliminarily designed to minimize risk of erosion, particularly along the slope on the west side of the site.
Wetland and Upland Ecology	7. Create habitat that supports multiple vegetation communities, a variety of fish and wildlife, especially bird life, including ducks.	7.1: Analysis and preliminary design of the water features will include habitat recommendations for fish and wildlife, including birds.

Issue Area	Objective	Criteria
Wetland and Upland Ecology (continued)	8. Remediate contaminated soils on site as necessary to minimize risks to people and other organisms.	8.1: The study and preliminary design will be compatible with potential need for soil remediation on the site and consistent with all relevant Response Action and Construction Contingency Plans that have been developed for the site.
	9. Create a natural greenway corridor from the Mississippi River to Lake McCarrons.	9.1: Analysis and preliminary design of the water features will include provision for diverse wetland, pond, and riparian communities that are compatible with the long term vision of establishing a diverse greenway from the Mississippi River to Lake McCarrons.
Education, Recreation and Aesthetics	10. Provide a bike and pedestrian trail onsite that is linked to the regional trail system.	10.1: The preliminary analysis and design will ensure that adequate and appropriately located space is available to create a trail on site that can be connected to other trails off site.
	11. Provide attractive, managed views both within the site and of the site from the adjacent neighborhood and regional trail.	11.1: To the extent possible without compromising water feature function, the preliminary design will incorporate flexibility with respect to vegetation types and heights to ensure compatibility with the desire to maintain viewscapes
		11.2: To the extent practical and allowable, the preliminary water features design will be compatible with potential buffers between the usable areas of the site and the railroad tracks and highway I35E to protect views and reduce noise.
	12. Provide access to water features with bridges over the stream and boardwalks through wetlands.	12.1: Through the design process, consideration will be given to the compatibility of stream crossings and wetland boardwalks with the conservation easement restrictions and other site restrictions. Locations will be identified that may be appropriate for such access features.
	13. Minimize mosquito population.	13.1: Site water features will be designed to maximize the duration of flowing water, to the extent practical, to minimize availability of stagnant water that is conducive to mosquito reproduction.
		13.2: Site water features will be designed to include suitable habitat for mosquito predators.
Operation and Maintenance	14: Create a sustainable design that minimizes maintenance and pumping.	14.1: Operation and maintenance requirements, including pumping, will be included in assessment of all source water alternatives.
	15. Ensure that access is sufficient to perform all maintenance and monitoring.	15.1: The preliminary design will ensure that all water features that will require maintenance are accessible by the necessary maintenance equipment.
General	16. Establish a model for multi-partner cooperation in creating an amenity that all partners can declare successful.	16.1: The analysis and design process will incorporate input from all partners involved.
	17. Ensure that partners understand potential water related regulatory implications of alternatives considered.	17.1: Minnesota Pollution Control Agency (MPCA) staff will be consulted during the feasibility study. Short and long term regulatory implications of the design alternatives will be documented based on the information MPCA provides. Information about the proposed project will be provided to MPCA for their consideration as they modify their standards.

4. Source Water Alternatives

The Trillium Site Natural Resource Management Plan (EOR, 2004) included identification of three primary alternative water sources for the daylighted Trout Brook:

- Runoff harvesting from adjacent subwatershed areas,
- Gravity pipe connection from the Trout Brook Interceptor (TBI),
- Gravity pipe connection from Arlington/Jackson Pond, and
- Pumping options from TBI or Sims/Agate Pond.

The source water analysis in this feasibility study expands on those alternatives and details costs, benefits, and construction considerations of the practical alternatives.

4.1. Methods and Approach

Datum. This study was completed in North American Vertical Datum of 1988 (NAVD88). Available data that referenced the St. Paul datum data was converted to NAVD88 by adding 694.26 ft to all elevations.

Climate and Hydrology. The Minneapolis-St. Paul International Airport (gage #215435) and the National Weather Station gage # 217377 were chosen as the sources for historical precipitation and evapotranspiration data. The airport gage site is approximately 8.75 miles southwest of the Trillium project site, and has the longest period of records available. The National Weather Station gage is located approximately 1 mile south east of the project site. Hourly precipitation data from 1985 to 2010 and potential evapotranspiration (PET) from 1990 to 2010 were included in our analysis. Daily PET rates were based on recorded weather parameters including temperature, dew point, relative humidity, and wind speed measured at the gage site. Further manipulation of this data set was completed to translate PET (maximum atmospheric capacity to evaporate available water) into an estimated actual evaporation rate. Since XPSWMM version 12.2 is incapable of incorporating a daily evapotranspiration (ET) interface file, 21 years of daily ET values were averaged by month over the entire record frame and were applied to the 25 years simulated.

The design team utilized an existing TBI draft XPSWMM model provided by CRWD, which includes the Horton infiltration method with inputs previously deemed reflective of each sub-watershed area. Site survey and sewer data were obtained from CRWD and the City of St. Paul. CRWD also supplied TBI West Branch discharge data, Arlington/Jackson Pond elevation data, rain gage data, and water quality data. St. Paul Regional Water Services supplied average discharge data from their facility.

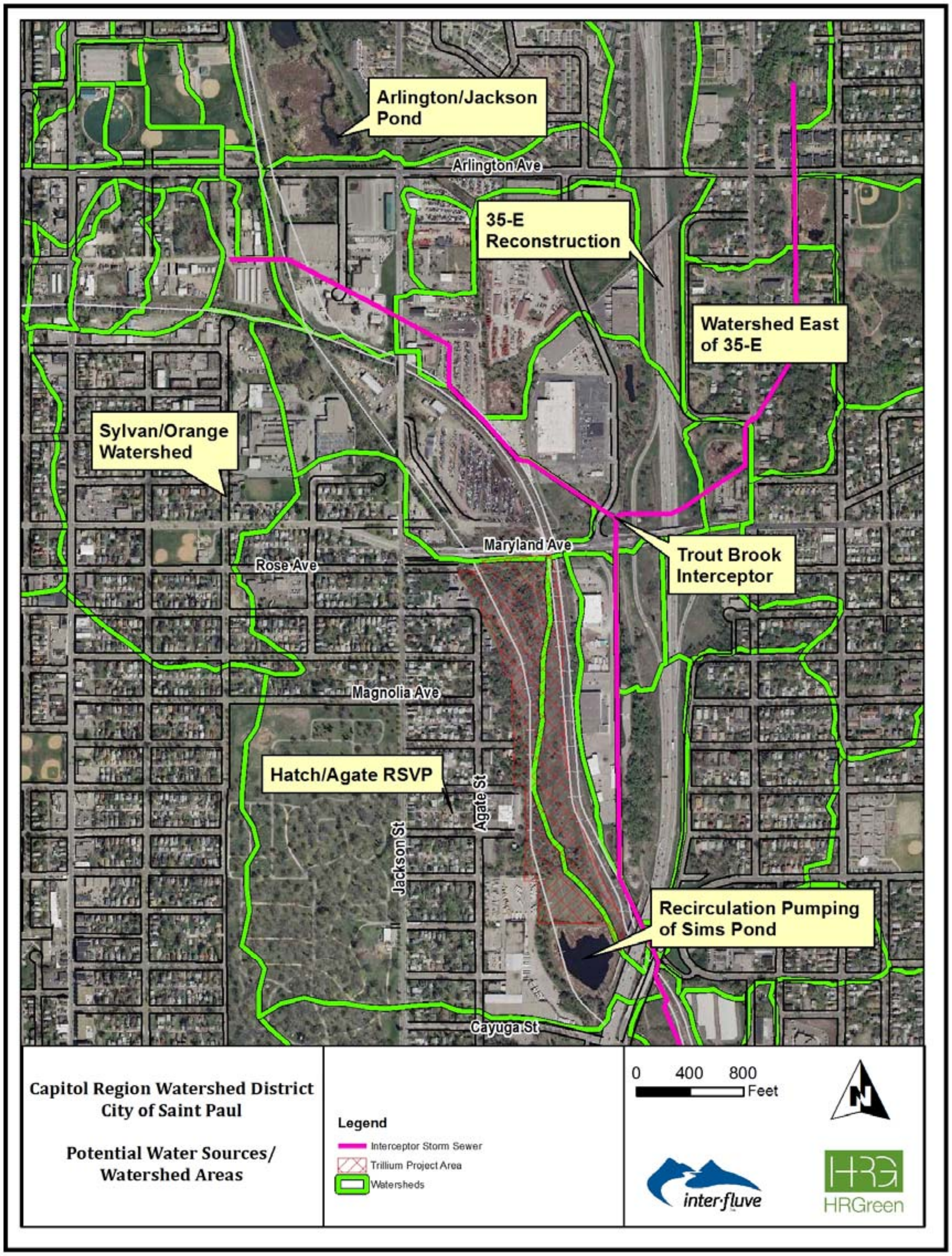


Figure 4.1 – Potential Water Sources for Trillium

Spatial Water Budget Analysis. A spatial water budget analysis was performed for the Hatch/Agate RSVP Area as well as for the Interstate 35-E (I-35E) Option. A spatial water budget was not completed for the-Sylvan Orange area. If water harvesting from the initial two sites were able to achieve 80% of the required flow, then additional analysis of the Sylvan Orange area would be warranted.

A continuous simulation XPSWMM model was developed to determine the average surface flow values for the sources surrounding the Trillium project site. The developed model incorporated some of the applicable direct inputs from the existing TBI draft XPSWMM model provided by CRWD. This simulation incorporated historical hourly precipitation and monthly averaged evapotranspiration data from 1985 to 2010 as described above.

The model included the sub-watershed comprising the Hatch/Agate RSVP area, the I-35E sub-watershed extending from the Hwy 36/I-35E interchange to 1500' south of Maryland Avenue and the sub-watersheds located between the I-35E sub-watershed and the Trillium site (Figure 4.2). The Spatial Water Budget model incorporated the previously calibrated hydrologic characteristics defined in the existing TBI model. However, to account for applicable areas which can drain to the project site, two watersheds found in the TBI model were delineated into smaller sub-watershed areas. The nomenclature relationship between the two models and the hydrologic characteristics used in the Spatial Water Budget model are shown in Table B1 in Appendix B. For preliminary design purposes, it was assumed that sub-watersheds TRT14_A through D and TRT14_12D, have the same infiltration characteristics of the TRT14 sub-watershed included in the TBI model. However, other characteristics such as sub-watershed area, average slope, width and percent impervious were calculated specifically for each sub-watershed.

A preliminary hydraulic network was built from the northern most sub-watershed along the I-35E corridor (TRT28) to the southern project limits at the Sims Agate Pond. Two existing stormwater ponds, one nearest the southern limits of TRT39 and one representing the Sims/Agate pond at node TRT14_12D were included in the model. Pond stage storage information was directly incorporated from the TBI model. ET parameters described previously were also included in the hydraulic calculations. This was included to account for water losses for the two ponds modeled. It was assumed infiltration losses for all hydraulic features are insignificant.

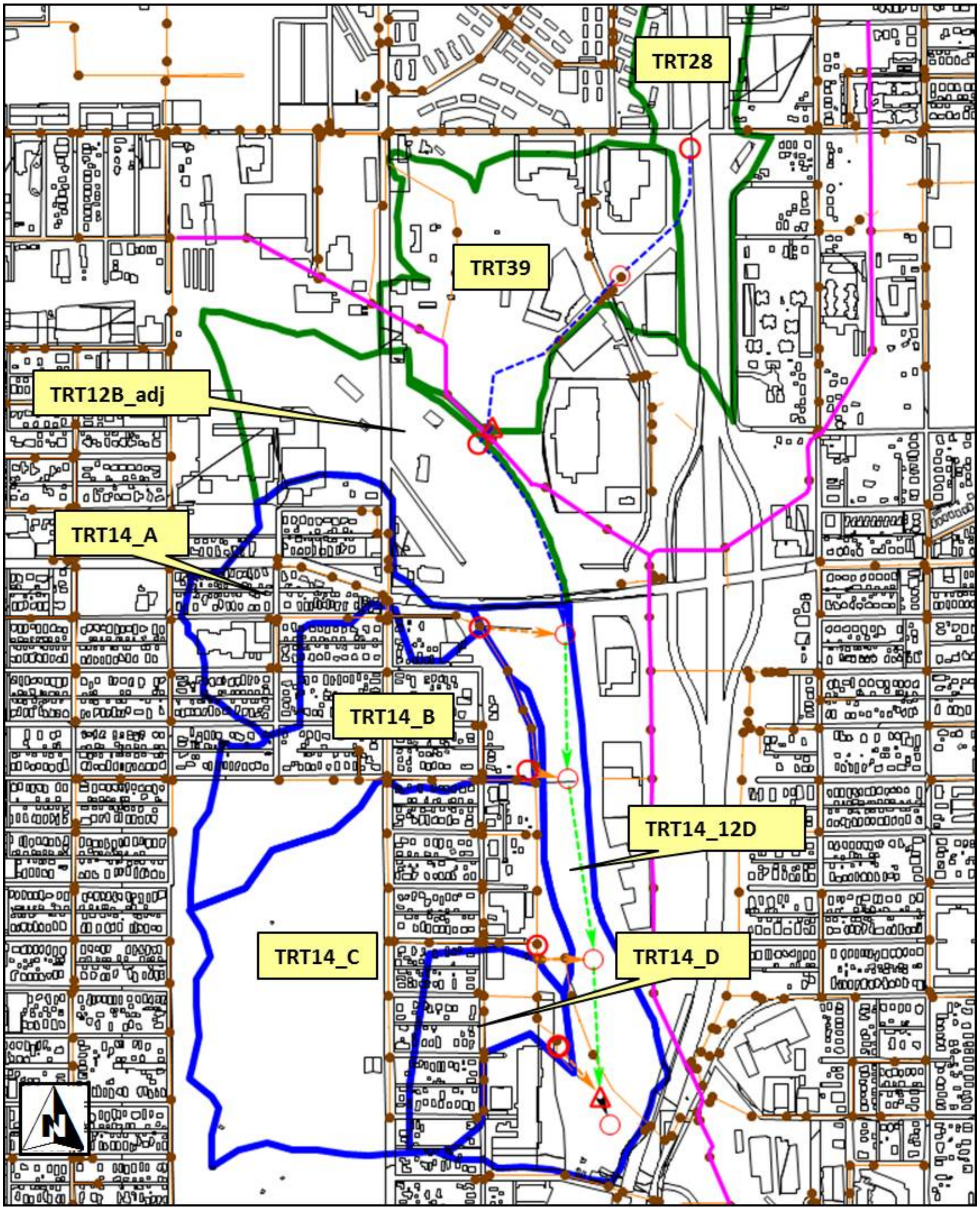


Figure 4.2 – Network configuration showing sub-watershed boundaries (Hatch Agate RSVP shown as solid blue lines, I-35E to Project site shown as solid green lines) and potential outfall (orange dashed lines). Green dashed line represents proposed stream.

Stormwater Treatment. Hatch/Agate RSVP area stormwater runoff routed to the stream will need to be treated to meet CRWD standards and stream water quality requirements. According to CRWD rules, the RSVP reconstruction will be required to meet volume reduction and water quality improvement goals. To ensure that adequate space is reserved, stormwater treatment elements were approximated at this stage to target CRWD's runoff volume retention requirements. Required storage volumes were based on the one inch and two inch rainfall applied over the entire impervious and Hatch/Agate RSVP sub-watershed areas (TRT14A- C), respectively. The one inch volume utilized a roughness coefficient of 0.9 while the two inch computation utilized a coefficient of 0.5. Results of the stormwater treatment analysis are described in Section 5.4.

4.2. Water Sources

The water sources being considered fall under three categories. The first category is direct rainfall harvesting - stormwater that runs off nearby watersheds is conveyed to the Trillium site. Routed stormwater will be filtered and treated within a series of proposed storage facilities with outflow discharge rates metered before entering the proposed stream. The second category is a TBI gravity connection, where a portion of the flow in the interceptor is diverted and conveyed via gravity storm sewer to the Trillium site. The third category is pumping from the TBI or Sims Agate Pond.

4.2.1. Direct Rainfall Sources

The direct rainfall harvesting option includes capture, storage and slow discharge of stormwater from nearby watersheds. Four general areas were considered for stormwater harvesting:

- The Hatch Agate neighborhood just west of the site,
- The watershed that contains the portion of Interstate 35 E (I-35E) scheduled for reconstruction in 2015,
- The Sylvan Orange neighborhood north and west of the site, and
- The watershed north and east of the I-35E watershed.

The Hatch Agate neighborhood is scheduled for comprehensive street improvements associated with the Residential Street Vitality Program (RSVP), which may offer some efficiency with respect to storm sewer retrofits.

Hatch/Agate RSVP Drainage Area Source

Hatch/Agate RSVP Area is a neighborhood that is west of the project area. The stormwater from this area could be routed to the project site with relative ease. There are three locations along existing stormsewers from which a portion of storm flows could be routed to the site through a series of stormwater treatment elements to improve water quality and reduce peak flows before entering the stream.

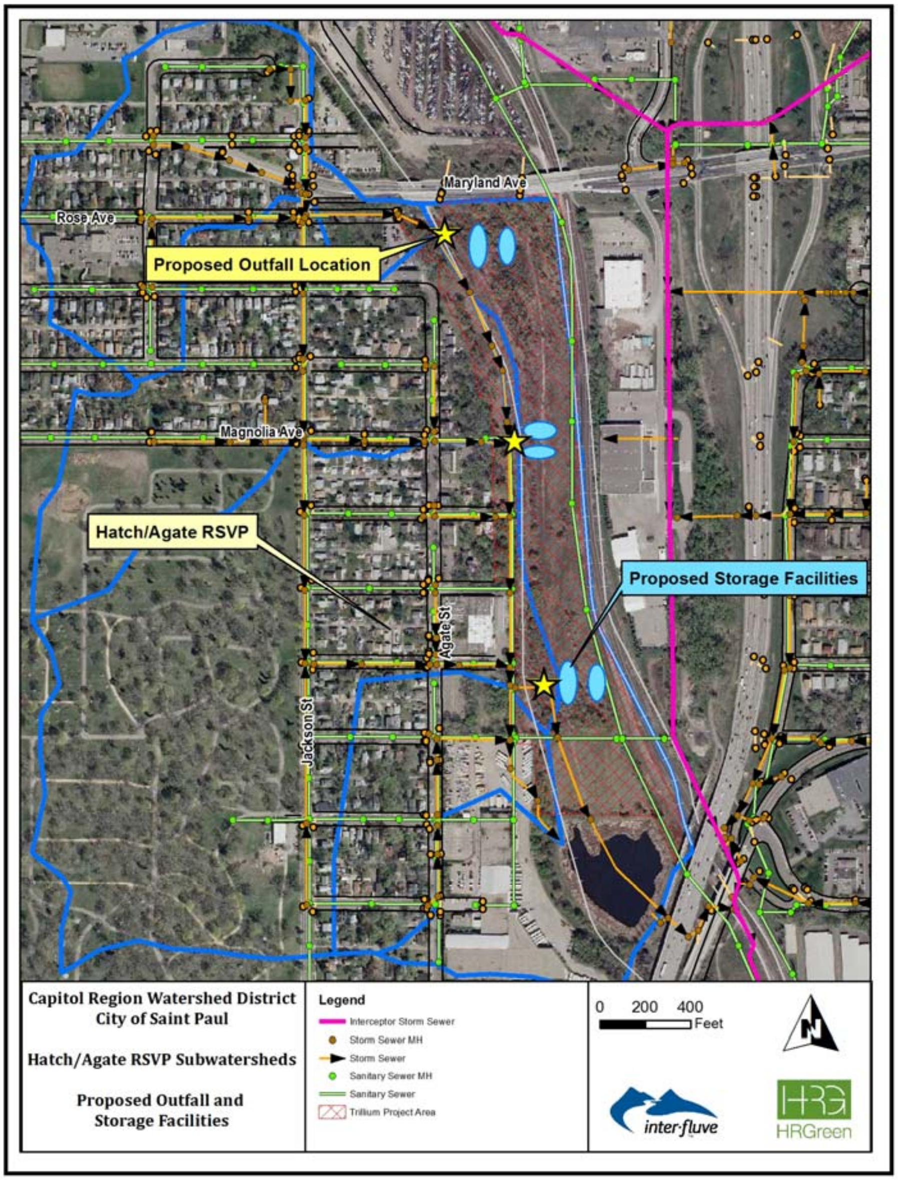


Figure 4.3 – Hatch/Agate RSVP Watershed and Potential Outfall Locations

The spatial water budget model provided flow values to assess the potential to harvest rainwater from adjacent watersheds to meet the desired baseflow criteria in the proposed stream. The model output parameters included statistics on the volume, average daily runoff flow, average runoff per event, peak runoff per event, storm event duration (wet time) and inter-event duration (dry time). A summary table of pertinent statistical values for each sub-watershed is shown in Table B2. Based on the model evaluation, it was determined that the mean runoff calculated from the 1985 to 2010 data set from the northern Hatch/Agate sub-watersheds (TRT14A - C) that could be directed via gravity to the head of a proposed stream during storm events would be 0.8 cfs per event (i.e. average runoff rate for all storm events). Although the average event-runoff meets the criteria baseflow, it does not account for dry periods. When considering both wet and dry days in mean flow computations over the 25 years period of study, the model results indicated that local runoff from the RSVP area would only generate an average flow of 0.11 cfs. Therefore, to provide a continuous baseflow of 0.5 cfs, a watershed 5 times the size of the Hatch Agate sub-watersheds TRT14A-C, or 750 acres, would be required.

The team also analyzed how much water should be stored to maintain a baseflow between rainfall events. The inter-event duration (i.e. dry time between storms) was determined from 21 years of daily precipitation data from gage # 217377. The data set was adjusted to only include rainfall data between the non-winter days defined as April 1st through November 30th. "Winter" precipitation was purged from the data set. Statistics were compiled for select daily rainfall events with a minimum rainfall depth recorded. The inter-event durations for a minimum rainfall depth of 0.25, 0.50, 0.75 and 1.0 inches are shown in Table B3 and Figure B1 (Appendix B). The mean inter-event dry period for the 0.25-inch storm event is approximately 6 days. To maintain 0.5 cfs of flow during 6 days of no rainfall, the proposed design would require 6 acre-feet of stormwater storage. Therefore, in addition to requiring a much larger watershed, a large volume of storage would be needed to supply continuous baseflow to the Trillium site.

I-35E Drainage Area Source

The watersheds that are north of Arlington Avenue and slope towards the I-35 E right-of-way drain approximately 233 acres. Stormwater from this area could be routed from the crossing to the project site, as shown in Figure 4.4.

The alignment would extend along an existing trail easement, utilize some existing storm sewer, and discharge to an existing pond. The pipe alignment would need to cross under the BNSF Railroad and over the TBI. An approximate profile of this alignment is shown in Figure 4.5.

One of the constraints in delivering water via gravity from the I-35E reconstruction area to the Trillium site is ensuring adequate slope, particularly between the existing pond and the upstream end of the proposed stream on the Trillium site. The TBI model indicates that the outlet elevation for the pond outfall structure is 802.16. If this sub-watershed will be included as a water source for the stream on the project site, this outlet elevation would control the most upstream bed elevation of the stream. For all conceptually proposed storm sewers from I-35E to the project site, a pipe slope of 0.5% was utilized to allow the pipe to daylight at elevation 795, similar to the Arlington/Jackson alternatives.

Because the TRT28 sub-watershed drains from north to south, the southernmost portion of the sub-watershed cannot be directed to the Trillium project site. The depth of proposed storm sewer varies between 15 to 25 feet to complete the proposed connection.

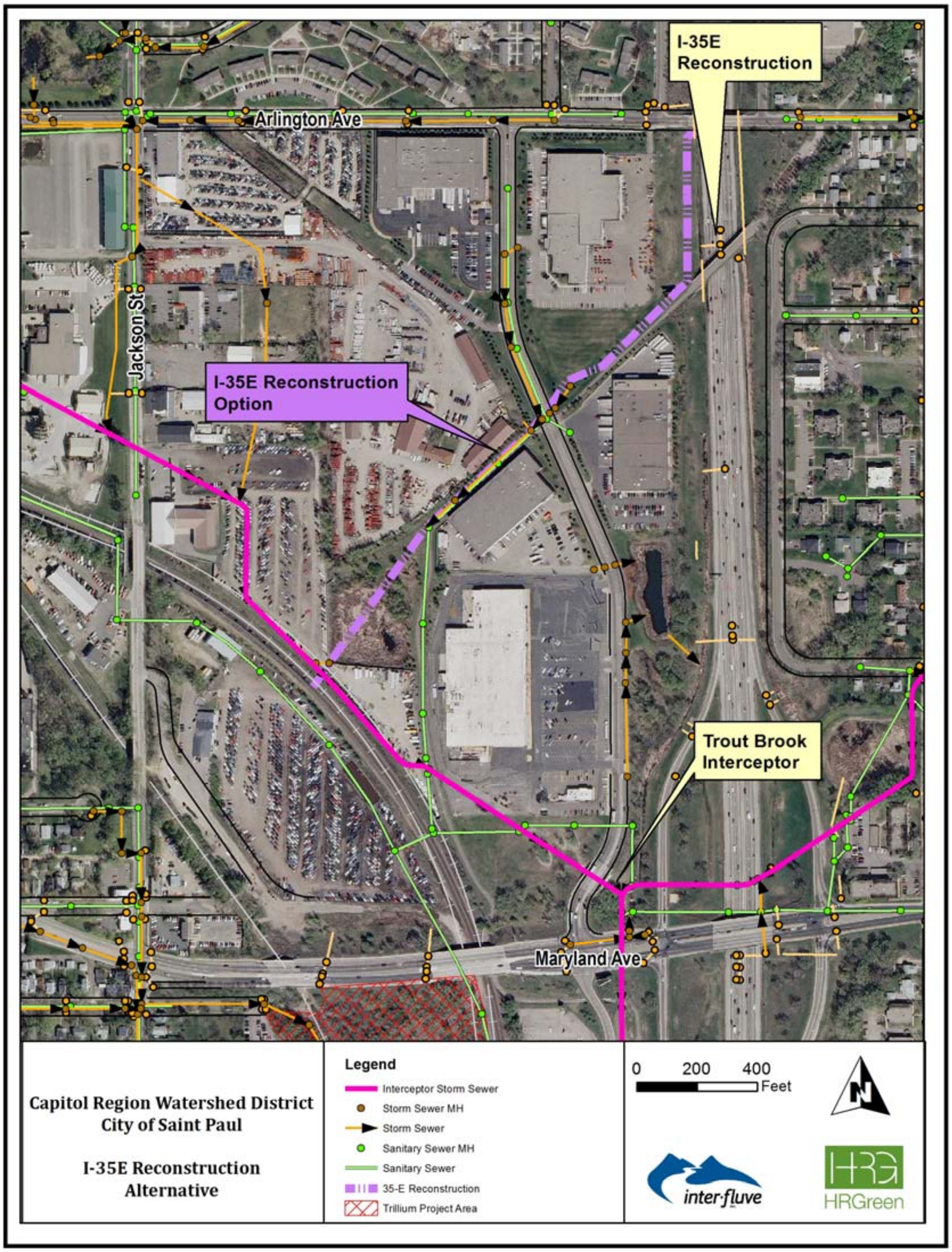


Figure 4.4 – 35-E Reconstruction Alternative showing alignment (purple), sanitary sewer (green), storm sewers (orange) and TBI (pink)

The I-35E watershed area (TRT28) plus the watershed area from I-35E to the site (TRT39 and TRT12B_adj) provides a mean total volume of 4.4 ac-ft for all storm events and a mean flow of 3.4 cfs based on the 1985 to 2010 data set. Based on the storage requirement to maintain even a 0.5 cfs stream flow, the spatial analysis indicated that this option could not supply the continuous flow desired.

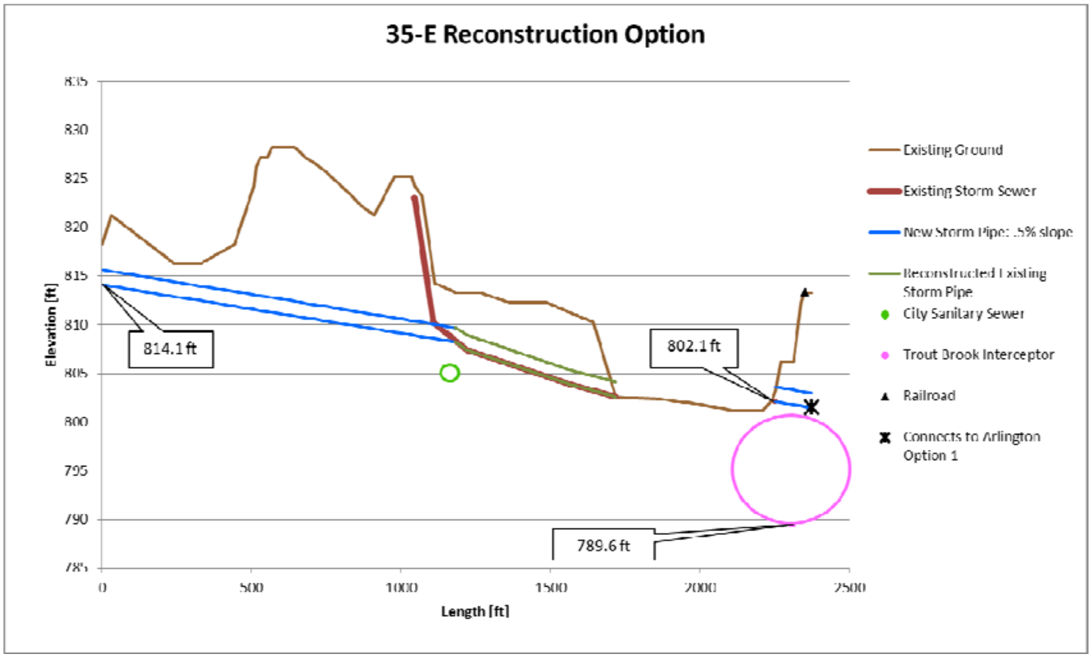


Figure 4.5 – 35-E Reconstruction Alignment

Sylvan/Orange Area

The watersheds to the north and west of the Trillium site were considered possible sources of stormwater. There are three different options to bring stormwater from the west watersheds that involve connecting to existing storm sewers and placing a weir to redirect the flow. They are shown in Figure 4.6

Sylvan/Orange Option #1

Option #1would require connecting to the existing storm sewer pipe located at the end of Ivy Street where it intersects with Sylvan Street. The existing invert elevation is 816.9 ft. The alignment would go north until it reaches the railroad and then east where it could follow the same alignment as any of the Arlington/Jackson alternatives.

Sylvan/Orange Option #2

Option #2 would intersect TBI at an elevation of 808.25 feet, where Sylvan Street meets West Cottage Avenue, which would require full connection to the TBI similar to the Arlington/Jackson options.

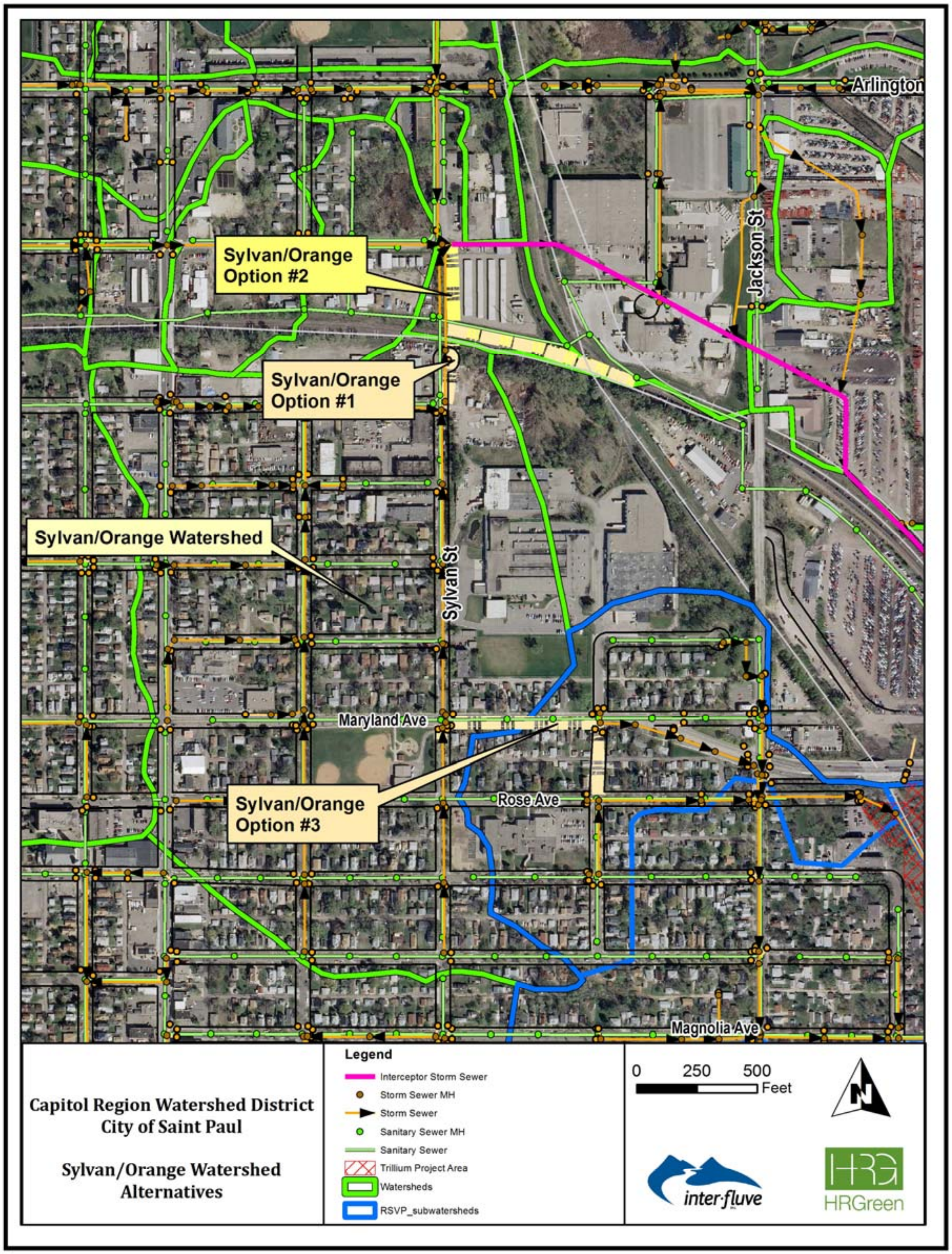


Figure 4.6 – Sylvan/Orange Watershed Alternatives

Sylvan/Orange Option #3

Option #3 would connect only the southern third of the Sylvan/Orange area (approximately 30 acres) to storm sewer within Hatch/Agate that would convey water to the Trillium site. Rerouting of storm sewer along Sylvan Street is feasible, but likely cost prohibitive. Also, based on the water budget analysis completed, the design team determined that it would not be cost effective to only connect a portion of the Sylvan/Orange area.

Watersheds to the East of I-35E

Connecting to the watersheds east of I-35E would involve crossing I-35E. Further investigation was not performed due to the infrastructure complexities associated with the existing sanitary sewer pipe contained within the storm sewer pipe at the I-35E crossing, elevation constraints associated with the existing I-35E crossing, and high costs anticipated for any new storm sewer network and I-35E crossing.

4.2.2. TBI Gravity Connections

Because providing stream flows based solely on rainfall and local storage was deemed not desirable, the next set of alternatives evaluated included gravity connections to water sources that provide a more consistent source of water. Those sources include the Arlington/Jackson Pond and the Trout Brook Interceptor.

Arlington/Jackson Pond

Arlington/Jackson Pond has an elevation of 813 feet. There is an existing inlet at the south end of the pond that would be reconstructed to discharge low flows into the proposed storm sewer that would be routed to the Trillium site. For Options #1, #1B, #1C, and #2, the alignment from the pond is west on Arlington Avenue within the inactive Soo Rail line along the east edge of the railroad right-of-way. For Options #3 and #4, the alignment discharge directly south from the Arlington/Jackson pond outlet. All alternatives except #3 would allow for a connection to TBI to capture flow within the interceptor during times when Arlington Jackson Pond does not provide sufficient flow.

Arlington Option #1

At the Soo / BNSF railroad right-of-way junction, this alternative would include routing the pipe east within a storm sewer that is located along the northern side of the BNSF Railroad. This alternative requires boring under one active railroad line and one overpass embankment (Jackson Street), as well as crossing over the Metropolitan Council Environmental Services (MCES) sanitary sewers six times as shown in the profile view in Figure 4.8. The average depth of Alternative #1 is 10 to 15 feet, which would allow for the future expansion north of the proposed daylighted stream to the TBI. This alignment is the same as 1B in Figure 4.7.

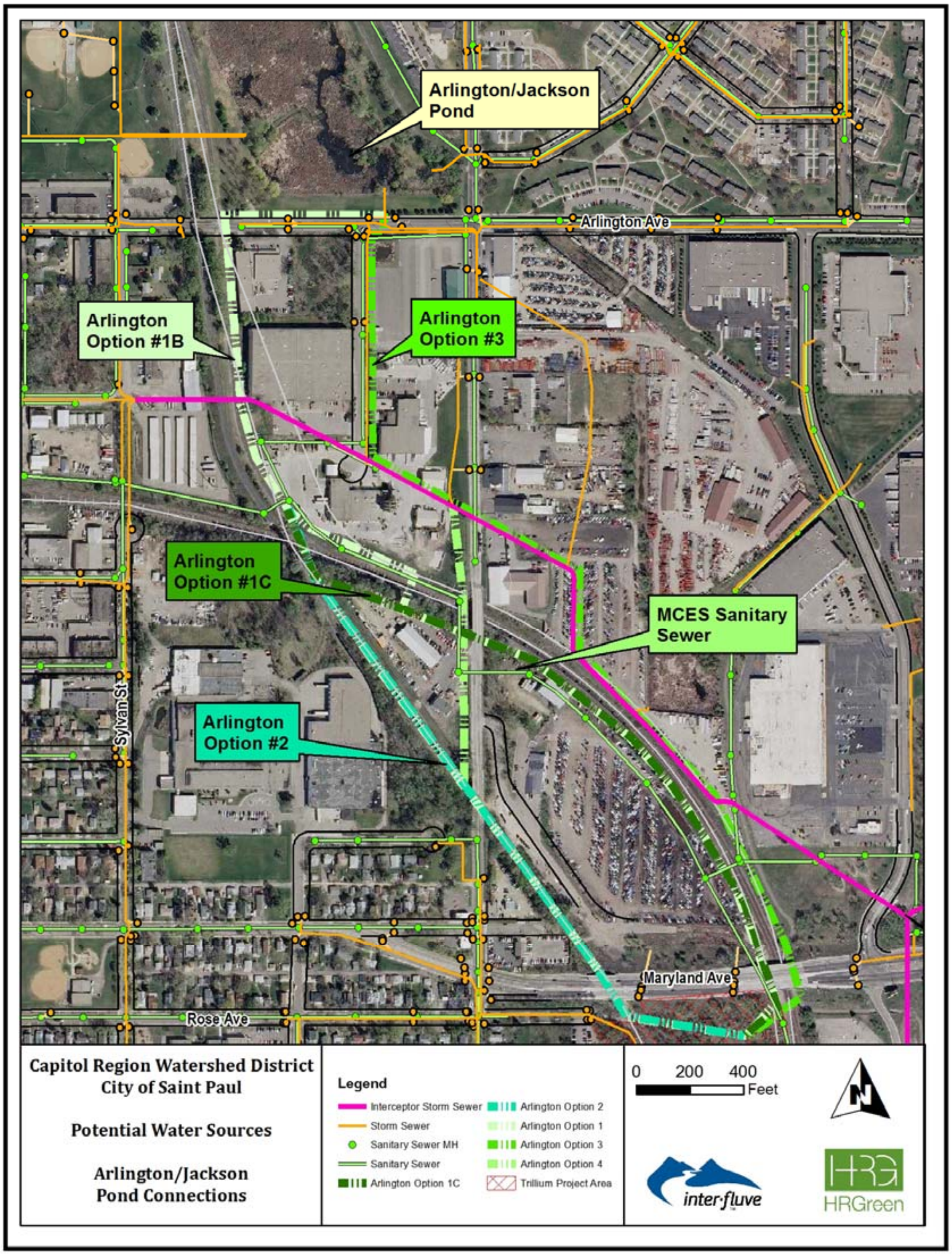


Figure 4.7 – Arlington/Jackson Alternatives

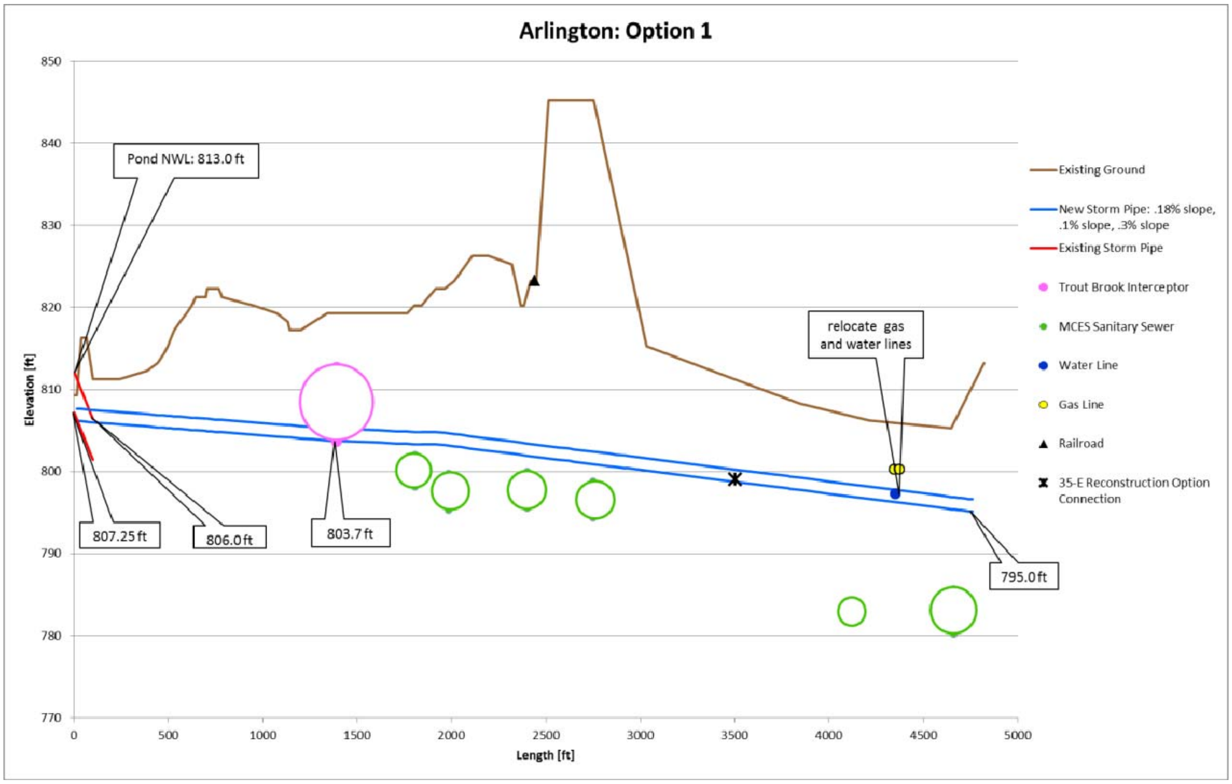


Figure 4.8 – Arlington/Jackson Option #1 Alignment

Arlington Option #1B

Option #1B is the same alignment as #1 but includes boring the stormsewer from the BNSF rail junction to the Trillium site. This alternative would eliminate the open trench along the BNSF alignment and reduce the associated easements needed to complete the work. This alignment would allow for the future upstream expansion of the daylighted stream channel to the TBI along the same easement.

Arlington Option #1C

Option #1C crosses the railroad sooner than Arlington Option #1 and only crosses MCES sanitary sewers once. The remainder of the alignment is anticipated to be open cut with full construction and permanent easements needed. This alignment would allow for the future expansion north of the daylighted stream channel to the connection to the TBI.

Arlington Option #2

Arlington Option #2, shown in Figure 4.9, follows the inactive Soo Railway alignment all the way to the Trillium project site. Due to the depth of the proposed pipe, this alternative would require boring the entire length and would not allow for the future daylight expansion of the stream to the north.

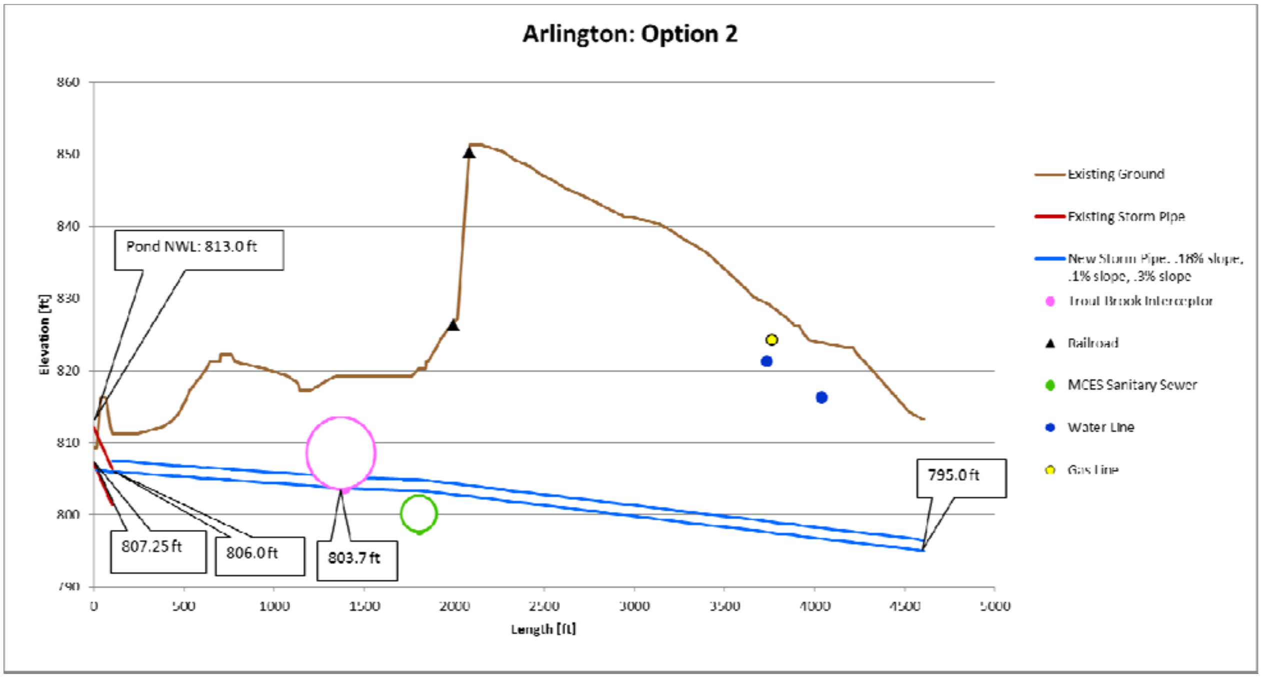


Figure 4.9 – Arlington/Jackson Option #2 Alignment

Arlington Options #3 and #4

Arlington Option #3 includes construction of a new stormsewer pipe adjacent to TBI along the same alignment. The proposed pipe would be within the CRWD easement, but it would expose one side of the TBI which results in structural concerns based on CRWD's previous experience with the interceptor.

Arlington Option #4 involves connecting into TBI further down the TBI alignment at Jackson Street. At this location, TBI is already at an elevation of 797.9 ft. The slope required to daylight at the Trillium site at 795 feet is too low to allow for gravity discharge to the Trillium site. Also, there is a sanitary pipe crossing the alignment that cannot be cleared.

As described in Section 4.3, the water quality coming from TBI is high during low flow, but decreases significantly during higher storm flows. The design team proposes a hydrodynamic separator, or actuated gate-valve to reduce storm flow into the Trillium gravity diversion line. A hydrodynamic separator would capture heavy solids. If sized to treat up to the full flow of the new diversion pipe (approximately 4cfs), higher flows would be allowable in the diversion system to achieve cleaning velocities without the solids associated with the high flow in TBI. The negative aspects of that alternative include the anticipated frequent cleaning of the hydrodynamic separator and the lower water quality discharged to the Trillium site. The actuated gate valve may eliminate the issue but would require maintenance and a power source.

All of these alternatives provide a base flow for the stream that meets the design criteria with either an 18-inch diameter or 24-inch diameter diversion system. The 18-inch system would meet the flow criteria, but would limit the flow to a peak of approximately 7 cfs. The 24-inch system would meet the low-flow needs and allow high flows up to approximately 14 cfs, which may allow for future system flexibility. Detailed flow analysis is provided in Appendix C. A portion of the diversion system will require auger boring, which would require a 30" sleeve regardless of whether an 18-inch or 24-inch storm sewer is installed. Consequently, the incremental cost of a 24-inch versus 18-inch storm sewer may be warranted to accommodate future design flexibility.

4.2.3. Pumping Options

The final options considered include pumping water, either out of the TBI just northeast of the site or out of Sims Agate Pond. These sources are shown in Figure 4.1 and the analysis of each is detailed in the following sections

TBI Pumping

The TBI runs near the Trillium site, and there is potential to harvest flow from it. However, the elevation of TBI near the Trillium site, where a connection could be made, is deeper than the starting elevation of the stream so pumping would be required. The invert of TBI at the connection point is 786.6 feet. This alternative, seen in Figure 4.10, requires crossing under Maryland Avenue, boring under the BNSF Railroad, and crossing one MCES sanitary sewer.

Recirculation Pumping of Sims/Agate Pond

Pumping water from Sims/Agate Pond to the top of the stream is another option. The water elevation in Sims/Agate pond is 780 ft. The length to the top of the Trillium site is approximately 3000 ft. This option does not incorporate bringing any new runoff to the stream and may require expansion of the pond to achieve adequate storage to meet stream flow requirements.

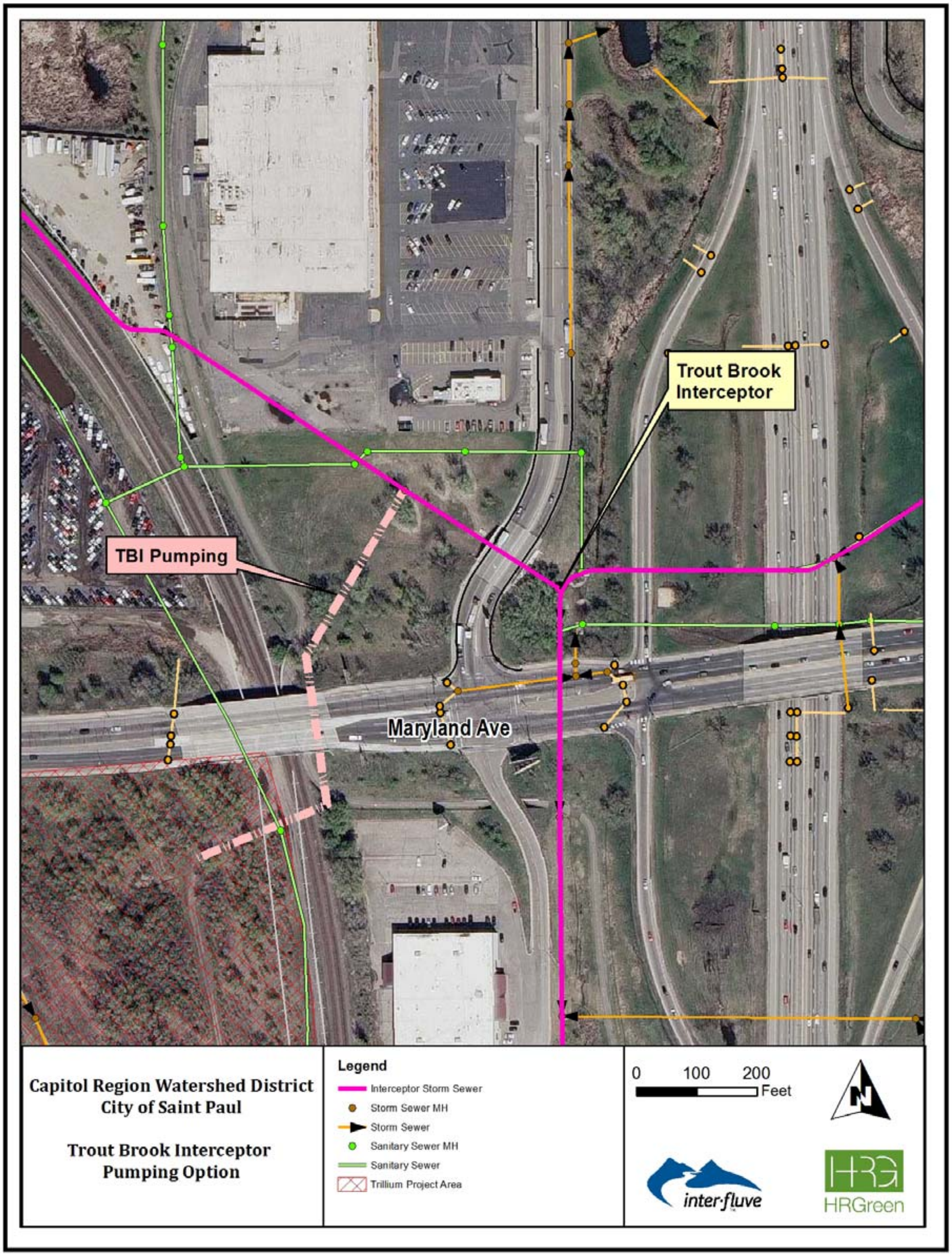


Figure 4.10 – Trout Brook Interceptor Pumping Option

4.3. Water Quality

Quality of the source waters for the new stream will be an important factor in determining the quality of the ecological system achievable. Two sets of water quality data were obtained from the CRWD that are expected to reflect the water quality of the various sources. The first set is the data collected by the District in several locations within the Trout Brook Interceptor watershed, including within the Trout Brook West Branch (TBWB) just north of the project site. This location is expected to reflect the water quality if water is either pumped or gravity drained from the TBWB. Because the base flow in TBWB is expected to be dominated by flow from Arlington Jackson Pond and because the Arlington Jackson Pond alternatives include connections to TBWB, this data set is also used to approximate water quality for the Arlington Jackson Pond alternatives. The data set includes orthophosphorus, chloride, metals, ammonia, total Kjeldahl Nitrogen, total phosphorus, nitrate, nitrite, total dissolved solids, total suspended solids, volatile suspended solids, E. coli, and hardness from both single grab samples and samples composited over several hours. Storm samples and base flow samples were collected between April 2005 and December 2010.

The second set of data used to approximate source water quality is data collected by the CRWD at the Arlington/Hamline Underground (AHUG) residential monitoring site. The characteristics of the AHUG watershed are similar to those of the Hatch Agate neighborhood. These data were used to approximate the quality of untreated stormwater runoff from residential areas.

In analyzing these data sets, the TBWB storm flow data was first separated from the baseflow data because those types of samples often reflect very different water quality and because organisms respond to pollutant concentrations over long durations differently than they do to concentrations over shorter durations such as during storm events. The baseflow in the Trout Brook Interceptor is augmented by discharges from the water treatment plant which are typically high quality. After separating, these two sets of TBWB data and the set of raw stormwater runoff data were compared to Minnesota Pollution Control Agency's water quality criteria and other water quality targets for those pollutants.

Selection of Targets. Not all of the parameters can be directly compared to water quality criteria due to the different forms of the pollutants. Ammonia is present in the environment as NH_3 and NH_4^+. The analytical results reflect the sum of both of these components, but the toxic form is NH_3, which is the basis for the water quality criterion. The portion of total ammonia present as NH_3 depends on the pH and temperature of the water. As pH increases, the portion present as NH_3 increases. Although temperature data was collected, pH data was not available. Therefore, for the purposes of comparing results to a water quality criterion, a pH of 7.7 was assumed based on the pH measured in TBWB on 6/10/11. Although the state does not have an adopted criterion for total ammonia, this parameter is still important as a macronutrient that can be associated with eutrophication and excessive algal growth.

The other parameter that is not directly comparable to water quality criteria or targets is chromium. Total chromium was analyzed, but chromium is typically found as Cr^{+3} and Cr^{+6}, with Cr^{+6} being the more rare but more toxic form. Because only total chromium was measured, we compared the total chromium results to the criterion for Cr^{+6}, which is conservative as it assumes all of the chromium is present in its most toxic form. However, before concluding that there may be a chromium toxicity concern, further analysis of the speciation of this metal would be necessary.

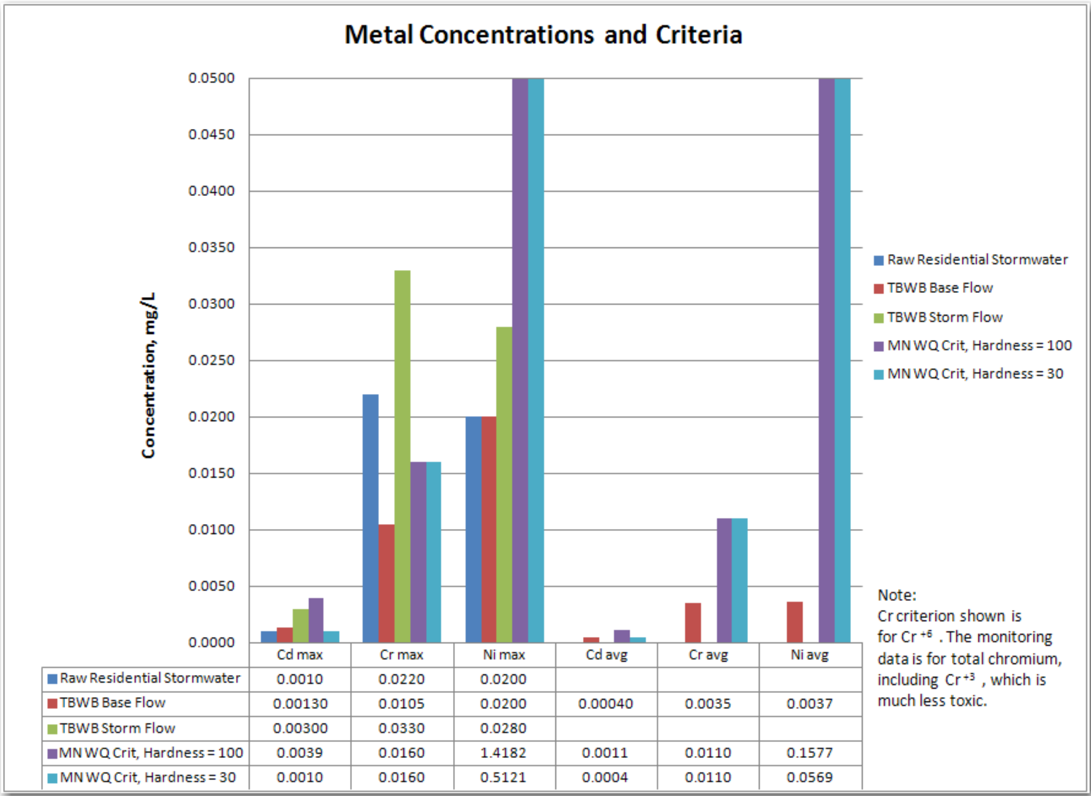
There are no adopted water quality criteria for total phosphorus (TP) or total suspended solids (TSS). The monitoring results for these parameters were compared to the average TP and TSS in minimally impacted streams in the North Central Hardwoods Forest ecoregion as reported by McCollor and Heiskary (1993).

Finally, most of the water quality criteria for metals are dependent on water hardness. As hardness increases, toxicity decreases, and the criterion concentration increases. In the TBWB data, there is a considerable difference between the hardness during baseflow conditions and stormflow. During base flow conditions, the minimum hardness monitored was 82 mg/L and the average was 187 mg/L. During storm flows, the minimum was 30 mg/L and the average was 71 mg/L. For untreated stormwater from a comparable neighborhood, the minimum was only 8 mg/L while the average was 30 mg/L. To capture much of the range, water quality criteria for metals are shown for hardness values of 30 mg/L and 100 mg/L.

Implications. Figure 4.11 to Figure 4.13 show plots of average and maximum contaminant concentrations in the water sources for several pollutants relevant to aquatic life and maximum and chronic criteria or targets shown for the same contaminants. Because storm flows are relatively short duration followed by periods of base flow, the long term average criteria typically are not applied. For this reason, the storm flow sample quality is only compared to the maximum criteria, while the base flow statistics are compared to both maximum and chronic criteria.

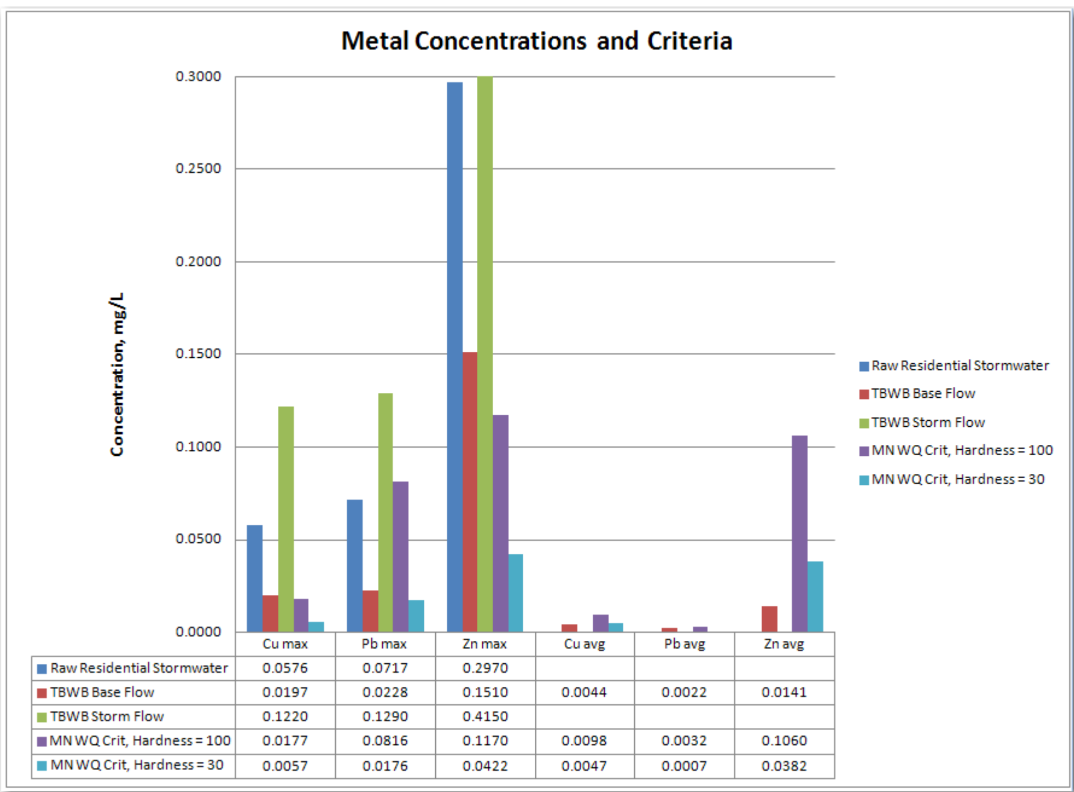
The data associated with base flow from Trout Brook suggests that if hardness levels are near or above 100 mg/L, monitored average concentrations are below all of the chronic criteria for the metals tested. However, maximum criteria for copper and zinc were exceeded at least once. Given that the hardness of the base flow samples was typically higher than 100, these criteria are more appropriate than those for lower hardness values. The Trout Brook base flow concentrations of chloride, ammonia, and total phosphorus were also below the criteria or targets for these parameters, but the average TSS concentration was slightly higher than the target.

The storm flow samples collected in TBWB contained higher maximum concentrations than the untreated residential stormwater runoff for all of the parameters, but for many metals, both sources exceeded maximum criteria. Given that the raw residential stormwater is better quality than the Trout Brook storm flow and that there are plans to incorporate treatment of the residential stormwater on site, this treated stormwater can be an important source for diluting the poorer quality water in the Trout Brook Interceptor. Further consideration of these data during final design will be important in considering pollutant removal efficiencies needed to achieve water quality suitable for sustaining a healthy assemblage of aquatic life in the stream.



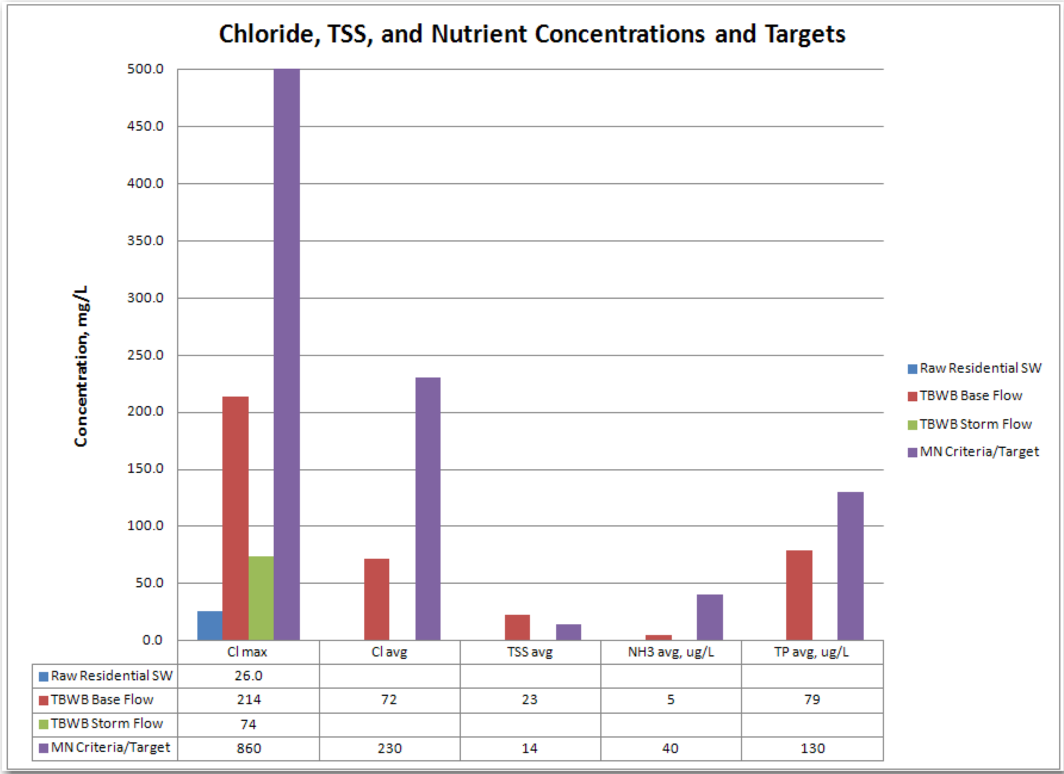
	Cd max	Cr max	Ni max	Cd avg	Cr avg	Ni avg
Raw Residential Stormwater	0.0010	0.0220	0.0200			
TBWB Base Flow	0.00130	0.0105	0.0200	0.00040	0.0035	0.0037
TBWB Storm Flow	0.00300	0.0330	0.0280			
MN WQ Crit, Hardness = 100	0.0039	0.0160	1.4182	0.0011	0.0110	0.1577
MN WQ Crit, Hardness = 30	0.0010	0.0160	0.5121	0.0004	0.0110	0.0569

Figure 4.11 – Metal Concentrations



	Cu max	Pb max	Zn max	Cu avg	Pb avg	Zn avg
Raw Residential Stormwater	0.0576	0.0717	0.2970			
TBWB Base Flow	0.0197	0.0228	0.1510	0.0044	0.0022	0.0141
TBWB Storm Flow	0.1220	0.1290	0.4150			
MN WQ Crit, Hardness = 100	0.0177	0.0816	0.1170	0.0098	0.0032	0.1060
MN WQ Crit, Hardness = 30	0.0057	0.0176	0.0422	0.0047	0.0007	0.0382

Figure 4.12 – Additional Metal Concentrations



	Cl max	Cl avg	TSS avg	NH3 avg, ug/L	TP avg, ug/L
Raw Residential SW	26.0				
TBWB Base Flow	214	72	23	5	79
TBWB Storm Flow	74				
MN Criteria/Target	860	230	14	40	130

Figure 4.13 – Chloride, TSS, and Nutrient Concentrations

Bacteria. A water quality parameter critical to ensuring that the water is safe for contact by visitors in a park setting is bacteria. State water quality criteria for bacteria specify a geometric mean limit of 126 E. coli organisms/100 mL for any given month and further require that less than 10% of all samples taken in a month exceed 1260 E. coli organisms/100 mL. Both criteria apply to the months of May through October. Because there was an insufficient number of samples to analyze each month individually, all samples were compiled and geometric mean values and 10% exceedance values were determined for each of the sources.

The geometric mean of the base flow samples collected from TBWB was 298 organisms/100 mL, which exceeds the criterion of 126 but is relatively close. The 10% exceedance value for the base flow samples was 1152, lower than the criterion of 1260. Therefore the baseflow alone would be close to satisfying water quality standards. However, when adding storm flow samples to the analysis, the combined data has a geometric mean of 718, and a 10% exceedance value of 13,430. The raw residential stormwater data had a geometric mean of 6560 and a 10% exceedance value of 15,360. It is clear that bacteria reduction must be an important consideration in designing stormwater treatment systems for the park, as discussed further in Section 5.4.

Evolving Water Quality Standards. State regulatory water quality standards are important tools for protecting and improving the quality of streams, lakes and wetlands. Standards establish designated uses for waterbodies as well as numeric and narrative criteria and an antidegradation policy that are designed to protect those uses. These standards are applied to natural waterbodies but not to stormsewer pipes. Workgroup members and project partners are therefore very interested in understanding the regulatory implications of re-creating a new waterbody that would be subject to water quality standards.

The Minnesota Pollution Control Agency (MPCA) is in the process of developing new water quality standards based on a "tiered aquatic life use" (TALU) system that would add complexity to the designated "aquatic life" use. Under such a system, different biological expectations are established for a more diversified set of "aquatic life uses" depending on both natural and human induced differences between different rivers and streams throughout the state. Whereas the existing water quality standard structure emphasizes chemical water quality, a tiered aquatic life use structure puts additional emphasis on the biological endpoints, typically fish and benthic macroinvertebrate communities.

No draft of the proposed standards is available, yet, but the MPCA staff has indicated an interest in ensuring that the new system does not discourage communities from engaging in projects to re-create or restore urban streams. Therefore, an objective of the system would be to ensure that additional regulatory burdens do not result from voluntary efforts to improve conditions of local waters. The TALU development process is ongoing, and continuing discussions between the Trillium site project partners and MPCA staff will be important as the new standards are developed.

4.4. Preferred Alternatives

A Decision Criteria Matrix was made to compare various aspects of these alternatives and narrow down the set of alternatives to be further analyzed. These aspects include the ability to provide reliable base flow, required pumping, utility conflicts, maximum bury depth, boring length, open cut length, availability of public ROW, requirement to obtain railroad easements, future stream extension, opportunity to provide stormwater treatment credits, pipe requirements, water quality, and cost. The Decision Criteria Table is shown in Table E1 (Appendix E) and is color coded such that red indicates negative quality, yellow is neutral and green is positive.

Construction cost and operation and maintenance cost estimates were also developed for each alternative selected for further investigation. Unit prices for the construction costs were generated based on similar construction projects, the RS Means published cost data, and industry professionals. These costs also include easement costs, erosion control, traffic maintenance, vegetative restoration, dewatering, mobilization, and a contingency of 20%. They also include costs for geotechnical investigation (i.e. test bores), design and engineering services, and field engineering and inspection, which are percentages of the subtotal costs. These cost estimates are detailed in Appendix F, and do not include all costs that would be incurred as part of the park development.

Because only one baseflow source is required, we selected the best alternative from each of the three major categories to simplify the decision criteria matrix. This summary together with the cost information, excluding design and engineering, is provided in Table 4.1.

Table 4.1 – Decision Criteria Matrix for Most Likely Options

Alternatives			Arlington/Jackson Pond: Option 1C	Hatch/Agate RSVP	Recirculation Pumping of Sims Pond	Trout Brook Pumping at Site
Decision Criteria	Description		Route storm sewer from Arlington/Jackson outfall west, then south boring under active RR before moving east to prevent crossing MCES interceptor multiple times	Route runoff from Hatch Agate neighborhood to pretreatment features along west side of project site	Pump water from Sims/Agate Pond to top of stream	NE connection into TBI, pump water from TBI into stream
	Pros		Reliable gravity flow option, only crossing MCES interceptor one time	Direct runoff to Trillium site.	System entirely within current Park	Lowest Capital Cost
	Cons		Entering NE corner of site under Maryland Ave. is tight - likely need to jack through embankment. Temporary and Permanent easements needed.	Small drainage areas alone don't have enough water for stream. Raw runoff is lower quality and needs treatment.	High operation cost, not as reliable as other alternatives	High operation cost, not as reliable as other alternatives
	Is there Base Flow?		Yes	N	Yes	Yes
	Pumping Required?		No	No	Yes	Yes
	Existing public ROW available?		No	Yes	Yes	No
	Potential for future stream extension along alignment?		Yes	No	No	No
	Stormwater Treatment Credit Potential?		No	Yes	No	No
	Water Quality of Source?		High	Medium	Low	Medium
	Cost	Capital	$950,000	$340,000	$590,000	$460,000
		Easement	$320,000	-	-	$120,000
		O&M	$11,000	$7500	$19,600	$18,000
		40 yr Cost	$440,000	$300,000	$790,000	$720,000
		Total Cost	$1,710,000	$640,000	$1,380,000	$1,300,000

The results of the analysis described in Section 4.2 indicate that direct runoff sources alone would not provide sufficient base flow between storms to meet the expectations of the project partners unless runoff from a much larger watershed could be captured and at least 6 acre-ft of water storage could be incorporated to store and slowly release water. Such a large storage volume would require either a very large area for storage, a large allowable water level fluctuation in that storage element, or a combination of both. Because large water level fluctuations with extended periods of deep water are not conducive to plant growth, such a storage system, would probably need to be buried for safety and aesthetic reasons. Given that there is not a large elevation drop from the I-35E corridor to the upstream end of the Trillium site, it would be difficult to gravity drain a deep pool from this location. For these reasons, direct runoff sources are not recommended as a sole source of water for the site. However, stormwater treatment is an objective of the project and a priority for the project partners. Treated stormwater will also be higher quality than water available from the Trout Brook Interceptor and important for diluting contaminants. Therefore, capture of water from the Hatch Agate neighborhood and treatment on the Trillium site is proposed to augment the chosen baseflow source.

The pumping options examined would provide a continuous baseflow with good water quality. However, there are concerns about the reliability and sustainability of a pumping system. If the pump failed, baseflow would cease to be delivered to the site and the stream would go dry. Additionally, funding for continued operation and maintenance of a pump cannot be guaranteed over the long term, and a future decision to discontinue funding for the ongoing pumping would turn the stream into a system that only flows during and after storm events. Project objectives include establishing a perennial stream that will provide habitat for an ecosystem typical of a perennial stream. Because the channel will not be connected to upstream or downstream riverine ecological communities, if the stream organisms are eliminated during a period of no flow, there are no sources to recolonize the stream other than with organisms that may survive in the ponds on site. This would likely compromise the diversity of the system.

Use of an external energy source for continuous operation of a pump for an indeterminate period of time is not desired because high energy consumption is not consistent with the sustainability objectives for the nature sanctuary. Project partners agreed that a system that would reliably and sustainably function as designed over the long term is important, and therefore, pumping will only be pursued if the capital funds or easements required for a gravity draining system cannot be obtained.

Of the gravity drain options, the recommended alternative is Option 1C, which provides the high quality continuous baseflow from Arlington Jackson Pond while minimizing costs associated with infrastructure conflicts. The pipe from Arlington Jackson can be hydraulically connected to Trout Brook augmented with Trout Brook Interceptor flow if necessary to ensure that sufficient flow is continuously provided, but as discussed above, this connection will require additional design and analysis to ensure that the pipe remains flushed and that water quality is not sacrificed. Further, this alignment coincides with the anticipated alignment of the stream when the daylighting project is expanded upstream. Because easements acquired for this alignment would be required at the time of expansion, this option is most compatible with future expansion.

5. Site Design

5.1. Site Constraints

There are a number of constraints imposed on the design by both infrastructure passing through the site and the need for the water delivery system and the proposed stream channel to function properly with minimal maintenance.

Starting Elevation. As described above, if water is delivered to the site from Arlington Jackson Pond through a gravity drain, the need to achieve a steep enough slope in the pipe to ensure that it does not become clogged with sediment and debris dictates the maximum starting elevation. For the Arlington Jackson alignment, avoidance of infrastructure and maintaining a minimum pipe slope of 0.5% results in a daylight elevation of 795 ft (NAVD88). Given that the existing ground elevation is at least 805 ft at the upper end of the site, significant excavation will be required to daylight at that elevation. A flatter slope along the stream alignment will also be required than if the stream started at a higher elevation.

Sims Agate Pond. The proposed stream will flow into Sims Agate Pond, which drains to a storm sewer at the southern end of the pond. The existing outlet elevation of the pond is 777.76 ft. The pond level establishes the elevation of the downstream end of the stream. Because creating a stream that ends at this elevation would require a large volume of excavation, there have been discussions about increasing this pond elevation. It is likely that this will be allowed if the design team can demonstrate that any stormwater management function currently provided by this pond would be replaced elsewhere on site and/or by raising the berm elevation around the pond to ensure an equivalent volume of active storage.

Case Ave Sanitary Sewer. There is a sanitary sewer pipe that runs at 0.5% slope across the lower portion of the site from Case Avenue west of the site to its junction with the Metropolitan Council interceptor on the eastern side of the site. At the junction, the invert elevation of the Case Avenue pipe is 781.87 ft. Most of the pipe is 3.5 ft diameter as it crosses the site, but this size is a legacy from a time when the sanitary and storm sewer flows were combined. With separation of the sanitary and storm flows, the last several feet of the pipe were replaced with a 1 ft diameter pipe, which has sufficient capacity for the sanitary flows. The 3.5 ft diameter pipe is only approximately 4 ft below the existing ground surface. Public Works has indicated that this is the minimum cover depth that would be allowed over the pipe.

If the existing pipe is left in its current location, the bottom of the stream bed would have to be located at the existing ground elevation and the stream banks and floodplain would have to be built up above the existing ground. Additionally, a dramatic slope break in the stream would be necessary, with a slope of 0.24% upstream of the sewer and 3.0% downstream of the sewer line. A 3% slope is quite steep for a stream, and would likely be a barrier to fish movement from the pond to the stream. Given that the pond may provide important refugia during some seasons, there is interest in ensuring that fish can move between the habitats. Therefore, the channel length would need to be increased substantially through increased sinuosity, which would require excavation of a large volume of material in the area downstream of the pipe crossing. In addition, if the channel slope is too high, a high sinuosity channel may not be geomorphically stable and may require stabilization that would render the design distinctly unnatural.

Alternatively, the project team discussed with Public Works the opportunities for modifying the pipe at this crossing. The result of those discussions was that Public Works agreed that the 3.5 ft pipe could be replaced with a 1.0 ft pipe and lowered to an invert of 780.72 ft, which corresponds to the spring line of Metropolitan Council interceptor. Given a 1.0 ft internal diameter of the pipe, 2 in. wall thickness, 0.5% pipe slope with the crossing approximately 80 ft from the junction, and 4 ft of cover, the stream bed elevation at that location would be 786.29. This produces an upstream valley slope of 0.37% and downstream slope of 2.2%. While these slopes are better than if the pipe is not adjusted, further reduction of the downstream slope through sinuosity is recommended to ensure that fish are capable of passage between the pond and the stream.

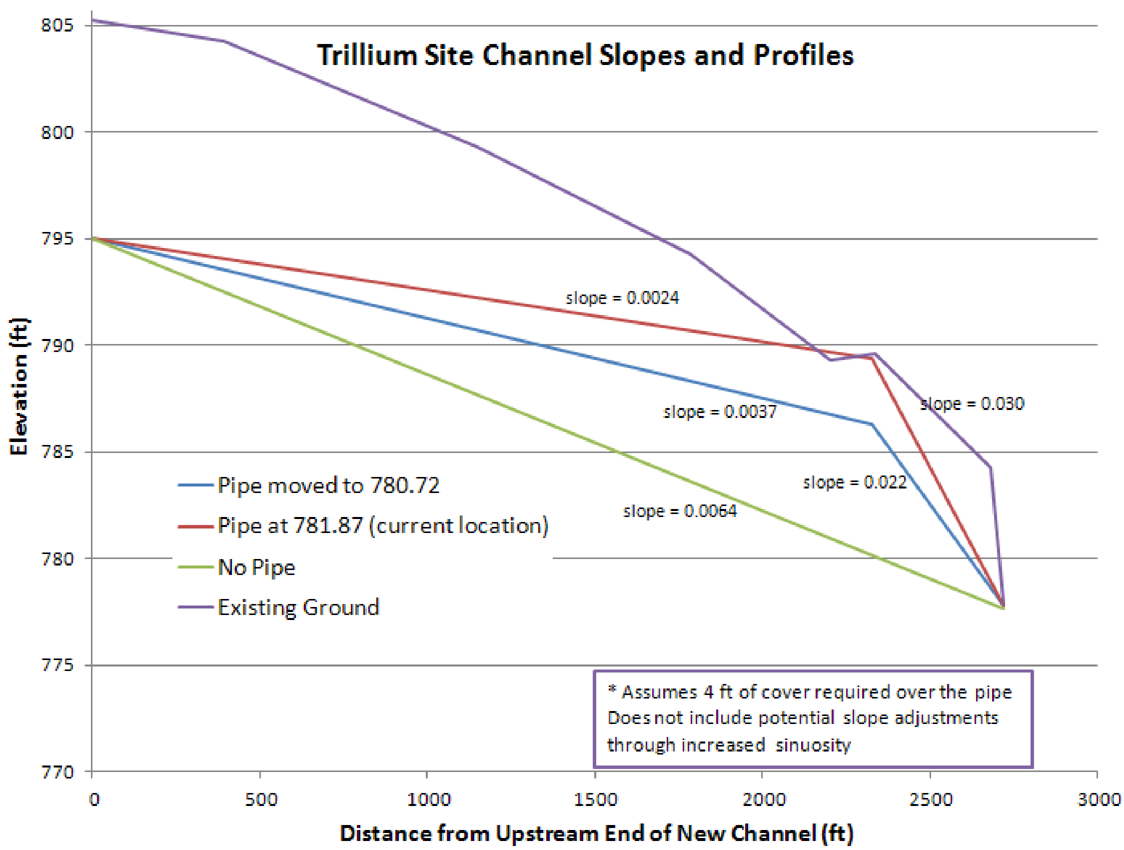


Figure 5.1 – Channel Slopes Necessary on Trillium Site to Avoid Case Avenue Sanitary Sewer

Other Utilities. A gas line runs across the site between Magnolia and Jessamine Avenues, but the design team anticipates that the line may be moved to an elevation that does not interfere with the site work. There is a telecommunications line that runs along the east side of the abandoned Soo line on the western portion of the site. This line may be moved during the site construction, but for the purposes of the water feature design, we have largely avoided proposing substantial work in this area.

The Metropolitan Council sanitary interceptor runs along the eastern edge of the site. Excavating the stream far enough west to avoid this line will be straightforward. However, given the large quantity of excavated material anticipated, and the desire to build a berm to screen the site from the railroad to the east, it will be important to better define the criteria for placing fill within the interceptor easement. In preliminary discussions, Metropolitan Council has indicated that placement of material within the easement should be acceptable if it is demonstrated that any increases of vertical or horizontal pressure on the pipe are within the structural capacity of the pipe system.

Likewise, there are storm sewers owned by Public Works that run to the Sims Agate Pond through areas of the western side of the site south of Jenks Avenue where placement of fill material is desirable. Public Works believes that there may be some capacity for limited additional fill placement on top of these pipes. The depth of additional material that may be placed on these pipes will be determined in the next stage of design.

Proposed Paths. A bicycle and pedestrian paved path is proposed along the alignment of the former Soo Line on the west side of the site. We understand that there may be opportunities to modify the elevation of this path if necessary, but we need to ensure that all water features are compatible with development of that path. Unpaved paths are also proposed throughout the interior of the Trillium site, including between the proposed stream and the active railroad line east of the site. Consideration of these future trails is required in laying out the stream and wetland features.

5.2. Preliminary Hydrology

The hydrology of the proposed channel requires very different analysis than a natural stream due to the unusual water delivery system proposed. Although there is a large drainage area to the West Branch of the Trout Brook Interceptor, the high flows in this watershed will remain in the interceptor, while a steady flow is proposed for diversion through an 18 or 24 in pipe. Likewise, the runoff from a 2.5 in storm on the subwatersheds of the Hatch Agate neighborhood will be routed to the stream through a series of stormwater treatment elements, but flows from larger events will continue to flow directly to Sims Agate pond. Therefore, typical flows in the channel will be comprised of the combined flows through the pipe and those from the stormwater treatment elements.

Pipe flow. Capitol Region Watershed District staff collected water depth and velocity data every ten minutes for the west branch of Trout Brook Interceptor from early April through mid-November in 2007 and 2008 and from early April 2009 – December 31, 2010. These data were analyzed to develop depth-duration curves for each year to determine the typical high and low flow depths for each year. Exceedance durations were also determined for the entire 4 year data set. The depth that was exceeded 99% of the time ranged from 0.2 to 0.4 ft, and the depth that was exceeded only 0.5% of the time ranged from 0.9 ft to 1.7 ft. Median flow depths ranged from 0.3 to 0.6 ft.

A rating curve was developed to predict flow in an 18 in. and a 24 in. pipe if connected at the invert of Trout Brook west branch interceptor given depth of flow in the interceptor (see Appendix C). The results of the analysis for an 18 in. pipe are included here because they were determined to be sufficient for a baseflow to the proposed channel.

Table 5.1 – Flow in 18 inch Gravity Drain Pipe

Depth of flow in Trout Brook West Branch, ft	Flow in 18 in. pipe, cfs	Exceedance Duration 2007 - 2010
0.21	0.21	Exceeded 99% of the time
0.31	0.41	Exceeded 50% of the time
0.87	2.6	Exceeded 1% of the time
1.1	3.9	Exceeded 0.5% of the time

Hatch Agate Storm Flow. Runoff from all storm events smaller than 2.5 inches (the 1-year, 24-hour storm event) from 150 acres of the Hatch Agate neighborhood are proposed to be routed to the stream at three different points. (See Figure 4.3) Available stormwater models of the Hatch Agate neighborhood were used to identify peak runoff values for the 2.5 in storm. This runoff will be treated on site prior to release to the constructed stream, and this treatment will produce a higher quality water and reduce the peak flow rates. In the next stage of design, the treatment elements will be refined to determine the projected quality and release rates. At this stage, we have approximated that the peak flow rates discharged from the treatment system can be reduced to 1/3 of the inflow rates. The flows from each of the three proposed stormwater treatment areas as well as the cumulative flows, assuming the peaks coincide and 4 cfs of flow from the gravity drain, are shown in Table 5.2. We expect that peak flows from the three watersheds will not coincide, and therefore the peak flows in the lower reaches are conservatively high. These peaks will be more precisely defined through final design modeling.

Table 5.2 – Preliminary 1-year Design Flows

Sub-watershed	Approx. Flow Rate to Stream from 2.5 in Storm Event, cfs	Cumulative Flow in Channel, cfs	Channel Reach
TRT14_A	14	18	Upper channel to Magnolia Ave
TRT14_B	11	29	Middle Channel (Magnolia to Jenks)
TRT14_C	14	43	Lower Channel (Jenks Sims Agate)

5.3. Stream Geometry

The constraints described in Section 5.2, the anticipated flows described in Section 5.3, and input from the workgroup were used to develop the preliminary stream geometry described in the next sections and shown in Figure 5.2 and Figure 5.3.

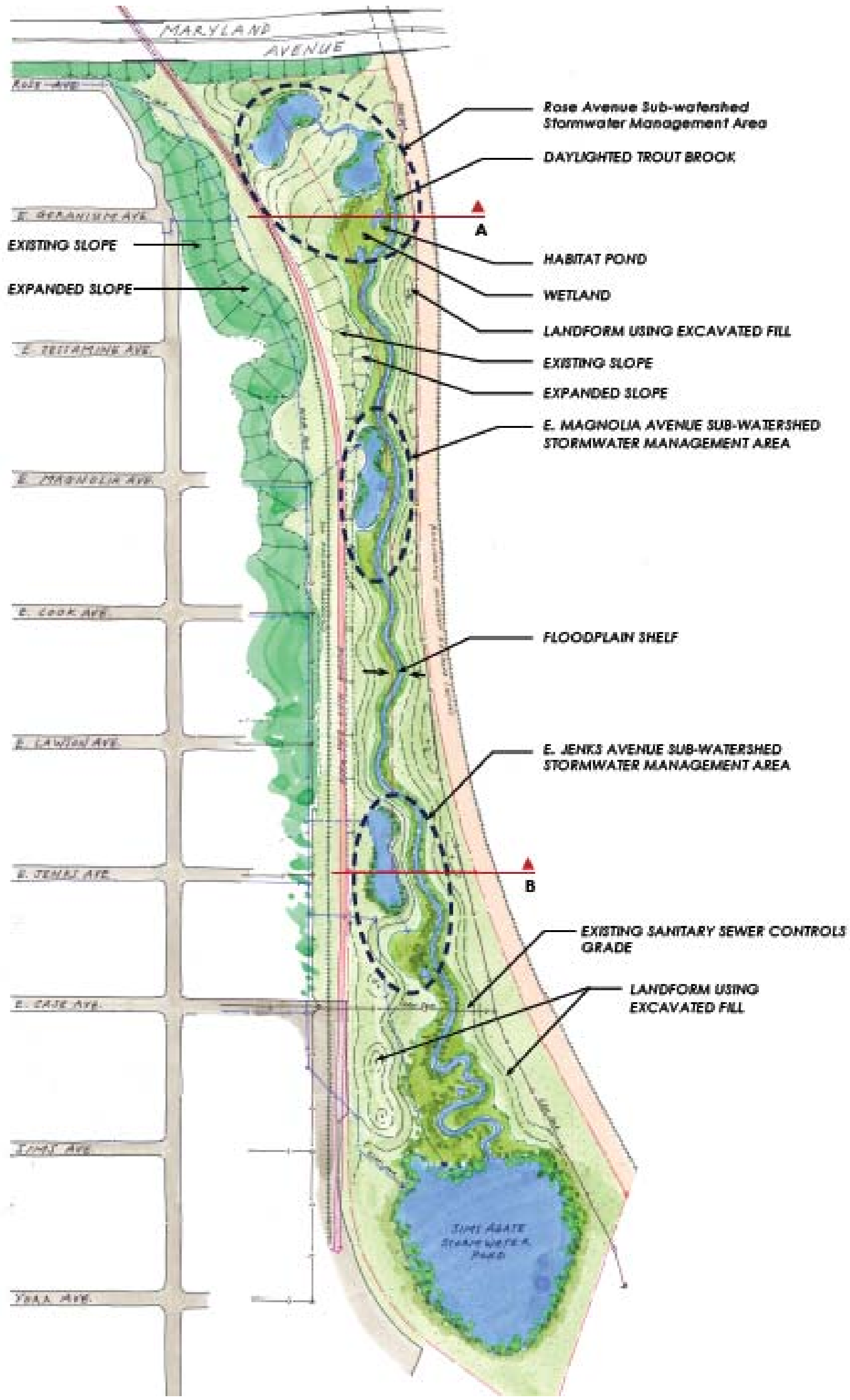


Figure 5.2 – Trillium Water Feature Concept Plan

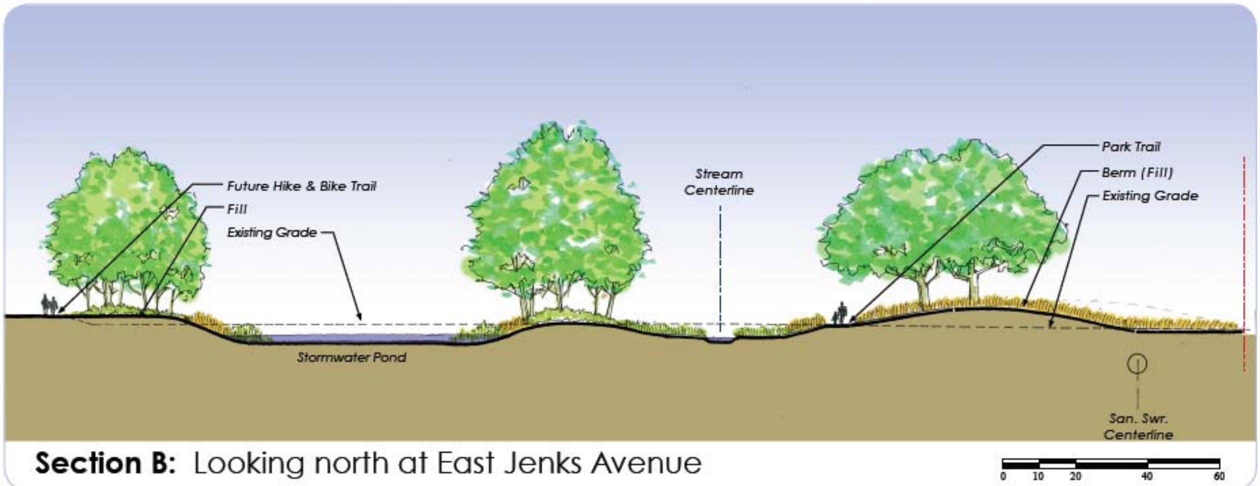


Figure 5.3 – Trillium Water Feature Concept Cross Section

5.3.1. Channel Slope

As discussed previously, the elevation of the upstream end of the channel (795 ft) is dictated by the need to gravity drain from Arlington Jackson at a slope that will ensure cleansing velocities in the pipe. The elevation of the downstream end will be set by the elevation of the Sims Agate pond (777.7 ft), and the elevation at the Case Avenue sewer crossing will be defined as described previously (786.3 ft). If the channel were straight with a uniform slope, the slopes dictated by these constraints are 0.37% upstream of the Case Avenue sewer and 2.2% downstream. Because the upstream elevation is at least 10 ft below the ground surface, a large volume of excavation is anticipated. To reduce this volume we propose a channel slope of 0.2% for the first section of the stream. This slope is flatter than the slope of the existing ground, so the channel will become closer to the surface as it proceeds down through the site. A slope break is proposed near the extension of Cook Avenue, such that the middle reach of the stream has a slope of 0.6%. To ensure that the lower channel is passable by a variety of organisms and to reduce the difference between upstream and downstream channel slopes, higher sinuosity is proposed downstream of the Case Avenue sewer to achieve a channel slope of 1%. (See Figure 5.4)

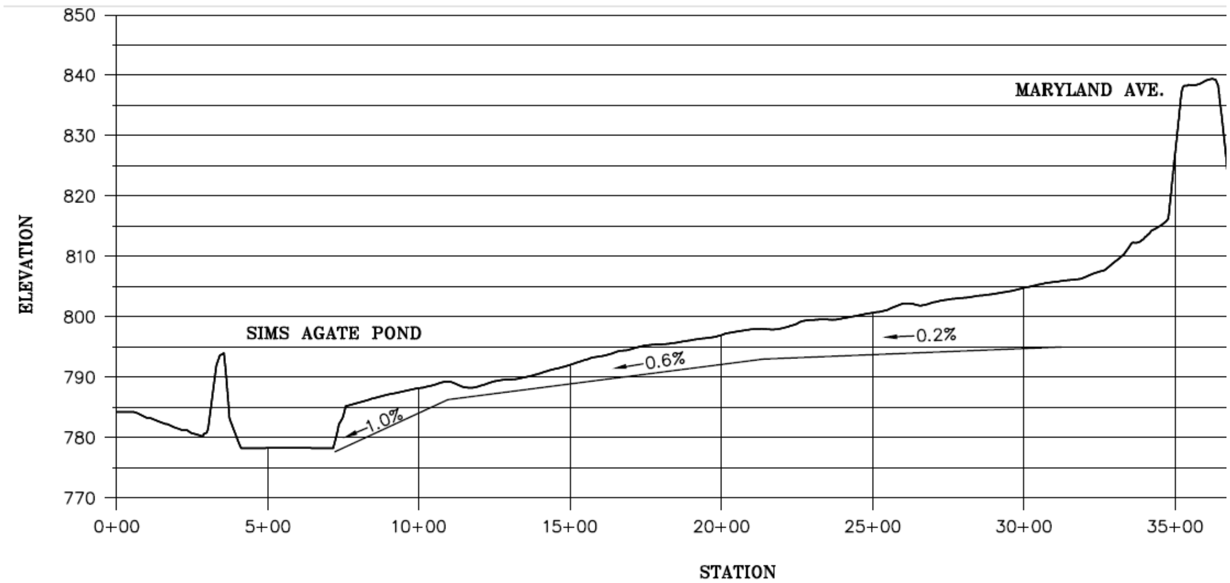


Figure 5.4 – Channel Slopes Proposed Along the Daylighted Trout Brook.

5.3.2. Channel Type

The workgroup discussed aesthetics and function of the stream channel with respect to the desired channel type(s) using the Rosgen stream classification terminology. We discussed the possibility that this could be a B, C, or E type channel or some hybrid. A B type channel is typically steeper than the other two types, with slopes often at least 2%, and has a narrower floodplain with the floodprone width typically less than 2.2 times the bankfull width of the stream. C and E channels typically have slopes less than 2% and floodprone widths greater than 2.2 times the bankfull width. E type channels are typically narrower and deeper than C type channels with width to depth ratios of less than 12.

High sinuosity with a large floodplain typical of an E channel in the upper section of the stream would require more space than is available, and flattening the slope further was not desired from an aesthetic and maintenance perspective. In the lower channel, the slope may be too steep to achieve a typical Midwestern E channel, but the high sinuosity proposed to achieve the connectivity of the system is higher than typical for a B channel. Further, though a more entrenched B channel would require less floodplain excavation volume, it would be less accessible to visitors and would not dissipate flood flow energy as effectively to reduce erosion potential. Therefore, it is clear that a hybrid of these channel types will be required, and the ultimate proposed geometry will depend on analysis of channel capacity and shear stresses to ensure that the channel functions as desired.

5.3.3. Channel Hydraulics and Cross Section

For preliminary channel sizing, a Manning's equation analysis of the flows and slopes described above was conducted. As mentioned previously, it is anticipated that the channel will convey flows from the Hatch Agate subwatersheds for all runoff from the 2.5 in storm event which corresponds to the 1-year, 24-hour event. Stormwater runoff that exceeds the runoff rate from this storm will continue to be conveyed through the site in the existing storm sewers and/or a new swale drainage system to Sims Agate. The existing system is sized to convey flows up to the 10-year peak runoff, so any runoff that exceeds this capacity will be conveyed in a new swale or be routed to the channel. Because these larger flood flows and the details of the conveyance of them will be defined during the next stage of design, this analysis is confined to the channel, which is proposed to contain the 1-year event within its banks. The flood flows will utilize the floodplain for conveyance, which at this stage is set at 20-24 feet total with additional width to allow for future channel capacity increase as described in the next section.

At this stage, a simple trapezoidal channel with 1.5:1 side slopes was used to approximate the shape of the channel, though channel complexity will be incorporated into the final design to improve habitat, water quality benefits, and aesthetic interest. Manning's roughness was set to 0.035 in the upper channel to reflect a moderate quantity of stones and woody debris in the channel. In the lower channel the roughness was increased to 0.04 to reflect larger boulders. The base width and flow depth were modified for each of the channel sections to define the conditions for both the anticipated 1-year annual peak flow, and for the median flow from the Arlington Jackson pipe. The goal was to ensure that the 1-year flow was contained within the channel, and the baseflow was a sufficient depth to ensure visible flow. The recommended base width is 6-7 ft.

Table 5.3 – Preliminary Channel Cross Section Geometry

Channel Section	Manning's roughness, n	Slope	Base width, ft	Depth, ft	Flow, cfs	Total Width, ft	Flow event
Upper Channel	0.035	0.002	6	1.25	17.94	9.75	Annual peak
	0.035	0.002	6	0.14	0.43	6.42	Median
Middle Channel	0.035	0.006	6	1.2	28.91	9.6	Annual peak
	0.035	0.006	6	0.1	0.43	6.3	Median
Lower Channel	0.04	0.01	7	1.3	43.21	10.9	Annual peak
	0.04	0.01	7	0.09	0.47	7.27	Median

Until the stormwater management elements are designed in more detail, the design flows are very approximate. While the preliminary design is based on the base width and bankfull estimate in the table, the design also incorporates flexibility to make this wider and/or deeper as a result of different design flows during final design. The conceptual cross section is shown in Figure 5.5.

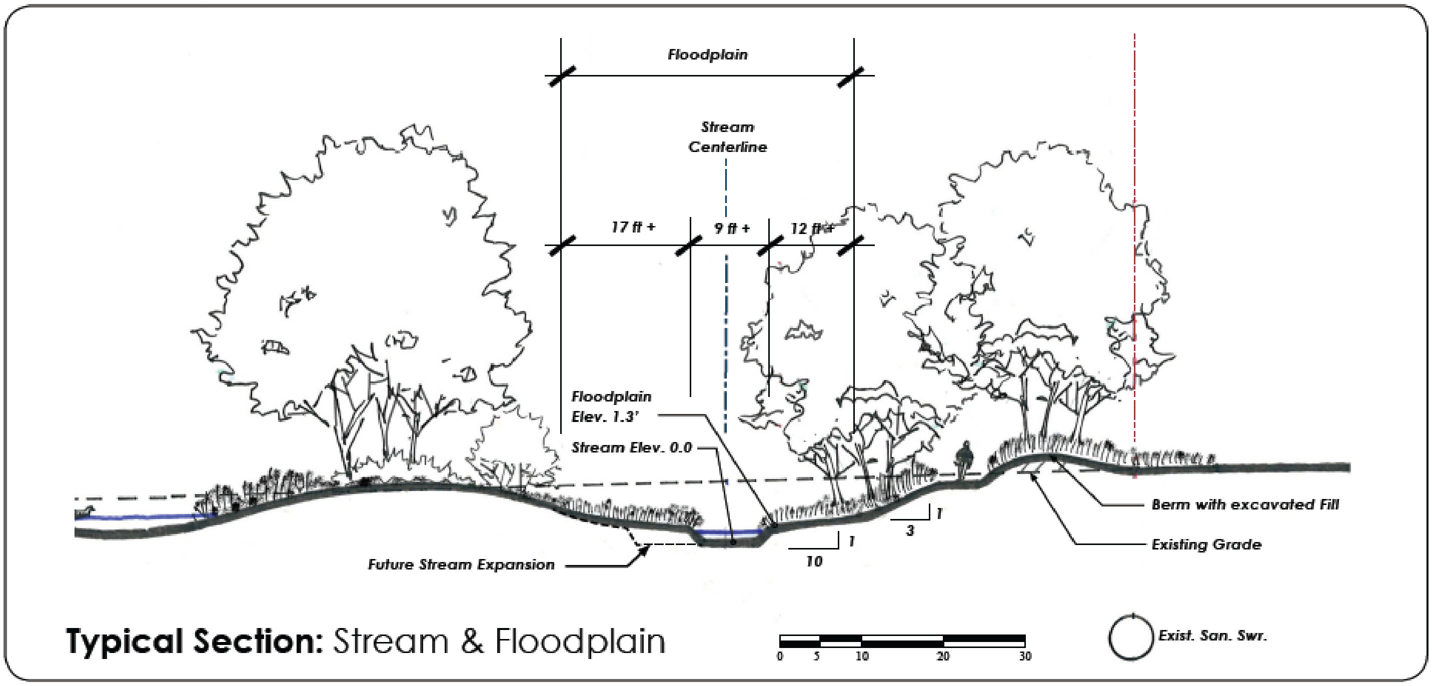


Figure 5.5 – Conceptual Channel Cross Section Dimensions

5.3.4. Future Expansion Considerations

The design team recognizes that the construction of a daylighted Trout Brook on the Trillium site represents the first step in bringing an entire stream from Lake McCarrons to the Mississippi River back to the community. Although we are currently designing only a section of that stream with defined flows from two sources, future expansion will increase the flows in the channel. This increase in flows over the long term needs to be addressed in the short term to minimize disturbance and expense necessary at the site at the time of expansion. Starting and terminating elevations also need to consider these upstream and downstream expansion needs.

Flows. While it is important to ensure that the channel is compatible with conveying larger flows at some point in the future, it is also important that the stream size fits the existing flow regime in the short term to maximize functionality and aesthetic value, which will help build support for expanding the project. Therefore, we propose designing the stream channel based on anticipated short term flows, but creating a larger floodplain on the west side of the channel that could be easily excavated in the future to increase the channel capacity (see Figure 5.5). Excavated material can be placed on the floodplain to increase both channel depth and width. The streambank and floodplain on the other side of the channel could remain undisturbed. In developing the planting plan for the banks and floodplain, this future plan can be accounted for with the highest density of high value woody species on the east bank and floodplain.

Channel Elevations. One of the challenges expanding upstream will be securing a corridor wide enough to excavate to channel elevations that may be significantly lower than the existing ground. If a line is drawn along the likely alignment, following the low points along the valley, from the upper end of the Trillum site channel to Arlington Jackson Pond, the slope is approximately 0.5%, and much of the route between Maryland Avenue and the railroad crossing is 10 feet or deeper below the existing ground surface. To minimize this excavation and reduce the corridor width needed, slope breaks could be incorporated such that a steep slope under Maryland Avenue brings the channel closer to the ground surface (Figure 5.6). To accommodate this option and the ability to route the creek under Maryland Avenue at a higher elevation, we propose starting the channel on the Trillium site a few hundred feet south of Maryland Avenue.

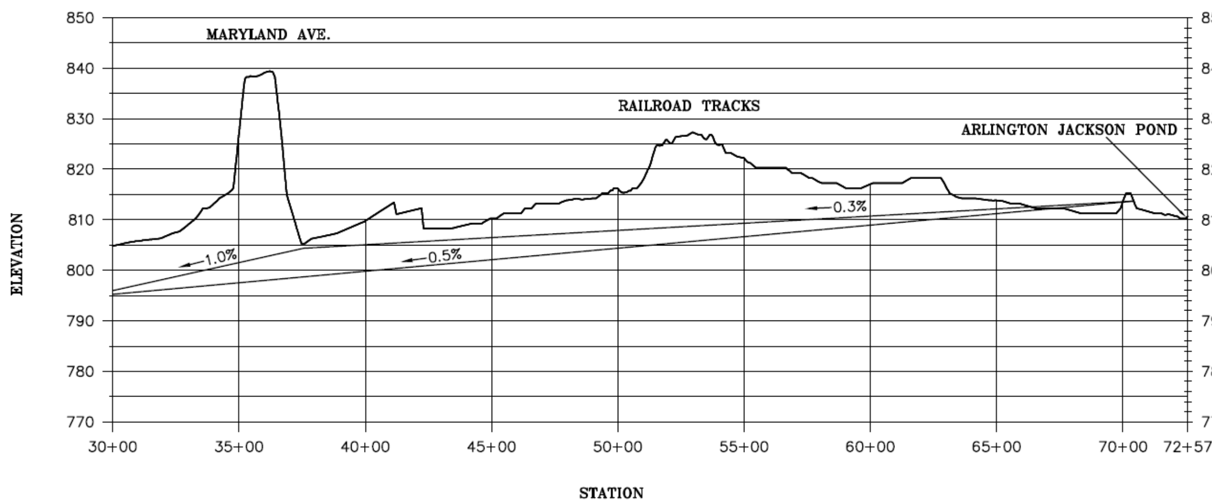


Figure 5.6 – Channel Slopes Possible Along the Daylighted Trout Brook from Trillium to Arlington Jackson.

Downstream, it is less clear where the stream may be routed. However, there is ample room between the proposed downstream end of the stream on the Trillium site, and the location where it would need to pass under Cayuga or I35E that we are confident that we can accommodate a variety of slopes and alignments downstream.

5.4. Stormwater Management

As concluded in Section 4, direct runoff is not a practical source of continuous base flow for the proposed stream. However, because it has the potential to be higher quality water than the flow from Trout Brook Interceptor during storm events, it can play an important role in improving water quality in the stream during those events. Additionally, project partners agreed that improving the quality of the stormwater from the Hatch Agate neighborhood through treatment on the Trillium site is an important objective of the site development to allow the City of St. Paul to meet CRWD requirements. Therefore, preliminary analysis was conducted to determine the space and potential grading required to achieve this treatment. These results are shown in Tables D1-D3 in Appendix D. The labels for the sub-watersheds described above and shown in Figure 4.2 were renamed for simpler reference. TRT14_A refers to sub-watershed 1, TRT14_B refers to sub-watershed 2, TRT14_C refers to sub-watershed 3, TRT14_D refers to sub-watershed 4, and TRT14_12D refers to sub-watershed 5 which is the primarily the project site.

The proposed treatment will be achieved through a BMP "treatment train", including ponds with sedimentation areas, filtration systems, and diverse redox potential within wetland systems. For this reason both deadpool and active storage volumes were combined to provide the treatment potential of both sedimentation and filtration of temporarily stored water. For the purposes of estimating the quantity of excavation, ponds were conservatively estimated at 3 feet deep with a safety bench at a 1V:10H slope. The proposed pond water levels are conceptually designed with approximately a 2-foot bounce during storm events, which accounts for an additional 1 inch of stormwater active storage for each BMP complex. Due to the known soil contamination on the site, the design team anticipates utilizing filtration rather than infiltration to reduce sediment and phosphorus loading and provide credits under the CRWD volume control permitting guidelines.

Since the Hatch/Agate area is not anticipated to be the primary water source for the Trillium site, as discussed in Section 4, treatment ponds are proposed near each of the three points where storm sewers direct flow into the trunk line on the Trillium site (locations adjacent to Rose Ave., Magnolia Ave., and Jenks Ave). This plan reduces excavation volume within the Trillium site and further refinement of the BMP locations may reduce required excavation volumes further. Weirs are proposed within the RSVP storm sewer system to direct low flows to the Trillium site. Additional modeling and storm sewer analysis would be required to design the weirs internal to the Hatch/Agate storm sewer system to ensure 10-year design protection with the RSVP area. Based on design iterations completed to date, the pond/wetland storage volumes for the subwatersheds are detailed in Appendix D and summarized in Table 5.4. Sub-watershed 4 is too far south to route to the stream and sub-watershed area 5 is the project area so runoff cannot be directed to pretreatment features.

Table 5.4 – Stormwater Treatment Requirements and Available Volumes

Subwatershed	Subwatershed Area (ac)	Impervious Area (ac)	CRWD 1-inch Retention Requirement (ac-ft)	CRWD 2-inch Banked Volume(ac-ft)	Total Available Treatment Volume(ac-ft)
1	31.39	15.04	1.13	2.62	1.52
2	41.61	10.13	0.76	3.47	1.93
3	77.52	11.73	0.88	6.46	3.3
Total	150.52	36.9	2.77	12.54	6.75

As indicated in Table 5.4, the conceptual stormwater complex meets CRWD's 1-inch treatment requirement for the impervious area runoff from the entire 150-acre drainage area. The design team expects, based on the design completed to-date, that the stormwater ponds and wetlands could be designed to accommodate the 2-inch runoff volume from the entire 150 acres by adjusting the grading design. The estimated volume credits that would be approved by the District for the City of St. Paul are as follows:

Table 5.5 – Hatch Agate Stormwater Credit Estimate

Hatch Agate Stormwater Treatment Estimate, Sept 2011					
Imp. Area (ac)	Rainfall Depth in.	Volume Req. /acre (cu ft)	Volume Credits (cu ft)	Volume Credits (ac ft)	
50	2	3,267	326,700	7.50	infiltration 100% Credit
			228,690	5.25	filtration 70% Credit

If the 2-inch credits are achieved, the District intends to handle future RSVP projects within the subwatershed in accordance with the following:

> *For future projects constructed within the Hatch-Agate drainage area, the project will not need to meet the volume control requirement on-site and will move directly to step 2 of alternative compliance sequencing (utilized banked volume credits).*

Additional detail associated with implementation of the stormwater credit policy will be developed during the next stage of design.

As discussed in Section 4, ecological objectives for the site will require site specific stormwater treatment considerations as well. Because review of the relevant water quality data suggests that metal toxicity may be a concern for aquatic life at the site, and many metals are less toxic to aquatic organisms with increasing water hardness, special measures may be appropriate for increasing water hardness in the water features. In natural waters, hardness is the combined concentration of calcium and magnesium ions. By increasing the concentrations of these constituents, hardness increases. Stormwater treatment elements that can be used to increase hardness should be explored in the next stage of design.

A second site specific concern, due to the desired and anticipated enjoyment of the stream and other water features by people, is bacteria. Sedimentation and filtration to remove particles on which bacteria may adhere and exposure to sunlight in shallow pools that are clear enough for light to penetrate and kill bacteria will be important strategies. However, many of the habitat enhancement features of the site will attract birds, mammals and other animals that will contribute to the e. coli concentrations in the system. Therefore, regardless of the effectiveness of the treatment systems, educational materials and outreach programs should emphasize the importance of caution when contacting any natural water, particularly during storm flow conditions.

5.5. Sims Agate Pond

The existing Sims Agate Pond has steep side slopes dropping to a fairly uniform flat pool bottom. There is currently no safety bench in this pond and little habitat value. It has been acknowledged that when the park is developed into a usable space for people, a safety bench must be incorporated into this pond. With introduction of a higher water quality source for that pond, through use of Arlington Jackson Pond water and stormwater that is treated prior to entering the pond, we anticipate potential for much greater ecological function in the Sims Agate pond and less need for it to serve stormwater management function. The ecological function can be improved by establishment of a much wider emergent vegetation zone, which is consistent with development of a safety bench, and incorporation of greater depth diversity within the pond. There may also be an opportunity to raise the elevation of at least a portion of the pond which would allow a shallower stream slope in the lower channel and less excavation. These opportunities will be examined thoroughly in the next stage of design.

5.6. Site Ecology

Several of the design criteria are derived from the project partners' and workgroup members' goals of developing an ecologically diverse and functional site. The Natural Resources Management Plan (2004) (NRMP) provides a good overview of the natural vegetation communities that are targeted for the site. It also contains lists of plant, mammal, bird, reptile, and amphibian species that will likely or potentially inhabit or pass through the site. The community types identified in the NRMP most relevant to the water features are Mesic Prairie, Lowland Hardwood Forest, Emergent Marsh, Wet Prairie, and Open Water. While these community type zones will be delineated more precisely with St Paul Parks and Recreation during the final park design, we have ensured that they are compatible with the preliminary water feature design. Lowland Hardwood Forest may be established along the stream in the floodplain, particularly on the east side of the stream where disturbance will not be required for future upstream expansion. In places where the floodplain widens to incorporate adjacent ponds and wetlands, a gradient from Open Water to Emergent Marsh, to Wet Prairie to Mesic Prairie will develop from the lowest elevation areas of the ponds to the shallow and upland areas around them. This vegetation zone gradient will also develop around the stormwater features. See the Typical Section sheet in Appendix G.

The potential aquatic ecology of the site is not as thoroughly described in the NRMP and is therefore the subject of the remainder of this section. The proposed stream channel will be atypical, and as such, it is difficult to predict how it will respond ecologically. Many urban streams suffer from flashy hydrology, poor water quality, and poor habitat quality. However, at the Trillium site, we have proposed a baseflow source that is higher quality than most urban runoff and we will be treating stormwater before it reaches the site to improve water quality. The hydrology will not be as flashy as that of most urban streams, because we will only be delivering Arlington Jackson Pond water at a rate that will flow through an 18 - 24 inch pipe. The remainder of the water will continue to flow in the Trout Brook Interceptor. Likewise, only stormwater runoff from events smaller than the 1 year storm event and larger than the 10 year event is proposed to be delivered to the stream. The peak flows from those events will be reduced through stormwater management on the site. While the 10 year and larger events will result in high flows in the creek, these events will be infrequent, with time for the ecology of the system to recover between these events. Finally, because we are designing the new Trout Brook to contain diverse habitat structure, the typical poor habitat of urban streams should not be a limiting factor. For these reasons, the potential for ecological integrity is greater in the proposed stream than most other urbanized streams.

A significant barrier to maximizing fish diversity at the Trillium site is the lack of connectivity to upstream and downstream source populations. While most aquatic macroinvertebrates have a terrestrial adult stage that allows dispersion beyond stream barriers, fish must have connected aquatic pathways to migrate. The section of Trout Brook that will be re-created at the Trillium site is connected to upstream and downstream waters only by storm sewer pipe, which is an effective barrier to fish movement. In the short term, the fish expected to thrive in this stretch will be limited to those that are introduced or may be flushed through the gravity drain pipe from upstream. In the long term, with expansion of the daylighting project upstream to Lake McCarrons and ultimately downstream to the Mississippi River, fish from both of these sources may inhabit or pass through the Trillium site.

Several reports provide information on the potential aquatic community that may develop at Trout Brook, based on sampling data from sites around the Upper Mississippi and even in the Twin Cities Metro Area. Specifically, Niemela and Feist (2001), Schmidt and Talmedge (2001), Genet and Chirhart (2004), and the Minnesota Department of Natural Resources' online FishMapper were used to determine the nature of the community that may be possible in Trout Brook within the early stages of the project.

Benthic macroinvertebrates, including the larval and nymph stages of many insects, and fish are the primary organisms used to characterize stream health. Ecological community metrics are used to define an index for stream health along a gradient from poor to excellent. Metrics often used are the Fish Index of Biotic Integrity (F-IBI) which rates the fish assemblage on a scale of 0 (poor quality) to 100 (excellent quality), and the Macroinvertebrate Index of Biotic Integrity (M-IBI), which rates the benthic macroinvertebrate assemblage on a scale from 0 (poor quality) to 40 (excellent quality).

Macroinvertebrates – Given the atypical nature of the proposed stream, as described, it is difficult to predict how the macroinvertebrate community will develop. Genet and Chirhart (2004) calculated M-IBI scores for a variety of streams in Minnesota, including four in urbanized watersheds in Ramsey and Hennepin counties. The M-IBI for these streams ranged from only 4 to 8 suggesting low quality of the macroinvertebrate assemblage. With higher water quality and better habitat anticipated at the Trillium site, a better assemblage of macroinvertebrates is possible. The physical habitat and flow regimes at the site will be sufficient to harbor caddis flies, mayflies, and stoneflies, which are representative of a higher quality assemblage. Sensitivity to pollutant concentrations anticipated in treated stormwater may be the factor that limits the quality attainable.

It may take some time for the insects to find the site, but as the project matures, the species diversity and abundance will increase. This will be reflected in the M-IBI, potentially within a few of years given dispersion rates of insects. Presence of individual species as well as feeding guilds, organisms grouped together by their method of eating (for example those that shred leaves and those that collect organic debris suspended in flow), will continue to evolve through time as pioneer species tolerant to a range of habitat conditions are displaced by habitat specialists.

The Trillium site will also provide a unique opportunity to study the effect of treated urban stormwater on development of the macroinvertebrate assemblage in isolation from other typical urban stream impairments. Because the hydrology will be relatively stable and the habitat will be very good, the main factors driving the macroinvertebrate community development will be the quality of treated urban stormwater and ability of colonizing organisms to access the site. In most studies of urban streams, researchers are unable to separate the effect of these multiple impacts.

Fish –Several important factors will affect the long term fish community at the Trillium site. As mentioned previously, connectivity to other source populations of fish will control which species are introduced over time. Another important factor is the temperature regime of the channel. Significant differences are found between warmwater and coldwater fish communities. The Metro area harbors both as well as transitional, coolwater communities (Schmidt and Talmage, 2001). We expect that the stormwater inputs and sunlight effects on ponded source waters, including those on site as well as the source water in Arlington Jackson pond, will maintain this fish community as a warmwater system. Finally, although measures will be taken to treat stormwater runoff to the extent practical, the stormwater will likely continue to contain elevated levels of some pollutants associated with urban runoff, including metals. Fish species most sensitive to these pollutants will not thrive at this site unless stormwater management practices improve to allow further reduction of these pollutants.

A study of fish communities at 133 stream sites in the Metro Area was conducted between 1998 and 2000 (Schmidt and Talmage, 2001). The F-IBI scores at these sites ranged from 0 (very poor) to 60 (good) with a median score of 20 (poor). The streams surveyed in southern Ramsey County all had scores between 0 and 20. In the short term, we would not expect the F-IBI score to exceed 20 until greater connectivity is achieved in the system to allow periodic introduction of new organisms. With expansion of the daylighting project upstream to Lake McCarrons, a higher score is anticipated. The maximum F-IBI, as with the macroinvertebrates, may be controlled by water quality parameters and connectivity to source populations because habitat, including hydrologic regime, should be suitable for a high quality community to develop.

Based on records from adjacent streams, we can predict the specific fish species that will likely colonize the site. Fish collected in Trout Brook upstream of Arlington Jackson pond in 1999 included black bullhead, white sucker, common carp, Iowa darter, green sunfish, and a hybrid sunfish. Individuals of these species may be flushed through the gravity drain pipe or transported by people downstream to the site overtime. The fathead minnow is a very common, tolerant native minnow that is present in most of the streams in the region. It is also a common bait fish used by anglers and will likely be among the first fish to appear at the Trillium site, potentially introduced as leftover bait fish are dumped at the site. These likely species and other species in nearby streams that may inhabit the Trillum site are listed in Table 5.5. Brook stickleback and brassy minnow are coolwater species that may occupy the site if water temperatures remain cool through shading and subsurface filtration of stormwater.

Table 5.6 – Potential Fish Species of the Trillium Site

Common name	**Latin Name**
black bullhead	*Ameiurus melas*
yellow bullhead	*Ameiurus natalis*
white sucker	*Catostomus commersonii*
common carp	*Cyprinus carpio*
spotfin shiner	*Cyprinella spiloptera*
bigmouth shiner	*Notropis dorsalis*
common shiner	*Luxilus cornutus*
Iowa darter	*Ethostoma exile*
Johnny darter	*Etheostoma nigrum*
Fathead minnow	*Pimephales promelas*
bluntnose minnow	*Pimephales notatus*
central mudminnow	*Umbra limi*
creek chub	*Semotilus atromaculatus*
western blacknose dace	*Rhinichthys obtusus*
green sunfish	*Lepomis cyanellus*
hybrid sunfish	*Lepomis hybrid*
pumpkinseed	*Lepomis gibbosus*
bluegill	*Lepomis macrochirus*
largemouth bass	*Micropterus salmoides*
brook stickleback	*Culaea inconstans*
brassy minnow	*Hybognathus hankinsoni*

Although many of these species are common, relatively tolerant, and therefore not likely to yield a high F-IBI score, they will represent a valuable food source for birds, mammals and reptiles. The centrarchids (largemouth bass, bluegill, green sunfish, and pumpkinseed) will readily colonize pond environments including larger pools in the stream system and may present an opportunity for young anglers to pursue. Carp, bullheads, suckers, and several of the minnows and shiners may occupy both stream and pond habitats. The darters, creek chub, bigmouth shiner, and common shiner will be more prevalent in the stream.

As with the macroinvertebrate assemblage, the nature of the Trillium site may provide a valuable research opportunity to study the effect of treated urban stormwater on fish species in isolation from other urban impacts such as poor habitat and flashy hydrology. Connectivity will remain a barrier to colonization in the short term, but introduced native species may be monitored to determine their survival and reproductive success given high quality habitat but slightly elevated levels of urban pollutants. The lack of connectivity also presents an opportunity to study the impact of patch size, or the size of suitable contiguous habitat available to a population, on a species' ability to thrive.

6. Preliminary Cost Estimate

Source Water Delivery System. Construction cost estimates associated with the water delivery systems are described in Section 4 and detailed in Appendix F.

Site Construction. Construction costs of the proposed stream, pond and wetland features are itemized separately from the water delivery costs in Appendix F and summarized in Table 6.1. Several of the unit items typically included in a construction cost estimate, such as mobilization, clearing and grubbing, planting, etc., will be required during construction at the park regardless of whether the site water features are constructed. Consistent with discussions between Capitol Region Watershed District and Saint Paul Parks and Recreation, these items were not included in the water feature construction estimate.

The estimated construction costs for stormwater facilities (ponds and wetlands) are based on the total treatment volumes noted in Table 5.4.Costs are based on the conceptual design of the water features. The design is anticipated to change following more detailed analysis of hydrology, stormwater treatment, and discussions with several partner and regulatory agencies during final design.

Table 6.1 – Preliminary Cost Estimate

Trillium Site Feasibility Study 30% Design Level Costs			
Description	**Capital Cost**	**Easement Cost**	**Annual O&M**
Gravity Drain from Arlington Jackson	$950,000	$320,000	$11,000
Stream Construction	$460,000	-	-
Stormwater Management	$340,000	-	$7,500
TOTAL	**$1,750,000**	**$320,000**	**$18,500**

7. Schedule

The preliminary schedule for completing design and construction of the Trillium Nature Sanctuary site is as follows:

Begin final analysis and design	April 2012
Submit 60% plans for permitting	November 2012
Complete final construction documents	February 2013
Construction bidding	March 2013
Award construction contract	April 2013
Begin construction	May 2013

8. Summary and Final Design Issues

The objectives of the Trillium Site Water Feature Feasibility Study included evaluating the feasibility of constructing a stream channel, wetlands and ponds on site and developing preliminary design of these water features to ensure that the project can quickly move into the final design stage. Consistent with these goals, preliminary analysis and design is described in this design report and the preliminary plan sets. Preliminary analysis and discussions with various state and city agencies and departments also led to identification of water-related issues that will require additional analysis and coordination during the final design process. This section summarizes those issues and our understanding of the process for resolving those issues during final design. Several elements of park design have not been analyzed at all as part of the water feature feasibility and are also not addressed here. However, some discussion of overall site objectives and criteria, including issues not related to the water features, occurred in the first Workgroup meeting and is captured in the Design Criteria memo.

Gravity Drain Alignment Easements. The preferred alternative for supplying a continuous base flow to the proposed stream is to route water from Arlington Jackson pond to the site in gravity drain pipe This will require securing easements from landowners along the alignment. If sufficient easements cannot be acquired along the entire alignment, a different source of water will be necessary.

Gravity Drain Pipe Crossing Trout Brook. The physical connection between the West Branch of the Trout Brook Interceptor and the pipe that will deliver water from Arlington Jackson Pond to the Trillium site will need to be designed. The connection will ideally allow diversion of low flows within TBI to the Trillium site, but potentially include a closure mechanism to prevent debris and low quality water from entering the Trillium gravity drain during larger storm events. Analysis of the flows and sediment loading within TBI is recommended to determine the need for a closure and at what flow elevation closure should occur. A hydrodynamic separator should also be considered at this location, to reduce sediment loading to the gravity drain connection.

Contaminated Soil. The available Environmental Site Assessment reports indicate that there are soils on site that may require special handling due to elevated concentrations of arsenic, mercury, and/or gasoline and diesel range organic compounds. In some locations, the soil was found to contain contaminant levels that allow it to be reused if it is covered with clean soil, but a portion of the soil may need to be hauled off site. In January 2004, a Draft Response Action and Construction Contingency Plan (RA/CCP) was developed for the northern portion of the Trillium site (Braun Intertec, 2004b). Although the RA/CCP was developed specifically for the northern portion of the site, we anticipate that the measures taken to address soil contamination will be consistent between the northern and southern portions.

In summary, the RA/CCP prescribes that all soil excavated from within a 20 ft radius of the sampling locations that contained high concentrations of contaminants be segregated and stockpiled based on organic vapor, and visual and olfactory indications. Grab samples from each stockpile and the excavation base or sidewalls were proposed to be collected and tested for a range of contaminants in a laboratory. Depending on analytical test results, the stockpiled soil may then be used on the site, used on site but capped with 2 ft of clean material, or hauled off site for disposal at a permitted landfill. The MPCA VIC Cleanup Unit approved the plan subject to modifications it detailed in an attachment to its letter dated February 4, 2004. It is not clear that the RA/CCP was ever finalized with the required modifications.

The extent to which soil will be hauled off site or sorted and covered with clean fill will have significant implications for the grading plan and overall project costs. Therefore, it would be useful to determine these quantities early in the final design process, rather than waiting until construction begins. Additionally, more detail regarding the extent and depth of proposed excavation has been developed through this feasibility study. This refinement may be sufficient to allow revisions to the RA/CCP that would rely on soil testing prior to excavation and stockpiling. We recommend that project partners meet with MPCA VIC staff very early in the final design process to determine if such modifications to the RA/CCP would be acceptable, and if so, what density of samples is required to proceed. With this information, and the known depth and volume of excavation required along the proposed stream, a sampling plan may be developed and implemented early in the final design process.

Placement of Fill Material. Excavating soil for the proposed stream channel, wetlands and ponds will generate a large quantity of excess material. Prior to further discussion and analysis of the soil quality, it is not clear exactly how much material, if any, will need to be hauled offsite. To minimize the amount of hauling and reduce costs, it will be beneficial to maximize the reuse of soil on site. This requires refining the criteria for placement of fill material on and within the easements of existing infrastructure, including sanitary and storm sewer pipes owned by St Paul Public Works and Metropolitan Council. Public Works has indicated that the 36" storm sewer pipe that enters the site from the west just south of Jenks Avenue and runs south to Sims Agate Pond can probably support some additional fill on top of it, but they have not yet quantified that amount. Likewise, Metropolitan Council has indicated that fill can be placed on and within the easement of its sanitary interceptor on the east side of the site as long as surface structures are modified to account for the increased ground elevation and analysis shows that the increase in vertical and/or horizontal pressures are acceptable. The design team is proceeding with this prior to beginning the final park design process.

Sims Agate Pond. MnDOT has proposed modifications to Sims Agate Pond to accommodate encroachment into the pond area that is proposed during construction of an interchange at I-35E and Cayuga Avenue. Additionally, the Trillium Site Workgroup members agreed that modifications should be made, if possible, to Sims Agate Pond that would improve its safety, aesthetics and ecological function. St. Paul Public Works has agreed that modifications to the pond are acceptable if all stormwater functions, including water quality and rate control, can be accommodated either within the modified pond or elsewhere in the watershed. Demonstration of this through modeling is underway in advance of the start of final design.

Stormwater Treatment. The stormwater treatment elements proposed on the site need to be designed. The pond and wetland designs will be based on providing volume credits to meet 2-inch banking criteria for the Hatch-Agate RSVP direct drainage area, meeting water quality design criteria, and meeting rate control criteria. The design criteria will adhere to CRWD standards, mitigate Sims Pond modifications as described above, meet aesthetic criteria that will be developed with CRWD and St. Paul Parks and Recreation, and include any ecologically specific needs of the new stream that may go beyond those criteria (for example increasing water hardness to decrease metals toxicity). The location and size of the stormwater treatment elements should be evaluated based on earthwork impacts on the site and location of known soil contamination.

Extreme Storm Considerations. We have discussed routing the entire runoff from the 1-year, 24-hour storm to stormwater treatment systems on site (approximately 2.5" runoff). The existing City stormwater system is comprised of inlets and storm sewers that are designed to capture and convey runoff from the 10-year, 24-hour storm. Unless future modifications include increasing inlet and conveyance system capacity within Hatch-Agate, overall capacity of the system is not expected to increase even though a portion of the 10-year runoff event will be re-routed to new stormwater elements on site. This will be verified during final design. A portion of the runoff from storms that exceed the 10-year, 24-hour event is expected to flow overland onto the Trillium site from the Hatch-Agate watersheds adjacent to the site on the west. These overland flows will be analyzed in detail during final design to ensure that they are routed through the site without erosion along the overland routes and without damage to the stream. If measures taken to convey these infrequent flows are suitable for conveying the flows that occur with a frequency between 1 year and 10 years, it may be possible to eliminate some storm sewer pipes on the site which may be beneficial for the site design. Elimination of storm sewer within the park should be discussed with Public Works staff after final design modeling of the site is complete.

Stream Design. When the peak flows from larger events are better defined through stormwater modeling described above the channel geometry will be reviewed to ensure that it is appropriate to convey annual peaks as well as less frequent flood flows that may be routed through the stream. Channel bed materials will be sized accordingly, and habitat elements, including pool/riffle sequences and woody debris structures, will be designed. If modifications to Sims Agate Pond are proposed that would shorten the channel from the Case Avenue sewer crossing to the pond, the alignment of this section of the channel may need to be redesigned to ensure that it does not become a barrier to fish and wildlife movement.

Permitting. Daylighting Trout Brook and enhancing other water features on the site will require coordination with multiple permitting agencies. Coverage under the state NPDES permit for stormwater runoff for construction activities will be necessary, and coordination with the City of Saint Paul and the Capitol Region Watershed District will be required to ensure that the site erosion and sediment control practices adequately protect water resources. Enhancements at the Sims Agate Pond may also require a Wetland Conservation Act permit from Minnesota Board of Water and Soil Resources, a 404 permit from the US Army Corps of Engineers, and/or a Public Waters Permit from the Minnesota Department of Natural Resources.

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Appendices

Appendix A – Design Criteria Development Summary

On April 20, 2011, the Capitol Region Watershed District hosted the kickoff meeting for the Trillium Site Water Resource Feature Feasibility Study. Attendees included:

Bob Fossum, CRWD
Mark Doneux, CRWD
Brian Tourtelotte, City of Saint Paul, Parks and Recreation Department
Kathleen Anglo, City of Saint Paul, Parks and Recreation Department
Wesley Saunders-Pearce, City of Saint Paul
Linda Jungwirth, Tri-Area Block Club
Jenny Reed, MN Department of Transportation
Scott Yonke, Ramsey County Parks and Recreation
Jonathon Kusa, HR Green
Marty Melchior, Inter-Fluve
Beth Wentzel, Inter-Fluve

Participants identified objectives for the Trillium Site. The project team intentionally did not limit the scope of the discussion to the current scope of the Trillium Site Water Feature Feasibility Study to ensure that all objectives for the site are understood. After the meeting each objective was evaluated to determine the relevance to the scope of the Feasibility Study (FS). For those objectives that do have implications for the feasibility study, design criteria (DC) for the feasibility study and preliminary design were developed. Those objectives that do not have significant implications for the feasibility study are listed at the end of this document.

Issue Area A: Stream Ecology

Objective 1: Create a stream that is as nature-like as possible.

Relevance to FS: Because the channel will remain buried upstream and downstream of the site in the short term, and the watershed is entirely urban, there are some inherent departures from a natural system. Within these constraints steps can be taken to improve natural function.

DC 1.1: Stream channel geometry will mimic channel geometry typical for a more natural stream in this region and will be adaptable to variable flow conditions including short term storm flows and long term increases due to expansion of the channel and watershed to ensure nature-like conditions in the future.

DC 1.2: Hydrologic and hydraulic conditions in the channel will be sufficient to support some native fish, macroinvertebrates and wildlife that are appropriate for riverine systems.

Objective 2: Create a stream that supports aquatic life.

Relevance to FS: As mentioned under Objective 1, the site is very constrained and realistic expectations regarding aquatic life must be established. However, steps can be taken during the feasibility study and preliminary design to ensure that, to the extent possible, the stream will support native aquatic life.

DC 2.1: The recommendation regarding water sources will include consideration of water quality.

DC 2.2: Given the anticipated conditions, including available water quality and quantity and contiguous size of the resource available in the short and long terms, aquatic life communities and species will be identified that can thrive.

Objective 3: Create a stream and riparian corridor connecting Lake McCarrons and the Mississippi River.

Relevance to FS: Although this study will not include detailed examination of the entire corridor, the preliminary design of the Trillium Site must include consideration of conditions along the proposed corridor to ensure that the design does not preclude future expansion of the corridor. Additionally, the study will include conceptual analysis of available baseflow and stormflows throughout the proposed corridor to assess potential for expansion

DC 3.1: Stream channel geometry (bed elevation, channel shape, planform, etc) through the Trillium site will be consistent with the vision for upstream and downstream expansion.

DC 3.2: The site plan will allow for increased flows that result from project expansion. The increased flows considered will be consistent with results of analytical results of flow availability.

Issue Area B: Stormwater Management

Objective 4: Treat stormwater to improve water quality such that it meets criteria for human contact and aquatic life use to the extent achievable given cost constraints and technology limitations.

Relevance to FS: The feasibility study includes analysis of stormwater treatment.

DC 4.1: Preliminary analysis and design will include stormwater BMPs to treat runoff from the neighborhood located to the west of the site. If feasible, treatment will be sufficient to achieve water quality criteria appropriate for recreation and aquatic life in the stream.

Objective 5: Utilize stormwater runoff as stream flow.

Relevance to FS: The feasibility study includes analysis of multiple potential sources of water for the stream feature including use of stormwater.

DC 5.1: The preliminary design will include use of stormwater to provide flow to the stream on the site to the extent practical.

DC 5.2: The preliminary design will ensure that storm flows in excess of flow rates desired for the water feature will remain in existing conveyance system including existing storm sewer pipes and existing overland flow routes.

Objective 6: Control erosion along hillside due to runoff from streets.

Relevance to FS: The study includes analysis of use of stormwater as stream flow. Stormwater capture from the neighborhood to the west of the site for use in the stream should be achieved in a manner that minimizes erosion.

DC 6.1: The stormwater treatment and conveyance elements proposed for the site will be preliminarily designed to minimize risk of erosion, particularly along the slope on the west side of the site.

Issue Area C: Wetland and Upland Ecology

Objective 7: Create habitat that supports multiple vegetation communities, a variety of fish and wildlife, especially bird life, including ducks.

> Relevance to FS: As mentioned previously, the FS does not include detailed analysis of upland ecological restoration opportunities, but the water features that are the subject of the FS should be compatible with upland restoration objectives. Water features including the stream and wetlands will be designed with consideration for fish and wildlife habitat.
>
> DC 7.1: Analysis and preliminary design of the water features will include habitat recommendations for fish and wildlife, including birds.

Objective 8: Remediate contaminated soils on site as necessary to minimize risks to people and other organisms.

> Relevance to FS: Determination of the need for soil remediation and planning for remediation is beyond the scope of the current study. However, the extent of soil contamination on site will impact how soils can be reused on site for building water features. It also can affect water quality if stormwater runoff flows through soils before reaching the stream.
>
> DC 8.1: The study and preliminary design will be compatible with potential need for soil remediation on the site and consistent with all relevant Response Action and Construction Contingency Plans that have been developed for the site.

Objective 9: Create a natural greenway corridor from the Mississippi River to Lake McCarrons.

> Relevance to FS: As mentioned above, this study will not include detailed examination of the entire corridor, but wetland and upland features on the site should be compatible with this long term objective. The FS also does not include detailed analysis of upland ecological restoration opportunities, but the water features that are the subject of the FS should be compatible with the upland restoration objectives.
>
> DC 9.1: Analysis and preliminary design of the water features will include provision for diverse wetland, pond, and riparian communities that are compatible with the long term vision of establishing a diverse greenway from the Mississippi River to Lake McCarrons.

Issue Area D: Education, Recreation and Aesthetics

Objective 10: Provide a bike and pedestrian trail onsite that is linked to the regional trail system.

> Relevance to FS: Providing detailed design of the trail and connections is outside the scope of the current study, but the study must ensure that such a trail can be incorporated.
>
> DC 10.1: The preliminary analysis and design will ensure that adequate and appropriately located space is available to create a trail on site that can be connected to other trails off site.

Objective 11: Provide attractive, managed views both within the site and of the site from the adjacent neighborhood and regional trail.

Relevance to FS: Designing viewscapes and viewing points is outside the scope of work for the present study. To the extent that location and design of water features may be affect views from key locations, the need to provide viewscapes will be considered in the water feature design.

DC 11.1 – To the extent possible without compromising water feature function, the preliminary design will incorporate flexibility with respect to vegetation types and heights to ensure compatibility with the desire to maintain viewscapes.

DC 11.2 – To the extent practical and allowable, the preliminary water features design will be compatible with potential buffers between the usable areas of the site and the railroad tracks and highway I35E to protect views and reduce noise.

Objective 12: Provide access to water features with bridges over the stream and boardwalks through wetlands.

Relevance to FS: Design of trails and boardwalks is outside of the current scope. This objective will be considered to the extent that it affects the location and layout of water features.

DC 12.1 – Through the design process, consideration will be given to the compatibility of stream crossings and wetland boardwalks with the conservation easement restrictions and other site restrictions. Locations will be identified that may be appropriate for such access features.

Objective 13 – Minimize mosquito population.

Relevance to FS: Mosquitoes are most problematic where stagnant water exists without aquatic predators (such as fish) to consume larvae and where predators on adult mosquitoes (such as dragonflies, birds, and bats) are insufficient. Therefore, the site should be designed to encourage these predators and minimize stagnant water. Bird and bat habitat is outside the scope of the current design.

DC 13.1 – Site water features will be designed to maximize the duration of flowing water, to the extent practical, to minimize availability of stagnant water that is conducive to mosquito reproduction.

DC 13.2 – Site water features will be designed to include suitable habitat for mosquito predators.

Issue Area E – Operation and Maintenance

Objective 14: Create a sustainable design that minimizes maintenance and pumping.

Relevance to FS: The Trout Brook Interceptor and the Sims-Agate pond are two potential water sources for the stream, and both would require pumping. Stormwater BMPs on site will require maintenance.

DC 14.1 – Operation and maintenance requirements, including pumping, will be included in assessment of all source water alternatives.

Objective 15: Ensure that access is sufficient to perform all maintenance and monitoring.

Relevance to FS: Maintenance and operations (including monitoring) are important for the long term success of the project and must be considered early in the planning and design process.

DC 15.1: The preliminary design will ensure that all water features that will require maintenance are accessible by the necessary maintenance equipment.

Issue Area F – General

Objective 16: Establish a model for multi-partner cooperation in creating an amenity that all partners can declare successful.

Relevance to FS: The feasibility study and design process includes involvement of partner agencies and organizations at several times during the process to ensure that objectives and means of satisfying those objectives reflect the needs of the partners involved.

DC 16.1: The analysis and design process will incorporate input from all partners involved.

Objective 17: Ensure that partners understand potential water related regulatory implications of alternatives considered.

Relevance to FS: Creating a new surface water may trigger application of state water quality standards that do not apply to the existing storm sewers. It is possible that application of water quality standards could have regulatory implications for discharges to the new surface water, and it is important to understand what those implications are.

DC 17.1: Minnesota Pollution Control Agency (MPCA) staff will be consulted during the feasibility study. Short and long term regulatory implications of the design alternatives will be documented based on the information MPCA provides. Information about the proposed project will be provided to MPCA for their consideration as they modify their standards.

Objectives Outside of Current Scope of Analysis

Objective 18: Manage plant succession to limit invasive species dominance and develop desired plant communities.

Relevance to FS: Addressing this specific objective will be deferred to future work. This objective will be considered in the feasibility study to the extent that it affects planning and preliminary design of the water features and is incorporated into DC 9.1.

Objective 19: Create a large-scale, natural, interesting, and attractive place with educational opportunities that will be used by people of all ages and abilities and help bring awareness of urban streams to residents.

Relevance to FS: The study and design of educational and recreational facilities will be deferred to future work. To ensure compatibility with this objective, water features should be designed to include diverse conditions that add interest to the site. This is covered by DC 9.1. They should also be accessible, which is covered by DC 12.1.

Objective 20: Manage foot traffic in open areas.

Relevance to FS: Addressing this specific objective will be deferred to future work.

Objective 21: Incorporate monitoring into the operation of the site to demonstrate functions and benefits.

Relevance to FS: Detailed assessment of monitoring opportunities is beyond the scope of this study. To the extent that data gaps are identified during the preliminary analysis and design that could be filled through monitoring on this site, these ideas will be shared with the project partners.

Objective 22: Provide tree protection from beavers.

Relevance to FS: Addressing this specific objective will be deferred to future work.

Appendix B: Spatial Water Budget Parameters

Table B1: Hydrologic Characteristics for Spatial Water Budget Analysis

Hydrologic Characteristics								
Watershed Description	Spatial Water Budget Model	Outfall Description	BARR Node Nomenclature	Adjustments Between Models	Area [ac]	Slope [ft/ft]	Width [ft]	% Imper
Hatch/Agate RSVP	TRT14_A	Northern Outflow	TRT 14	Y	31.39	0.0329	691.82	47.91%
	TRT14_B	Middle Outflow	TRT 14	Y	41.61	0.0329	726.74	24.34%
	TRT14_C	Southern Outflow	TRT 14	Y	77.52	0.0428	1268.77	15.14%
	TRT14_D	To Sims Pond	TRT 14	Y	17.20	0.0353	383.47	26.97%
	TRT14_12D	Project Site	Part of TRT14 &12D	Y	39.78	0.0215	541.20	16.59%
From 35E to Site	TRT39	-	TRT39	N	52.96	0.014	724.02	23.70%
	TRT12B_adj	-	TRT12B	Y	42.99	0.020	803.37	20.65%
35E	TRT28	-	TRT28	N	232.86	0.0885	1140.789	29.1%

Table B2: Summary of Statistical Moments

Summary of Statistical Moments												
Node	Runoff Volume, ac-ft		Average Runoff, cfs	Average Runoff Per Event, cfs		Peak Runoff Per Event, cfs		Event Duration, hrs		Inter-Event Duration, days	
	Mean	Std Dev	Mean	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
TRT28	3.26	6.81	0.19	2.43	5.26	14.42	27.67	19.1	17.39	7.98	8.82
TRT39	0.67	1.56	0.04	0.51	1.14	2.91	6.05	18.3	16.99	8.01	8.82
TRT12B_adj	0.45	1.13	0.03	0.42	1.10	2.15	4.86	16.3	15.78	8.03	8.87
TRT14_A	0.42	0.89	0.04	0.28	0.85	2.00	4.40	19.5	19.14	4.66	4.18
TRT14_B	0.30	0.82	0.03	0.22	0.90	1.43	3.88	18.3	18.50	4.66	4.18
TRT14_C	0.30	0.82	0.04	0.30	1.53	1.81	6.16	17.2	18.02	4.65	4.18
TRT14_D	0.14	0.36	0.01	0.10	0.42	0.66	1.76	17.9	18.35	4.66	4.18
TRT14_12D	0.20	0.66	0.02	0.15	0.68	0.95	2.86	18.5	18.63	4.66	4.18

Table B3: Inter-Event Statistics – Duration between rainfall events

Inter- Event Statistics				
Statistics/Min. Rainfall Depth	**0.25"**	**0.5"**	**0.75"**	**1.0"**
Min (days)	0.0	0.0	0.0	0.0
Mean (days)	**6.2**	**10.7**	**18.3**	**26.8**
Max (days)	68.0	76.0	88.0	163.0
Std Dev (days)	7.8	11.3	18.4	28.1

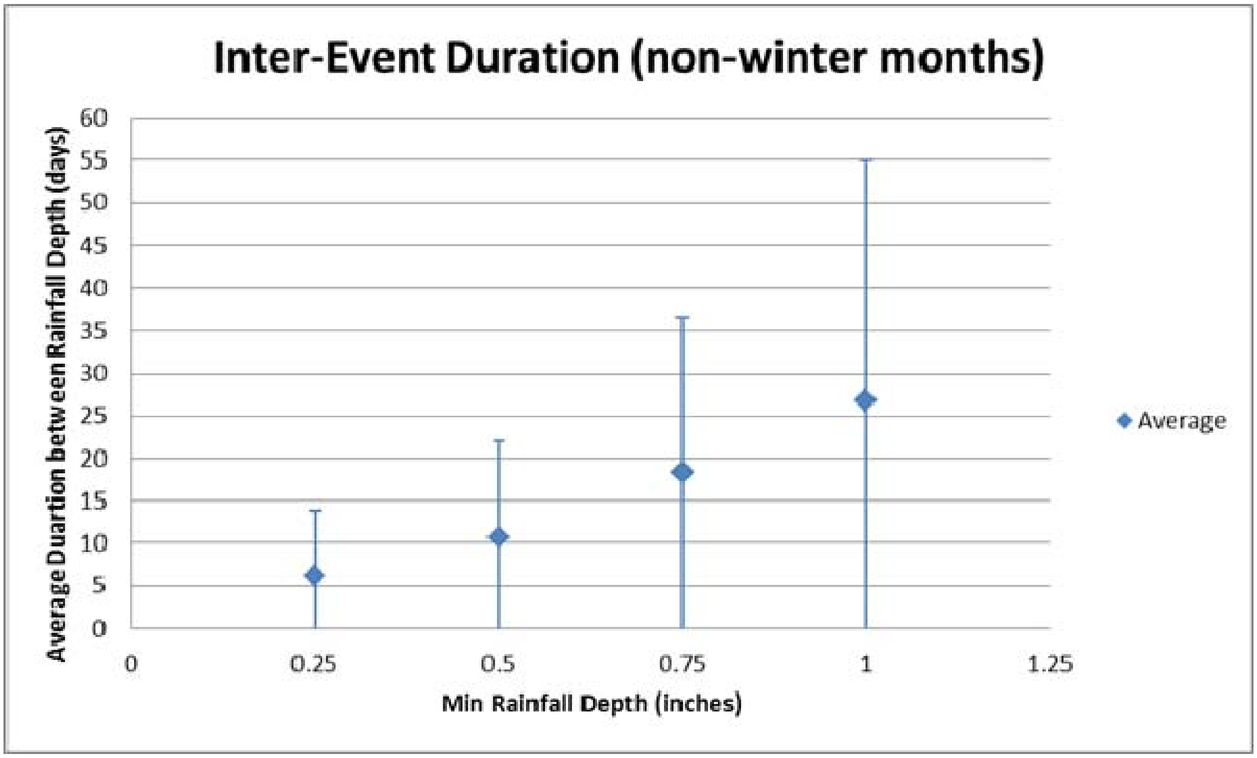


Figure B.1 : Inter-Event Durations

Appendix C: TBI Pipe Flow Results

Table C1: Pipe Flow Parameters for 18" Pipe

18" Pipe		
Assumed:		
TW	18	inch
Ke	0.5	
Length of 18" Pipe	3400	feet
Invert of Interceptor	803.7	
High WSE Monitored for Interceptor	810.97	
Crown of Interceptor	813.7	
18" Max Capacity	3.3	cfs
Average Depth Within Interceptor	0.42	feet

Table C2: Pipe Flow Results for 18" Pipe

HWE (Interceptor)	**Depth in Interceptor (ft)**	**Q through 18" Pipe (cfs)**	**Description**
804.05	0.35	0.5	
804.12	0.42	**0.7**	**Flow through 18" when TBI at average flow depth of 0.42'**
804.21	0.51	1	
804.33	0.63	1.5	
804.44	0.74	**2**	
804.54	0.84	**2.5**	
804.64	0.94	**3**	Potentially install weir up to .94' if 3 cfs targeted
804.69	0.99	**3.3**	Flow when 18" at gravity flow capacity
804.82	1.12	4	
804.9	1.2	4.5	
804.99	1.29	5	
805.75	2.05	5.5	
807.56	3.86	6	
809.53	5.83	6.5	
810.58	6.88	6.75	
811.01	7.31	**6.85**	**Flow through 18" when TBI at highest recorded elevation**
811.66	7.96	7	
812.79	9.09	7.25	
813.67	9.97	7.44	Flow through 18" when TBI at capacity

Table C3: Pipe Flow Parameters for 24" Pipe

24" Pipe		
Assumed:		
TW	24	inch
Ke	0.5	
Length of 24" Pipe	3400	feet
Invert of Interceptor	803.7	
High WSE Monitored for Interceptor	810.97	
Crown of Interceptor	813.7	
24" Max Capacity	7.2	cfs
Average Depth Within Interceptor	0.42	feet

Table C4: Pipe Flow Results for 24" Pipe

HWE (Interceptor)	Depth in Interceptor (ft)	Q through 24" Pipe (cfs)	Description
804.02	0.32	0.5	
804.12	0.42	**0.85**	**Flow through 24" when TBI at average flow depth of 0.42'**
804.16	0.46	1	
804.37	0.67	2	
804.53	0.83	3	Potentially install weir up to .83' if 3 cfs targeted
804.67	0.97	4	
804.8	1.1	5	
804.93	1.23	6	
805.05	1.35	7	
805.07	1.37	**7.2**	Flow when 24" at gravity flow capacity
805.11	1.41	7.5	
805.16	1.46	8	
805.28	1.58	9	
805.39	1.69	10	
805.5	1.8	11	
806.61	2.91	12	
808.33	4.63	13	
810.18	6.48	14	
810.97	7.27	**14.4**	**Flow through 24" when TBI at highest reorded elevation**
811.16	7.46	14.5	
812.18	8.48	15	
813.23	9.53	15.5	
813.7	10	15.72	Flow through 24" when TBI at capacity

Appendix D: Pond Sizing

Table D1: Pond/Wetland Volumes for Sub-watershed 1

Pretreatment for Hatch/Agate sub-watershed 1					
	Elevation [ft]	Surface Area [sq. ft]	Surface Area [acres]	Volume [cubic ft]	Volume [ac-ft]
3' deep pond	815	13483.51	0.31	24299.86	0.56
	813	10816.35	0.25	8845.285	0.20
	812	6874.22	0.16	11685.17	0.27
	810	4810.95	0.11		
			Dead Pool Volume=	**20530.46**	**0.47**
			Active Volume=	**24299.86**	**0.56**
			Total Volume=	**44830.32**	**1.03**
Wetland	799	12121.63	0.28	11468.99	0.26
	798	10816.35	0.25	10192.01	0.23
	797	9567.67	0.22		
			Dead Pool Volume=	**10192.01**	**0.23**
			Active Volume=	**11468.99**	**0.26**
			Total Volume=	**21661**	**0.50**

Table D2: Pond/Wetland Volumes for Sub-watershed 2

Pretreatment for Hatch/Agate sub-watershed 2					
	Elevation [ft]	Surface Area [sq. ft]	Surface Area [acres]	Volume [cubic ft]	Volume [ac-ft]
3' deep pond	808	16376.69	0.38	29753.03	0.68
	806	13376.34	0.31	11127.42	0.26
	805	8878.5	0.20	15359.95	0.35
	803	6481.45	0.15		
			Dead Pool Volume=	**26487.37**	**0.61**
			Active Volume=	**29753.03**	**0.68**
			Total Volume=	**56240.4**	**1.29**
Wetland	797	15786.11	0.36	14847.15	0.34
	796	13908.18	0.32	12997.49	0.30
	795	12086.8	0.28		
			Dead Pool Volume=	**12997.49**	**0.30**
			Active Volume=	**14847.15**	**0.34**
			Total Volume=	**27844.64**	**0.64**

Table D3: Pond/Wetland Volumes for Sub-watershed 3

Pretreatment for Hatch/Agate sub-watershed 3					
	Elevation [ft]	Surface Area [sq. ft]	Surface Area [acres]	Volume [cubic ft]	Volume [ac-ft]
3' deep pond	790	26311.73	0.60	48837.03	1.12
	788	22525.3	0.52	19621.44	0.45
	787	16717.58	0.38	30252.39	0.69
	785	13534.81	0.31		
	Dead Pool Volume=			**49873.83**	**1.14**
	Active Volume=			**48837.03**	**1.12**
	Total Volume=			**98710.86**	**2.27**
Wetland	788	24390.22	0.56	23457.76	0.54
	787	22525.3	0.52	21621.13	0.50
	786	20716.96	0.48		
	Dead Pool Volume=			**21621.13**	**0.50**
	Active Volume=			**23457.76**	**0.54**
	Total Volume=			**45078.89**	**1.03**

Appendix E - Decision Criteria Matrix

Table E1:

Alternatives	Decision Criteria															Cost			
	Description	Pros	Cons	Is there Base Flow?	Pumping Required?	Utility Conflicts?	Maximum Bury Depth? (ft)	Open Cut Length (ft)	Bore Length (ft)	Existing public ROW available?	Railroad Easements needed?	Potential for future stream extension along alignment?	Stormwater Treatment Credit	Estimated Proposed Pipe Size (in)	Water Quality of Source?	Capital	O&M	40 yr Cost	Total Cost
Arlington/Jackson Pond: Option 1	Route stormsewer from Arlington/Jackson outfall west, then south along north (active) RR alignment. Install pipe by open trench through salvage yard.	Bury depth of pipe is shallow - future daylighting possible if property aquired.	Coming through NE corner of Maryland is tight - likely need to jack through embankment. Temporary and Permanent easements needed.	Y	N	Move water and gas line	45	4066	4726	No	Yes	Yes	No	24	High	$ 1,698,000.00	$ 11,000.00	$ 440,000.00	$ 2,138,000.00
Arlington/Jackson Pond: Option 1B	Same as Option 1C below but install pipe through trenchless methods through salvage yard.	Less impact to easment areas in salvage yard than Option 1. Less temporary easement.	Coming through NE corner of Maryland is tight - likely need to jack through embankment. Temporary and Permanent easements needed.More expensive than Option 1	Y	N	No	45	2289	2437	No	Yes	Yes	No	24	High	$ 2,562,000.00	$ 11,000.00	$ 440,000.00	$ 3,002,000.00
Arlington/Jackson Pond: Option 1C	Route stormsewer from Arling/Jackson outfall west, then south boring under active RR before moving east to prevent crossing MCES interceptor multiple times	Only crossing MCES interceptor one time	Coming through NE corner of Maryland is tight - likely need to jack through embankment. Temporary and Permanent easements needed.	Y	N	No	49	4000	727	No	Yes	Yes	No	24	High	$ 1,604,000.00	$11,000.00	$ 440,000.00	$ 2,044,000.00
Arlington/Jackson Pond: Option 2	Route stormsewer from Arlington/Jackson outfall west, then south along south (inactive) RR alignment	Within ROW that may be aquired for future trail.	Large hill at RR, tunelling needed. Future surface stream expansion more difficult than Option 1.	Y	N	No	49	4204	307	No	Yes	No	No	24	High	$ 1,434,000.00	$ 10,500.00	$ 420,000.00	$ 1,854,000.00
Arlington/Jackson Pond: Option 3	Rebuild splitter at TBI just east of Jackson, construct new pipe adjacent to TBI along same alignment.	Proposed pipe would be within CRWD easement.	Construction would expose one side of TBI - structural concerns; RR crossing needed; likely difficult to stay within CRWD easement during construction	Y	N		33			Yes, Existing CRWD Permanent Easement, No Temporary	Yes	Yes	No	24	High				
Arlington/Jackson Pond: Option 4	Alignment south on Jackson then follows (active) RR alignment	Direct route to Trillium Site.	Connection point a TBI is too low to allow for gravity discharge to Trillium site.	N	Y	Yes, can not clear Sanitary pipe	62			No	Yes		No	24	High				
35-E Reconstruction	Collect water from 35E watersheds, route down Gateway trail easement	Large drainage area to site. Alignment along existing Gateway Trail possible.	RR crossing, temporary and permanent easement needed.	N	N	No	17				Yes	No	Yes		Medium				
Hatch/Agate RSVP 1	Route runoff from sub-watershed 1 to pretreatment feature in W of project site	Direct runoff to Trillium Site.	Lower water quality and small drainage areas.	N	N	No				Yes	No		Yes	18	Medium	$ 386,164.31	$ 2,500.00	$ 100,000.00	$ 486,164.31
Hatch/Agate RSVP 2	Route runoff from sub-watershed 2 to pretreatment feature in W of project site	Direct runoff to Trillium Site.	Lower water quality and small drainage areas.	N	N	No				Yes	No		Yes	18	Medium	$ 277,724.59	$ 2,500.00	$ 100,000.00	$ 377,724.59
Hatch/Agate RSVP 3	Route runoff from sub-watershed 3 to pretreatment feature in W of project site	Direct runoff to Trillium Site.	Lower water quality and small drainage areas.	N	N	No				Yes	No		Yes	18	Medium	$ 324,450.44	$ 2,500.00	$ 100,000.00	$ 424,450.44
Hatch/Agate RSVP 4	Route runoff from sub-watershed 4 to pretreatment feature in W of project site	Direct runoff to Trillium Site.	Lower water quality and small drainage areas.	N	N	No				Yes	No		Yes	18	Medium				
Hatch/Agate RSVP 5	Project Site	Runoff could not be directed to a new water feature on the Trillium Site.	Runoff may only be directed to Sims Agate Pond.	N	N	No				Yes	No			18	Medium				
Sylvan/Orange: Option1	Bring runoff from W watersheds From point S of TBI, up to RR, then along N RR to project site			N	N						No				Medium				
Sylvan/Orange: Option2	Bring runoff from W watersheds From TBI point down to RR, then along N RR to project site			N	N						No				Medium				
Sylvan/Orange: Option3	Bring runoff from watersheds W of RSVP by connecting existing storm sewers			N	N						No				Medium				
Recirculation Pumping of Sims Pond	Pump water from Sim/Agate Pond to top of stream			N	Y			3000		Yes	No				Low	$ 703,000.00	$ 20,000.00	$ 800,000.00	$ 1,503,000.00
Trout Brook Pumping at Site	NE connection into TBI, pump water from TBI into stream			Y	Y		15	700	200	Yes					Medium	$ 632,000.00	$ 18,000.00	$ 721,000.00	$ 1,353,000.00

Appendix F: Cost Estimates

Table F1: Arlington Option #1 Construction Cost

Alignment: **Arlington/Jackson Pond: Option 1**

Total Alignment Length	4726	ft
Open Cut Length	4066	ft
Length in Street	45	ft
Bore Length	660	ft

Item	Description	Units	Quantity	HRG Unit Cost	Total Cost
	Arlington/Jackson Pond				
1	Inlet Reconstruction at Arlington Pond	each	1	$ 4,000.00	$ 4,000.00
	Street Crossing				
2	Saw cut pavement	LF	45	$ 3.00	$ 135.00
3	Remove pavement	SY	50	$ 6.00	$ 300.00
4	Remove curb and gutter	LF	20	$ 3.00	$ 60.00
5	Repave (assume 4" bituminous section and aggregate)	SY	50	$ 50.00	$ 2,500.00
6	Replace curb and gutter	LF	20	$ 20.00	$ 400.00
	Construct 18" Pipe				
7	Furnish and Install 18" RCP (Class III assumed)	LF	4066	$ 45.00	$ 182,970.00
	Construct Manholes				
	Manhole	each	14	$ 4,000.00	$ 56,000.00
	TBI Connection				
12	Connection into Trout Brook	each	1	$ 20,000.00	$ 20,000.00
	Utilities				
13	Crossings - Insulation, additional support	each	8	$ 500.00	$ 4,000.00
14	Relocate gas line	each	2	$ 5,000.00	$ 10,000.00
15	Relocate water line	each	1	$ 2,000.00	$ 2,000.00
16	Auger Bore (under rail)	160	LF	See Table F2	$ 120,219.47
17	Directional Bore (remainder of project)	500	LF	See Table F2	$ 160,054.37
19	Dewatering	lump sum	1	$ 50,000.00	$ 50,000.00
20	Traffic Maintenance	lump sum	1	$ 10,000.00	$ 10,000.00
21	Hydrodynamic Separator	each	1	$ 25,000.00	$ 25,000.00
22	Erosion Control	lump sum	1	$ 50,500.00	$ 50,500.00
23	Vegetative Restoration	lump sum	1	$ 20,000.00	$ 20,000.00
24	Mobilization	lump sum	1	$ 90,000.00	$ 90,000.00
				Subtotal	$ 808,138.84
			Contingency	20%	$ 161,627.77
				Construction Subtotal	$ 969,766.61
				Easement Cost	$ 360,000.00
				TOTAL	**$ 1,329,766.61**

Table F2: Arlington Option #1 Boring Costs

Auger Bore

Pipe Diameter	18	in
Casing Diameter	24	in

Item	Desciption	Units	Quantity	Unit Cost	Total Cost
	Pit	each	2	$ 15,000.00	$ 30,000.00
	5 Man Crew	per day	10	$ 2,800.00	$ 28,000.00
	Auger Machine	per day	10	$ 600.00	$ 6,000.00
	Generator	per day	10	$ 500.00	$ 5,000.00
	Compressor	per day	10	$ 250.00	$ 2,500.00
	Backhoe	per day	10	$ 1,200.00	$ 12,000.00
	Loader	per day	10	$ 500.00	$ 5,000.00
	Casing (7/8" thick, 24" diameter)	LF	160	$ 150.00	$ 24,000.00
	18" RCP (Push-on joint)	LF	160	$ 40.00	$ 6,400.00
	Grout	CF	220	$ 6.00	$ 1,319.47
				Subtotal	$ 120,219.47

	# of Days Needed
Mobilization	1
Setup	3
Bore (100' per day)	2
Grout	1
Breakdown	2
Demob	1
Total # of days =	10

Directional Bore

Item	Desciption	Units	Quantity	Unit Cost	Total Cost
	Pit	each	2	$ 5,000.00	$ 10,000.00
	5 Man Crew	per day	16	$ 2,800.00	$ 44,800.00
	Direct Bore Rig	per day	16	$ 3,500.00	$ 56,000.00
	Generator	per day	16	$ 400.00	$ 6,400.00
	Compressor	per day	16	$ 200.00	$ 3,200.00
	Backhoe	per day	16	$ 1,200.00	$ 19,200.00
	Loader	per day	16	$ 500.00	$ 8,000.00
	18" HDPE	LF	500	$ 20.00	$ 10,000.00
	Bentonite	CY	33	$ 50.00	$ 1,636.25
	Bentonite Disposal	CY	33	$ 25.00	$ 818.12
				Subtotal	$ 160,054.37

	# of Days Needed
Mobilization	1
Setup	2
Bore (100' per day)	5
Weld Pipe	2
Pull Pipe/Dispose Ber	2
Connect	1
Breakdown	1
Demob	1
Total # of Days =	15

Table F3: Arlington Option #1 O&M Costs

Item	Description	Units	Quantity	Unit Cost	Total Cost
1	Pipe Flushing	hr	38	$ 235.00	$ 8,930.00
2	Hydrodynamic Separator Cleaning	lump sum	1	$ 2,000.00	$ 2,000.00
				Total Annual	$ 10,930.00
		O&M*40		40 yr cost	$ 437,200.00

Table F4: Arlington Option #1B Construction Cost

Alignment: **Arlington/Jackson Pond: Option 1B**

Total Alignment Length	4726	ft
Open Cut Length	2289	ft
Length in Street	45	ft
Bore Length	2437	ft

Item	Description	Units	Quantity		HRG Unit Cost		Total Cost
	Arlington/Jackson Pond						
1	Inlet Reconstruction at Arlington Pond	each	1	$	4,000.00	$	4,000.00
	Street Crossing						
2	Saw cut pavement	LF	45	$	3.00	$	135.00
3	Remove pavement	SY	50	$	6.00	$	300.00
4	Remove curb and gutter	LF	20	$	3.00	$	60.00
5	Repave (assume 4" bituminous section and aggregate)	SY	50	$	50.00	$	2,500.00
6	Replace curb and gutter	LF	20	$	20.00	$	400.00
	Construct 18" Pipe						
7	Furnish and Install 18" RCP (Class III assumed)	LF	2289	$	45.00	$	103,005.00
	Construct Manholes						
	Manhole	each	8	$	4,000.00	$	32,000.00
	TBI Connection						
12	Connection into Trout Brook	each	1	$	20,000.00	$	20,000.00
	Utilities						
13	Crossings - Insulation, additional support	each	8	$	500.00	$	4,000.00
14	Relocate gas line	each	2	$	5,000.00	$	10,000.00
15	Relocate water line	each	1	$	2,000.00	$	2,000.00
16	Auger Bore (under rail)	160	LF		See Table F5	$	771,412.19
17	Directional Bore (remainder of project)	2277	LF		See Table F5	$	299,456.25
19	Dewatering	lump sum	1	$	50,000.00	$	50,000.00
20	Traffic Maintainance	lump sum	1	$	10,000.00	$	10,000.00
21	Hydrodynamic Separator	each	1	$	25,000.00	$	25,000.00
22	Erosion Control	lump sum	1	$	85,000.00	$	85,000.00
23	Vegetative Restoration	lump sum	1	$	34,000.00	$	34,000.00
24	Mobilization (~10%)	lump sum	1	$	170,000.00	$	170,000.00
					Subtotal	$	1,419,268.44
			Contingency		20%	$	283,853.69
					Construction Subtotal	$	1,703,122.13
					Easement Cost	$	360,000.00
					TOTAL	**$**	**2,063,122.13**

Table F5: Arlington Option #1B Boring Costs

Auger Bore

Item	Desciption	Units	Quantity	Unit Cost	Total Cost
	Pit	each	7	$ 20,000.00	$ 140,000.00
	5 Man Crew	per day	31	$ 2,800.00	$ 86,156.00
	Auger Machine	per day	31	$ 600.00	$ 18,462.00
	Generator	per day	31	$ 500.00	$ 15,385.00
	Compressor	per day	31	$ 250.00	$ 7,692.50
	Backhoe	per day	31	$ 1,200.00	$ 36,924.00
	Loader	per day	31	$ 500.00	$ 15,385.00
	Casing (7/8" thick, 24" diameter)	LF	2277	$ 150.00	$ 341,550.00
	18" RCP (Push-on joint)	LF	2277	$ 40.00	$ 91,080.00
	Grout	CF	3130	$ 6.00	$ 18,777.69
				Subtotal	$ 771,412.19

	# of Days Needed
Mobilization	1
Setup	3
Bore (100' per day)	23
Grout	1
Breakdown	2
Demob	1
Total # of days =	31

Directional Bore

Item	Desciption	Units	Quantity	Unit Cost	Total Cost
	Pit	each	2	$ 5,000.00	$ 10,000.00
	5 Man Crew	per day	0	$ 2,800.00	$ -
	Direct Bore Rig	per day	0	$ 3,500.00	$ -
	Generator	per day	0	$ 400.00	$ -
	Compressor	per day	0	$ 200.00	$ -
	Backhoe	per day	0	$ 1,200.00	$ -
	Loader	per day	0	$ 500.00	$ -
	18" HDPE	LF	160	$ 20.00	$ 3,200.00
	Bentonite	CY	33	$ 50.00	$ 1,637.50
	Bentonite Disposal	CY	33	$ 25.00	$ 818.75
				Subtotal	$ 299,456.25

	# of Days Needed
Mobilization	1
Setup	2
Bore (100' per day)	23
Weld Pipe	2
Pull Pipe/Dispose Ber	2
Connect	1
Breakdown	1
Demob	1
Total # of Days =	33

Table F6: Arlington Option #1B O&M Cost

Item	Description	Units	Quantity	Unit Cost	Total Cost
1	Pipe Flushing	hr	38	$ 235.00	$ 8,930.00
2	Hydrodynamic Separator Cleaning	lump sum	1	$ 2,000.00	$ 2,000.00
				Total Annual	$ 10,930.00
		O&M*40		40 yr cost	$ 437,200.00

Table F7: Arlington Option #1C Construction Cost

Alignment: **Arlington/Jackson Pond: Option 1C**

Total Alignment Length	4726	ft
Open Cut Length	3999	ft
Length in Street	45	ft
Bore Length	727	ft

Item	Description	Units	Quantity	HRG Unit Cost	Total Cost
	Arlington/Jackson Pond				
1	Inlet Reconstruction at Arlington Pond	each	1	$ 4,000.00	$ 4,000.00
	Street Crossing				
2	Saw cut pavement	LF	45	$ 3.00	$ 135.00
3	Remove pavement	SY	50	$ 6.00	$ 300.00
4	Remove curb and gutter	LF	20	$ 3.00	$ 60.00
5	Repave (assume 4" bituminous section and aggregate)	SY	50	$ 50.00	$ 2,500.00
6	Replace curb and gutter	LF	20	$ 20.00	$ 400.00
	Construct 18" Pipe				
7	Furnish and Install 18" RCP (Class III assumed)	LF	3999	$ 45.00	$ 179,955.00
	Construct Manholes				
8	Manhole	each	14	$ 4,000.00	$ 56,000.00
	TBI Connection				
12	Connection into Trout Brook	each	1	$ 20,000.00	$ 20,000.00
	Utilities				
13	Crossings - Insulation, additional support	each	8	$ 500.00	$ 4,000.00
14	Relocate gas line	each	2	$ 5,000.00	$ 10,000.00
15	Relocate water line	each	1	$ 2,000.00	$ 2,000.00
16	Auger Bore (under rail)	160	LF	See Table F8	$ 267,725.34
19	Dewatering	lump sum	1	$ 50,000.00	$ 50,000.00
20	Traffic Maintenance	lump sum	1	$ 10,000.00	$ 10,000.00
21	Hydrodynamic Separator	each	1	$ 25,000.00	$ 25,000.00
22	Erosion Control	lump sum	1	$ 48,000.00	$ 48,000.00
23	Vegetative Restoration	lump sum	1	$ 19,000.00	$ 19,000.00
24	Mobilization	lump sum	1	$ 95,000.00	$ 95,000.00
				Subtotal	$ 794,075.34
			Contingency	20%	$ 158,815.07
				Construction Subtotal	$ 952,890.40
				Easement Cost	$ 320,000.00
				TOTAL	**$ 1,272,890.40**

Table F8: Arlington Option #1C Boring Costs

Auger Bore

Pipe Diameter	18	in
Casing Diameter	24	in

Item	Desciption	Units	Quantity	Unit Cost	Total Cost
1	Pit	each	2	$15,000.00	$ 30,000.00
2	5 Man Crew	per day	16	$ 2,800.00	$ 44,800.00
3	Auger Machine	per day	16	$ 600.00	$ 9,600.00
4	Generator	per day	16	$ 500.00	$ 8,000.00
5	Compressor	per day	16	$ 250.00	$ 4,000.00
6	Backhoe	per day	16	$ 1,200.00	$ 19,200.00
7	Loader	per day	16	$ 500.00	$ 8,000.00
8	Casing (7/8" thick, 24" diameter)	LF	727	$ 150.00	$109,050.00
9	18" RCP (Push-on joint)	LF	727	$ 40.00	$ 29,080.00
10	Grout	CF	999	$ 6.00	$ 5,995.34
				Subtotal	**$267,725.34**

	# of Days Needed
Mobilization	1
Setup	3
Bore (100' per day)	8
Grout	1
Breakdown	2
Demob	1
Total # of days =	16

Table F9: Arlington Option #1C O&M Cost

Item	Description	Units	Quantity	Unit Cost	Total Cost
1	Pipe Flushing	hr	38	$ 235.00	$ 8,930.00
2	Hydrodynamic Separator Cleaning	lump sum	1	$ 2,000.00	$ 2,000.00
				Total Annual	$ 10,930.00
		O&M*40		40 yr cost	$ 437,200.00

Table F10: Arlington Option #2 Construction Cost

Alignment: Arlington/Jackson Pond: Option 2

Total Alignment Length	4511	ft
Open Cut Length	4204	ft
Length in Street	45	ft
Bore Length	307	ft

Item	Description	Units	Quantity	HRG Unit Cost	Total Cost
	Arlington/Jackson Pond				
1	Inlet Reconstruction at Arlington Pond	each	1	$ 4,000.00	$ 4,000.00
	Street Crossing				
2	Saw cut pavement	LF	45	$ 3.00	$ 135.00
3	Remove pavement	SY	50	$ 6.00	$ 300.00
4	Remove curb and gutter	LF	20	$ 3.00	$ 60.00
5	Repave (assume 4" bituminous section and aggregate)	SY	50	$ 50.00	$ 2,500.00
6	Replace curb and gutter	LF	20	$ 20.00	$ 400.00
	Construct 18" Pipe				
7	Furnish and Install 18" RCP (Class III assumed)	LF	4204	$ 45.00	$ 189,180.00
	Construct Manholes				
8	Manhole	each	14	$ 4,000.00	$ 56,000.00
	TBI Connection				
9	Connection into Trout Brook	each	1	$ 20,000.00	$ 20,000.00
	Utilities				
10	Crossings - Insulation, additional support	each	4	$ 500.00	$ 2,000.00
11	Auger Bore (under rail)	307	LF	See Table F11	$ 171,062.00
13	Dewatering	lump sum	1	$ 50,000.00	$ 50,000.00
14	Traffic Maintainance	lump sum	1	$ 10,000.00	$ 10,000.00
15	Hydrodynamic Separator	each	1	$ 25,000.00	$ 25,000.00
16	Erosion Control	lump sum	1	$ 43,000.00	$ 43,000.00
17	Vegetative Restoration	lump sum	1	$ 17,000.00	$ 17,000.00
18	Mobilization (~10%)	lump sum	1	$ 85,000.00	$ 85,000.00
				Subtotal	$ 675,637.00
			Contingency	20%	$ 135,127.40
				Construction Subtotal	$ 810,764.40
				Easement Cost	$ 320,000.00
				TOTAL	**$ 1,130,764.40**

Table F11: Arlington Option #2 Boring Costs

Auger Bore

Item	Desciption	Units	Quantity	Unit Cost	Total Cost
1	Pit	each	2	$20,000.00	$ 40,000.00
2	5 Man Crew	per day	12	$ 2,800.00	$ 33,600.00
3	Auger Machine	per day	12	$ 600.00	$ 7,200.00
4	Generator	per day	12	$ 500.00	$ 6,000.00
5	Compressor	per day	12	$ 250.00	$ 3,000.00
6	Backhoe	per day	12	$ 1,200.00	$ 14,400.00
7	Loader	per day	12	$ 500.00	$ 6,000.00
8	Casing (7/8" thick, 24" diameter)	LF	307	$ 150.00	$ 46,050.00
9	18" RCP (Push-on joint)	LF	307	$ 40.00	$ 12,280.00
10	Grout	CF	422	$ 6.00	$ 2,532.00
				Subtotal	**$171,062.00**

	# of Days Needed
Mobilization	1
Setup	3
Bore (100' per day)	4
Grout	1
Breakdown	2
Demob	1
Total # of days =	12

Table F12: Arlington Option #2 O&M Cost

Item	Description	Units	Quantity	Unit Cost	Total Cost
1	Pipe Flushing	hr	36	$ 235.00	$ 8,460.00
2	Hydrodynamic Separator Cleaning	lump sum	1	$ 2,000.00	$ 2,000.00
				Total Annual	$ 10,460.00
		O&M*40		40 yr cost	$ 418,400.00

Table F13: Hatch/Agate Construction Cost

Sub-watershed: 1

3' Deep Pond

Item	Description	Units	Quantity	Unit Cost		Total Cost	
	Flow Diversion						
1	Low Flow Weir	each	3	$	4,000.00	$	12,000.00
	Pretreatment Ponds						
2	Excavation	CY	15775	$	5.00	$	78,875.00
3	Riprap	CY	0	$	90.00	$	-
4	Flared end section	each	1	$	500.00	$	500.00
5	Install 18" RCP	LF	225	$	45.00	$	10,125.00
6	Clearing	Acre		$	1,200.00	$	-
7	Grubbing	Acre		$	600.00	$	-
8	Mobilization (10%)	lump sum		$	10,200.00	$	-
9	Restoration (pond/wetland only) (2%)	lump sum		$	2,000.00	$	-
10	Traffic Maintenance	lump sum		$	5,000.00	$	-
11	Erosion Control (5%)	lump sum		$	5,100.00	$	-
				Subtotal		$	101,500.00
			Contingency	30%		$	30,450.00
				Total		**$**	**131,950.00**

Sub-watershed: 2

3' Deep Pond

Item	Description	Units	Quantity	Unit Cost		Total Cost	
	Flow Diversion						
1	Low Flow Weir	each	3	$	4,000.00	$	12,000.00
	Pretreatment Ponds						
2	Excavation	CY	11217	$	5.00	$	56,085.00
3	Fill	CY	260	$	12.00	$	3,120.00
4	Riprap	CY	0	$	90.00	$	-
5	Flared end section	each	1	$	500.00	$	500.00
6	Install 18" RCP	LF	20	$	45.00	$	900.00
7	Clearing	Acre		$	1,200.00	$	-
8	Grubbing	Acre		$	600.00	$	-
9	Mobilization (10%)	lump sum		$	6,100.00	$	-
10	Restoration (pond/wetland only) (2%)	lump sum		$	1,200.00	$	-
11	Traffic Maintenance	lump sum		$	5,000.00	$	-
12	Erosion Control (5%)	lump sum		$	3,000.00	$	-
				Subtotal		$	72,605.00
			Contingency	30%		$	21,781.50
				Total		**$**	**94,386.50**

Sub-watershed: 3

3' Deep Pond

Item	Description	Units	Quantity		Unit Cost		Total Cost
	Flow Diversion						
1	Low Flow Weir	each	3	$	4,000.00	$	12,000.00
	Pretreatment Ponds						
2	Excavation	CY	13226	$	5.00	$	66,130.00
3	Riprap	CY	0	$	90.00	$	-
4	Flared end section	each	1	$	500.00	$	500.00
5	Install 18" RCP	LF	115	$	45.00	$	5,175.00
6	Clearing	Acre		$	1,200.00	$	-
7	Grubbing	Acre		$	600.00	$	-
8	Mobilization (10%)	lump sum		$	8,400.00	$	-
9	Restoration (pond/wetland only) (2%)	lump sum		$	1,700.00	$	-
10	Traffic Maintenance	lump sum		$	5,000.00	$	-
11	Erosion Control (5%)	lump sum		$	4,200.00	$	-
					Subtotal	$	83,805.00
			Contingency		30%	$	25,141.50
					Total	**$**	**108,946.50**

Table F14: Hatch/Agate O&M Cost

Item	Description	Units	Quantity		Unit Cost		Total Cost
1	Dredging	lump sum	0.05	$	50,000.00	$	2,500.00
					Total	$	2,500.00
		O&M*40 yr			40 yr cost	$	100,000.00

Table F15: TBI Pumping Construction Cost

Pumping Option:	Trout Brook			TBI Depth	786
				Distance	900

Item	Description	Units	Quantity	Unit Cost	Total Cost
	Pump Station Vehicle Access				
1	Remove curb and gutter	LF	10	$ 3.00	$ 30.00
2	Construct drive opening	each	1	$ 5,000.00	$ 5,000.00
3	Grading	SY	25	$ 10.00	$ 250.00
4	Class V aggregate surface	CY	50	$ 22.00	$ 1,100.00
	Pump Station				
5	12" RCP	LF	40	$ 30.00	$ 1,200.00
6	Sump/sediment removal device	each	1	$ 25,000.00	$ 25,000.00
7	Pump manhole	each	1	$ 20,000.00	$ 20,000.00
8	Manifold manhole	each	1	$ 10,000.00	$ 10,000.00
9	1 cfs submersible pumps	each	2	$ 20,000.00	$ 40,000.00
10	Pump control panel	each	1	$ 12,000.00	$ 12,000.00
11	Valves	lump sum	1	$ 10,000.00	$ 10,000.00
12	Electrical hook-up	lump sum	1	$ 15,000.00	$ 15,000.00
13	6" D.I.P. force main	LF	325	$ 100.00	$ 32,500.00
	Crossings: RR and Sanitary Sewer				
14	Auger 6" D.I.P.	LF	200	See Spreadsheet	$ 136,724.67
15	6" D.I.P	LF	500	$ 40.00	$ 20,000.00
16	Surge basin	each	1	$ 1,000.00	$ 1,000.00
17	Flared end section	each	1	$ 500.00	$ 500.00
18	Riprap	CY	15	$ 90.00	$ 1,350.00
20	Restoration (2%)	lump sum	1	$ 7,100.00	$ 7,100.00
21	Traffic maintenance	lump sum	1	$ 3,000.00	$ 3,000.00
22	Dewatering	lump sum	1	$ 20,000.00	$ 20,000.00
23	Erosion Control (5%)	lump sum	1	$ 25,000.00	$ 25,000.00
24	Mobilization (10%)	lump sum	1	$ 35,500.00	$ 35,500.00
					$ 380,374.67
			Contingency	20%	$ 76,074.93
				Construct Subtotal	$ 456,449.60
				Easement Cost	$ 120,000.00
				Total	**$ 576,449.60**

Table F16: TBI Pumping Boring Costs

Auger Boring

Pipe Diameter	6
Casing Diameter	12

Item	Desciption	Units	Quantity	Unit Cost	Total Cost
1	Pit	each	2	$20,000.00	$ 40,000.00
2	5 Man Crew	per day	10	$ 2,800.00	$ 28,000.00
3	Auger Machine	per day	10	$ 600.00	$ 6,000.00
4	Generator	per day	10	$ 500.00	$ 5,000.00
5	Compressor	per day	10	$ 250.00	$ 2,500.00
6	Backhoe	per day	10	$ 1,200.00	$ 12,000.00
7	Loader	per day	10	$ 500.00	$ 5,000.00
8	Casing (7/8" thick, 24" diameter)	LF	200	$ 150.00	$ 30,000.00
9	18" RCP (Push-on joint)	LF	200	$ 37.00	$ 7,400.00
10	Grout	CF	118	$ 7.00	$ 824.67
				Subtotal	**$136,724.67**

	# of Days Needed
Mobilization	1
Setup	3
Bore (100' per day)	2
Grout	1
Breakdown	2
Demob	1
Total # of days =	10

Table F17: TBI Pumping O&M Cost

TBI

Item	Description	Units	Quantity	Unit Cost	Total Cost
	Operation				
1	Power	yr	1	$ 5,520.00	$ 5,520.00
2	Labor	yr	1	$ 10,500.00	$ 10,500.00
	Maintainenance				
3	Rebuild pumps every 5 yrs	yr	0.2	$ 10,000.00	$ 2,000.00
				Total Annual	**$ 18,020.00**
		O&M*40		40 yr cost	$ 720,800.00

Table F18: Recirculation Pumping Construction Cost

Pumping Option: Recirculation of Sims Pond — 15 Δ elevation; 3000 ft

Item	Description	Units	Quantity		Unit Cost		Total Cost
	Pump Station Vehicle Access						
	Grading	CY	25	$	10.00	$	250.00
	Class V aggregate surface	CY	50	$	22.00	$	1,100.00
	Pump Station						
	12" RCP	LF	40	$	30.00	$	1,200.00
	Sump/sediment removal device	each	1	$	25,000.00	$	25,000.00
	Pump manhole	each	1	$	20,000.00	$	20,000.00
	Manifold manhole	each	1	$	10,000.00	$	10,000.00
	1 cfs submersible pumps	each	2	$	20,000.00	$	40,000.00
	Pump control panel	each	1	$	12,000.00	$	12,000.00
	Valves	lump sum	1	$	10,000.00	$	10,000.00
	Electrical hook-up	lump sum	1	$	15,000.00	$	15,000.00
	6" D.I.P. force main	LF	3000	$	100.00	$	300,000.00
	Outlet at Top of Stream						
	Flared end section	each	1	$	500.00	$	500.00
	Riprap	CY	15	$	90.00	$	1,350.00
	Restoration (2%)	lump sum	1	$	9,100.00	$	9,100.00
	Traffic maintenance	lump sum	1	$	-	$	-
	Dewatering	lump sum	1	$	20,000.00	$	20,000.00
	Erosion Control (5%)	lump sum	1	$	22,800.00	$	22,800.00
	Mobilization (10%)	lump sum	1	$	45,600.00	$	45,600.00
					Subtotal	$	488,300.00
			Contingency		20%	$	97,660.00
					Total	**$**	**585,960.00**

Table F19: Recirculation Pumping O&M Cost

Recirculation

Item	Description	Units	Quantity		Unit Cost		Total Cost
	Operation						
1	Power	yr	1	$	7,160.00	$	7,160.00
2	Labor	yr	1	$	10,500.00	$	10,500.00
	Maintainenance						
3	Rebuild pumps every 5 yrs	yr	0.2	$	10,000.00	$	2,000.00
					Total Annual	**$**	**19,660.00**
		O&M*40			40 yr cost	$	786,400.00

Table F20. Stream Construction Cost Estimate

Trillium Site Feasibility Study Engineer's Opinion of Probable Stream Construction Costs 30% Design Level - Not for Construction					
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Cost**
1	Mobilization & Demobilization		Covered by St. Paul Div of Parks and Rec Estimate		
2	Erosion and Pollution Control		Covered by St. Paul Div of Parks and Rec Estimate		
3	Clearing and Grubbing		Covered by St. Paul Div of Parks and Rec Estimate		
4	Earthwork	CY	39,000	$5	$195,000
5	Clay Liner	CY	2,000	$15	$30,000
6	Streambed Material	CY	1,400	$30	$42,000
7	Grade Control Riffle Stone	CY	800	$80	$64,000
8	Woody Debris Placement	EA	100	$200	$20,000
9	Utility Relocation		1	$34,000	$34,000
10	Seeding		Covered by St. Paul Div of Parks and Rec Estimate		
11	Tree Planting		Covered by St. Paul Div of Parks and Rec Estimate		
12	Shrub Planting		Covered by St. Paul Div of Parks and Rec Estimate		
	Contingency			20%	
	TOTAL				**$462,000**

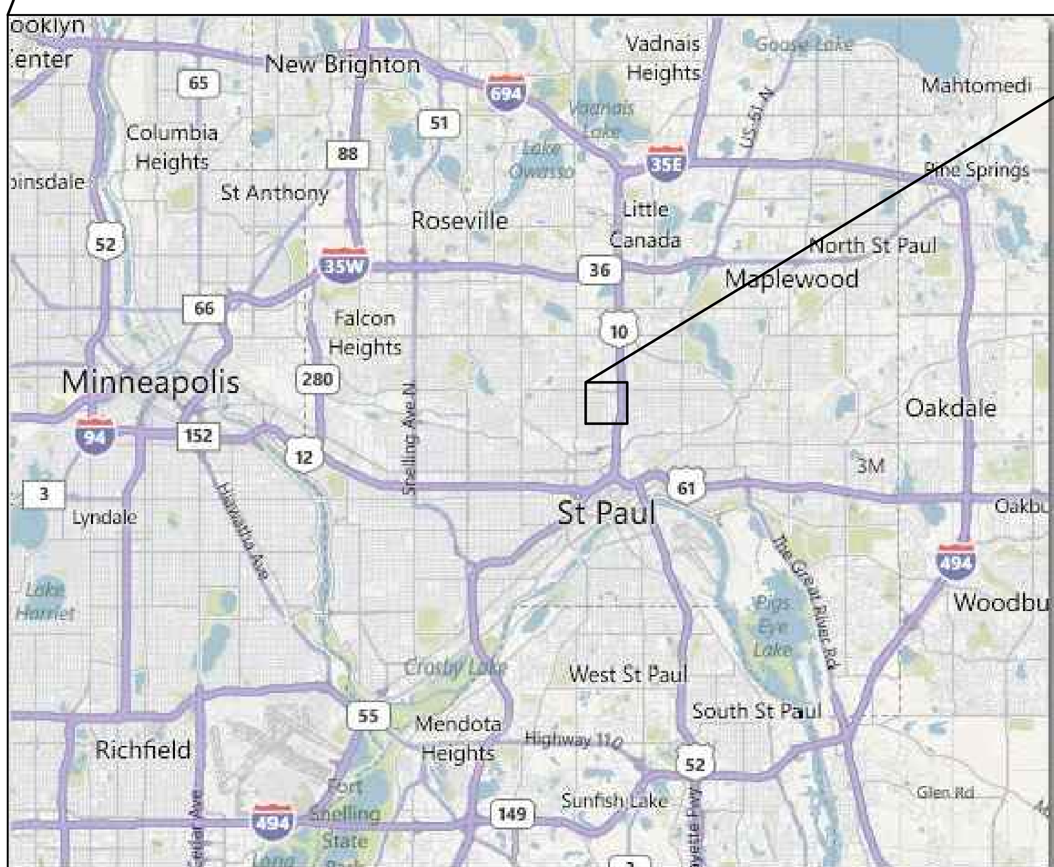
Appendix G – Conceptual Plan Set

TRILLIUM NATURE SANCTUARY
WATER FEATURE FEASIBILITY STUDY

CONCEPT PLAN
SAINT PAUL, MN
MARCH 19, 2012

SHEET INDEX

LOCATION MAP



NO.	BY	DATE	REVISION DESCRIPTION

MBW	MBW	MJM
DRAWN	DESIGNED	CHECKED
x	03/19/12	
APPROVED	DATE	PROJECT

CAPITOL REGION WATERSHED DISTRICT
SAINT PAUL, MN
TRILLIUM NATURE SANCTUARY WATER FEATURES

inter-fluve
3602 Atwood Avenue Suite 3
Madison, WI 53714
608.441.0342
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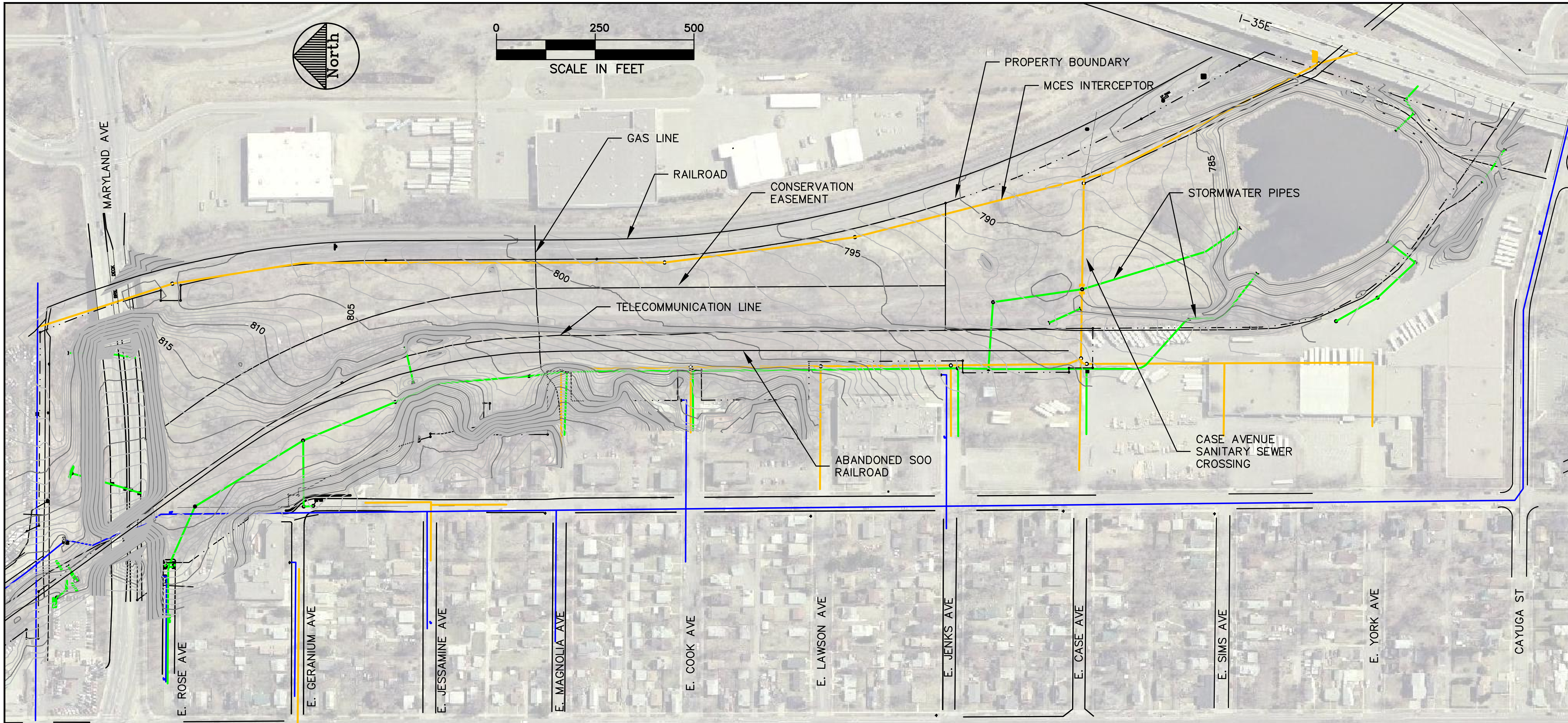
COVER SHEET

SHEET 1 OF 6



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DRAWN	DESIGNED	CHECKED
x	01/17/12	
APPROVED	DATE	PROJECT

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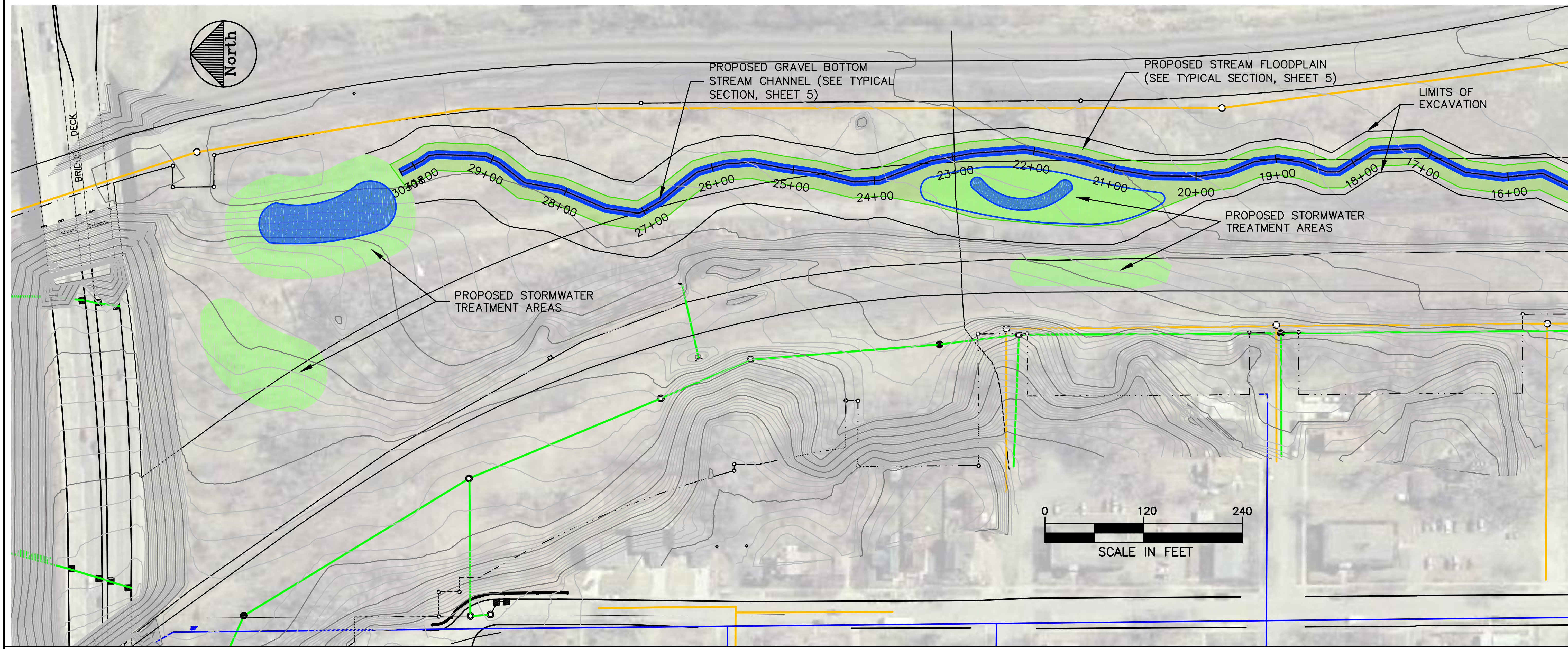
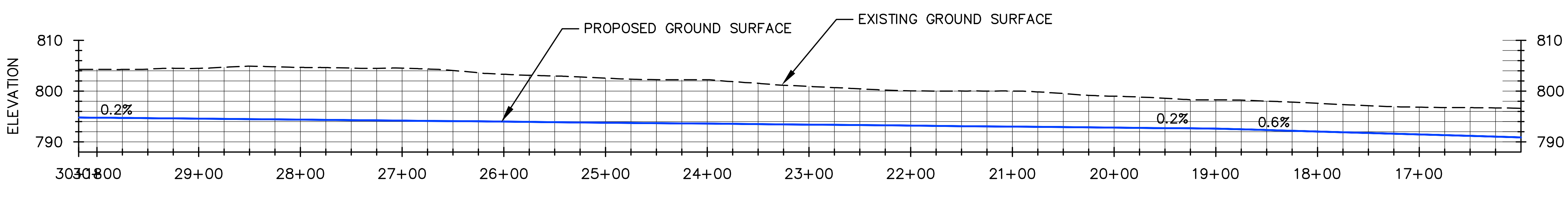
EXISTING CONDITIONS

SHEET 2 OF 6



PLAN VIEW



PROFILE VIEW

NO.	BY	DATE	REVISION DESCRIPTION

MBW	MBW	MJM
DRAWN	DESIGNED	CHECKED
x	03/19/12	
APPROVED	DATE	PROJECT

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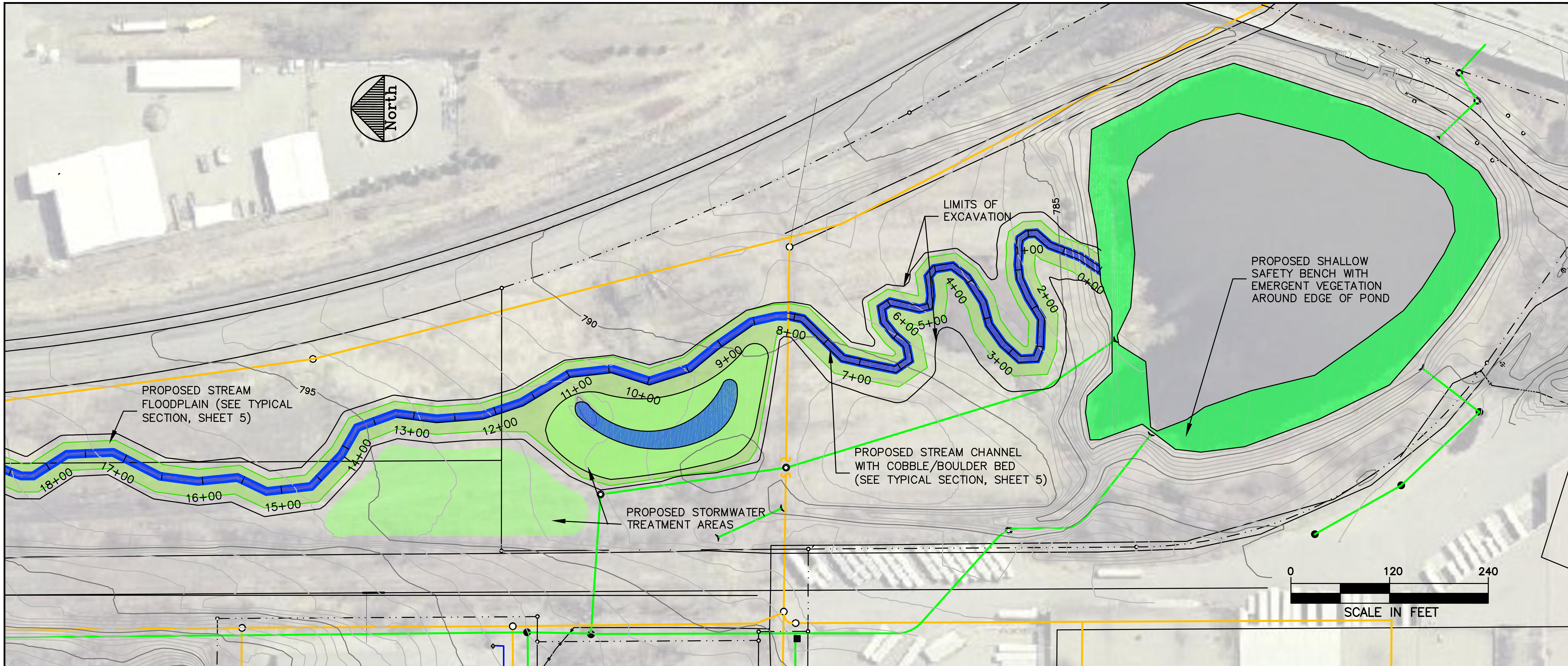
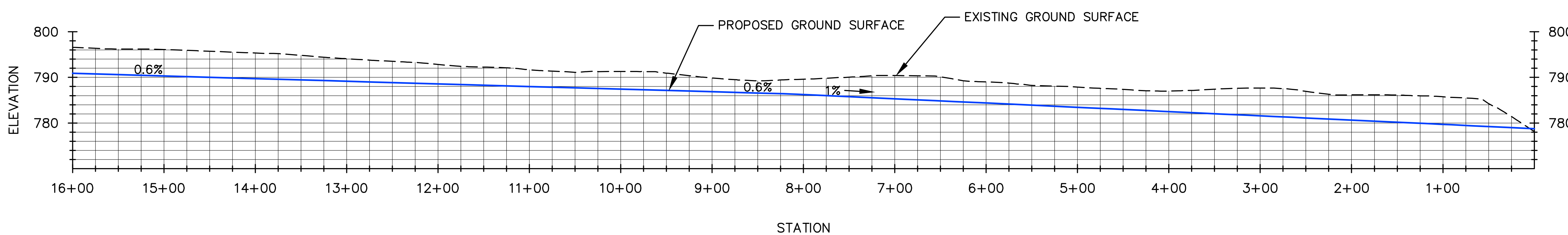
PROPOSED CONDITIONS
NORTHERN PORTION OF SITE

SHEET
3 OF 6



PLAN VIEW



PROFILE VIEW

NO.	BY	DATE	REVISION DESCRIPTION

MBW DRAWN	MBW DESIGNED	MJM CHECKED
x APPROVED	03/19/12 DATE	PROJECT

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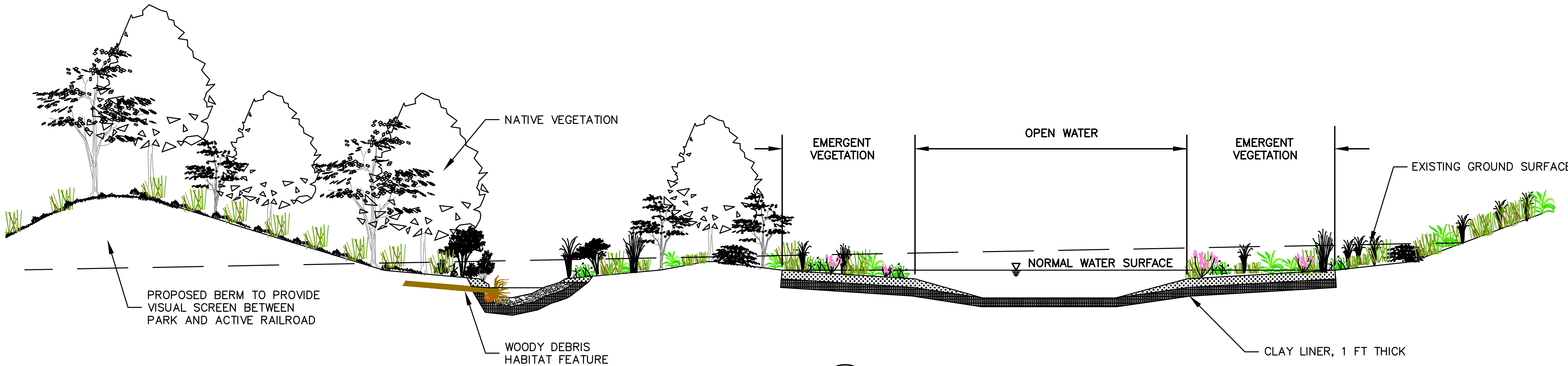
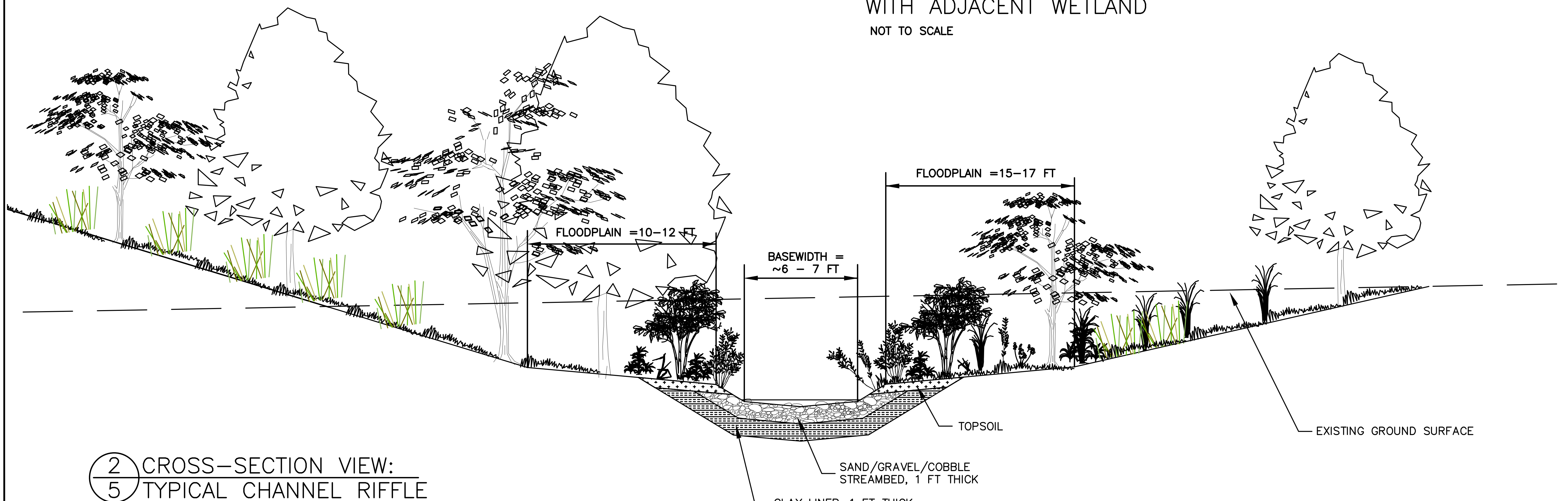
PROPOSED CONDITIONS
SOUTHERN PORTION OF SITE

SHEET
4 OF 6



1/5 CROSS–SECTION VIEW
TYPICAL CHANNEL POOL WITH ADJACENT WETLAND
NOT TO SCALE



2/5 CROSS–SECTION VIEW:
TYPICAL CHANNEL RIFFLE
NOT TO SCALE

NO.	BY	DATE	REVISION DESCRIPTION

MBW	MBW	MJM
DRAWN	DESIGNED	CHECKED
x	03/19/12	
APPROVED	DATE	PROJECT

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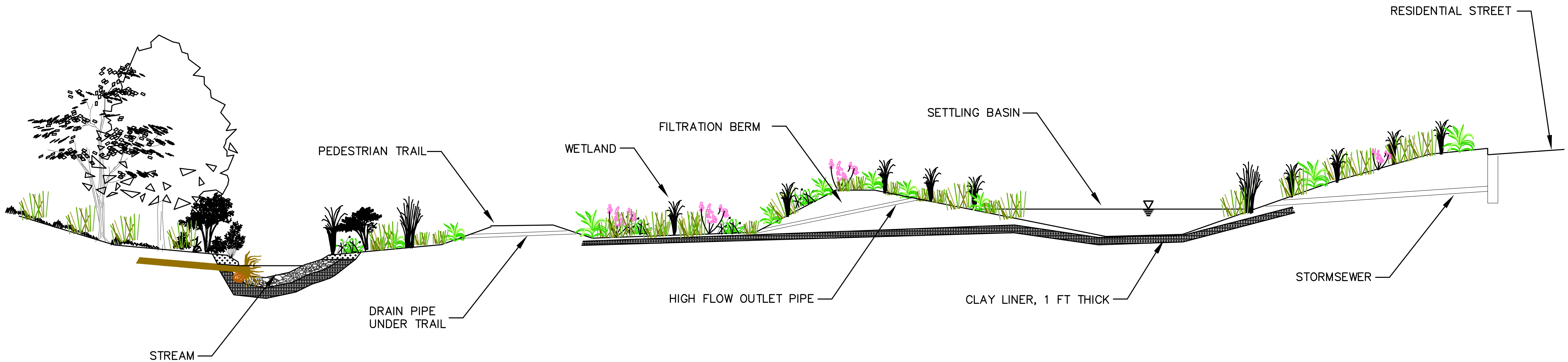
TYPICAL SECTIONS



1/6 CROSS-SECTION VIEW
STORMWATER TREATMENT SYSTEM

NOT TO SCALE

NO.	BY	DATE	REVISION DESCRIPTION

DRAWN	DESIGNED	CHECKED
MBW	MBW	MJM

APPROVED	DATE	PROJECT
x	03/19/12	

CAPITOL REGION WATERSHED DISTRICT
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STORMWATER TREATMENT
TYPICAL SECTION