Feasibility Report for Plymouth Creek Restoration Project

Plymouth, Minnesota

Prepared for
Bassett Creek Watershed Management Commission

July 2009

BARR

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

Karen L. Chandler

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Reg. No 19252   Date July 30, 2009

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1.0 Summary and Conclusions

1.1 Background

In January 2007 the Bassett Creek Watershed Management Commission's Technical Advisory Committee recommended that the Commission add stream channel restoration projects to the Commission's 10 year Capital Improvements Program (CIP). The restoration projects included the main stem of Bassett Creek, the North Branch of Bassett Creek, the Sweeney Lake Branch of Bassett Creek, and Plymouth Creek. Increased runoff volumes and higher peak discharges that have occurred with development of the watershed have resulted in stream bank erosion and streambed aggradation and scour. The resulting sediment load from the erosion and scour increases phosphorus loads to downstream water bodies, decreases the clarity of water in the stream, and reduces the discharge capacity of the channel.

The Commission added several of these channel restoration projects to their long range CIP in May of 2007. The added projects are listed in Table 1.

Table 1 Channel Restoration Projects added to CIP

Location	Estimated Project Cost
Golden Valley	
Main stem, Highway 100 and Briarwood Area	$450,000
Sweeney Lake Branch, King Hill Area	$500,000
Main stem, Duluth Street Area	$550,000
Plymouth	
Plymouth Creek, West Medicine Lake Drive to 26th Avenue, Reach 4	$550,000
Plymouth Creek, 26th Avenue to Northwest Blvd, Reach 3	$170,000
Plymouth Creek, Northwest Blvd to 494, Reach 2	$150,000
Plymouth Creek, 494 to 37th Avenue, Reach 1	$230,000

In 2008, the City of Golden Valley completed the Commission's first channel restoration project – the Sweeney Lake Branch, King Hill Area project. That project involved restoration of approximately 600 feet of the upstream end of the Sweeney Lake Branch of Bassett Creek. Restoration of the reach of Plymouth Creek from West Medicine Lake Drive to 26th Avenue North, Reach 4 (see **Figure 1**, Location Map) is included in the Commission's CIP for construction in 2010. The City of Plymouth completed a survey of Plymouth Creek in 2004 to prepare the preliminary estimate of the cost to restore the creek. The City of Plymouth's May 2006 feasibility study for construction of the West Medicine Lake Park Pond identified the need for additional study to address issues in Plymouth Creek upstream of the proposed pond project, including 1) stream bank erosion and needed stream restoration and 2) possible rerouting and stabilization of part of the creek. The feasibility study noted that the "eroding stream banks upstream of the proposed pond will contribute significant sediment loads to the pond and increase the frequency of pond maintenance." The City of Plymouth updated their creek restoration cost estimate in April 2007.

1.2 General Project Description and Estimated Cost

Similar to many other urban streams, this reach of Plymouth Creek from West Medicine Lake Road to 26th Avenue North suffers from stream bank and streambed erosion, which is caused by increased urban runoff. A portion of the stream channel was also historically relocated in the lower portion of this reach. Erosion issues develop because the creek is attempting to return to a stable condition with the increased flow that the channel carries. This evolution occurs through stream bank slumping, formation of sediment bars in the channel, which direct flow from one bank to the other, and channel widening. Storm sewers which carry flow from adjacent development also have caused some of the bank and channel erosion.

The project along this reach of Plymouth Creek consists of removal of some trees and vegetation, regrading some reaches of stream bank, installation of a variety of stream stabilization measures to address erosion and sedimentation problems, excavation of sediment from portions of the channel, relocation of approximately 1,500 feet of the stream channel to a location closer to its historic location, modification of some of the storm sewers tributary to the channel and establishing new vegetation on areas disturbed by construction (see **Figure 2)**. Proposed stream stabilization measures to be installed include riprap, root wads, biologs, cross vanes, j-vanes and vegetated reinforced slope stabilization (VRSS). A more detailed description of these measures is given in **Section 4.1** and listed in **Table 2**.

The total project cost is estimated to be $965,200, which includes $120,000 for construction easements since a major portion of the stream channel is currently on private property. The estimated construction costs are $845,200; a detailed cost estimate is included in **Section 4.3**. This construction cost assumes wetland mitigation is not necessary; however, if wetland mitigation is required under WCA for the stream channel realignment, the mitigation costs for 1.7 acres of wetland are estimated would add an estimated $75,000 – $100,000 in additional project construction and related costs. The principal difference in the cost of the project and the $550,000 that was budgeted in the CIP is the cost of the channel relocation between approximately station 5+00 and station 30+00, the excavation of sediment upstream of the fish barrier, and the cost of easement acquisition, none of which were included in the original estimate.

1.3 Recommendations

The restoration of Plymouth Creek from West Medicine Lake Road to 26th Avenue North was originally included in the Commission's CIP for construction in 2009. Since much of the proposed restoration work is on private property, the City of Plymouth recommended that the project be delayed, and included in the Commission's 2010 CIP to allow the City more time to conduct public informational meetings, prepare environmental assessments, and construct the West Medicine Lake Park ponds project. The City also indicated that more time is necessary to acquire easements. The public meetings and easement acquisition process could result in changes to the restoration features proposed for construction.

The project will provide the following benefits:

- Stabilized streambanks, which will result in reduced erosion and sedimentation, and reduced sediment loading and phosphorus loading)
- Prevention of future channel and streambank erosion
- Elimination of creek encroachment on adjacent private properties

Considering these benefits and the cost efficacy of the project, it is recommended that the Commission include the restoration of Plymouth Creek from West Medicine Lake Road to 26th Avenue North in its 2010 CIP and that the Bassett Creek CIP be revised to reflect the revised cost estimate. For project construction to occur in 2010, the Commission must hold a public hearing and order the project in time for the Commission's submittal of its 2010 ad valorem tax levy request to Hennepin County (by October 1, 2009). It is further recommended that the project proceed into the design and construction phase.

2.0 Background and Objective

2.1 Background

Medicine Lake Watershed Implementation and Management Plan

In 2003, the City of Plymouth and its Medicine Lake Watershed Sub-committee prepared the *Medicine Lake Watershed Implementation and Management Plan* (June 2001). That plan sets forth water quality goals for the lake and specifies watershed best management practices (BMPs) and management activities to be undertaken to improve the quality of stormwater inflow in order to meet those goals. Medicine Lake is classified as a Level I water body by the Bassett Creek Watershed Management Commission and City of Plymouth. Specific water quality goals for Medicine Lake are:

- A summer average concentration for total phosphorus of 38 µg/L.
- A minimum Secchi disc transparency depth of 1.5 – 1.75 meters (about 5 - 7 feet).

Phase II: Medicine Lake Watershed Implementation and Management Plan.

In 2004, the City and its Medicine Lake Watershed Subcommittee prepared the *Phase II: Medicine Lake Watershed Implementation and Management Plan* (August 2004). The objective of this plan was to reduce Medicine Lake external watershed phosphorus loading by 1,000 pounds per year and to reduce its internal loading by controlling curly leaf pondweed. The plan recommended a goal of removing 336 pounds of phosphorus from the Plymouth Creek outfall by realigning the creek and excavating a 4-acre pond in the vicinity of West Medicine Lake Park. The plan was adopted by the City Council on September 28, 2004.

August 30, 2005 Technical Meeting

City of Plymouth staff scheduled a meeting on August 30, 2005 with technical staff from the city, Bassett Creek Watershed Management Commission (BCWMC) and Three Rivers Park District to discuss implementation of the Plymouth Creek portion of its plan for removal of 336 pounds of phosphorus. Several preliminary tasks were identified during the meeting that needed to be completed prior to preparation of construction documents. Some of these tasks included:

- Prepare detailed topographic and boundary survey of project area.
- Take soil borings and classify soils in project area.
- Revise the P8 water quality model of the Plymouth Creek watershed with recent monitoring and watershed data to assess water quality issues.

- Revise or prepare hydraulic model to assess water quantity and flooding issues.
- Prepare Feasibility study.

The City performed the detailed topographic survey and obtained soil borings during the winter when frozen ground conditions allowed access to the wetland areas. The City also revised the P8 Model as discussed during the meeting.

March 24, 2006 Technical Meeting

On March 24, 2006 a meeting regarding the Plymouth Creek BMP project was held at the Plymouth City Hall. Representatives from the Bassett Creek Watershed Management Commission, Three Rivers Park District, Blue Water Science and the City of Plymouth engineering and parks staff attended the meeting. Several issues regarding drainage, nutrient loading, localized street flooding, stream bank erosion and aesthetics were discussed. In addition, the revised information including topographical survey, soil borings, revised P8 modeling and recent monitoring results were discussed. A number of project components were considered and identified as essential to the success of the Plymouth Creek BMP project. The group also developed a preliminary list of potential best management practices (BMPs) that could be considered for Plymouth Creek. Preliminary potential BMPs included ponding, aeration, stream restoration and alum treatment. The City selected West Medicine Lake Park, located along the east side of West Medicine Lake Drive, as its desired location for implementation of a water quality pond to meet the goal of removing 336 pound of phosphorus annually from Plymouth Creek. This location offered the easiest access for construction and maintenance and provided opportunity for park and recreation use. The group/City decided to further pursue a water quality pond at this location and indicated the initial step would be to perform modeling and complete a feasibility study prior to design and preparation of engineering plans.

The subsequent feasibility study (*Plymouth Creek Phase 1 Feasibility Report for Construction of the West Medicine Lake Park Pond, City Project #3105*) was completed in May 2006 and approved by the Bassett Creek Watershed Management Commission on April 19, 2007 as a minor plan amendment to the Commission's *Watershed Management Plan* (2004) (Resolution 07-08). The Commission also ordered the improvement on April 19, 2007 (Resolution 07-09).

2.2 Goals and Objective

The objective of this study is to review the feasibility of implementing stream stabilization measures and of rerouting Plymouth Creek.

Stream Stabilization

Stream bank restoration to prevent erosion along the channel was addressed during the March 24, 2006 technical meeting. The City of Plymouth recognized the importance of addressing these erosion and sedimentation issues; however, funding limitations have prevented aggressive repair of these sites to date. With the availability of funding from the Bassett Creek Water Management Commission (BCWMC), repair of these sites can now proceed.

During 2004 the City of Plymouth prepared an inventory of the erosion and sedimentation sites along Plymouth Creek. Its September 7, 2004 report identified sixteen sites requiring maintenance or repair in "Section 1." The report identified "Section 1" to include the reach of Plymouth Creek from West Medicine Lake Road to 26th Avenue North (now identified as "Reach 4"). The report indicated that 3,350 feet of channel requires maintenance. In April 2007, the City updated the cost estimate to perform the maintenance to $550,000.

Rerouting of Plymouth Creek

As noted in the 2006 feasibility study, rerouting Plymouth creek requires adequately designing the channel to eliminate erosion and encroachment, address flooding and ensure other problems are not created. The feasibility study further noted that the design of the rerouted creek may require a revised hydraulic model to ensure that the flood profile does not change. Following is a list of goals and objectives and project considerations for this portion of the project (taken from 2006 feasibility study):

Goals & Objective

- Reroute Plymouth Creek to eliminate creek encroachment on adjacent private properties.
- Prevent channel erosion along the creek to eliminate its water quality impact on Medicine Lake.
- Minimize localized flooding along streets and private properties.
- Reroute Plymouth Creek to restore the historic channel. Review of the 1855 public land survey, and aerial photographs from 1937, 1940, 1947, 1953, 1957, 1964, 1969, and 2004 (base photos for GIS maps) show that the creek channel has changed its course over the years. **Appendix A** includes copies of the 1855 public land survey and the historic aerial photographs. Comparing the 1947 and 2004 aerial photographs indicate that the channel has

migrated approximately 350 feet north. The main creek appears "channelized" in the 1947 photograph. In addition, brief review of the Plymouth's 1960 topography indicates the creek may have taken a course located further south than is shown in the 1947 aerial photo.

- Create a meandering stream to be an asset to West Medicine Lake Park (park, trails, etc.).
- Improve water quality monitoring access.

Considerations

- Restoration must minimize floodplain impacts. Due to homes adjacent to the creek it is critical to ensure the proposed project does not increase flood elevations that impact these properties.
- The existing erosion may be most economically addressed by focusing on the encroachment areas and relocating portions of the creek at its current location and armoring other areas to create a stable channel.
- The new reconstructed channel alignment (Site 1) should be constructed with a temporary diversion and kept offline from stream flow for one growing season to allow good vegetation establishment on the shorelines and floodplain areas; this one-year offline phase will require that restoration of the old channel to the wetland would be completed one year later than the bulk of the restoration construction.
- Complete relocation of Plymouth Creek along this reach may be unreasonable from a permitting perspective unless the relocation of public waters includes restoration of the historic channel. These permitting issues should be addressed with the Minnesota Department of Natural Resources, Minnesota Pollution Control Agency and Corps of Engineers staff.

3.0 Site Characteristics

3.1 Plymouth Creek Watershed

The 6,380-acre Plymouth Creek watershed is located west of Medicine Lake and represents more than half of the Medicine Lake watershed. Plymouth Creek drains a large portion of south and central Plymouth and passes through West Medicine Lake Park before discharging into the southwest bay of Medicine Lake. Approximately 30 percent of this watershed, including the Parkers Lake subwatershed, enters Plymouth Creek at the West Medicine Lake Drive bridge over Plymouth Creek. The City has referred to this area as the 18th Avenue Drainage. Most of the remaining Plymouth Creek watershed area drains through four large, channelized wetlands downstream of Turtle Lake. Existing land use includes approximately 28 percent commercial/industrial; 40 percent single-family residential; 4 percent multi-family residential; 7 percent highway; 7 percent parks and undeveloped land; and water surface area over the remaining land area.

Medicine Lake receives more than 30 percent of its total annual phosphorus load (including internal loading) and more than 60 percent of its external phosphorus load (excluding internal loading) from Plymouth Creek. Stormwater runoff from this watershed passes through a channelized wetland area upstream of West Medicine Lake Road before discharging to Medicine Lake.

3.2 Stream Characteristics

The project area (Reach 4, see **Figure 1**) extends from West Medicine Lake Road to approximately 500 feet north of 26th Avenue North. The existing creek channel travels 5,400 feet through the project area. With the proposed rerouting of Plymouth Creek in the lower portion of the project area, the channel length would increase to over 6,500 feet.

The upstream portion of the creek flows south and then generally east, and traverses private property. In a number of locations, erosion has caused the creek to move closer to buildings, creating safety concerns. The upper two-thirds of the project site are heavily wooded. The resultant heavy shade prevents vegetation from growing on the stream banks, which exacerbates the erosion problems. Representative photos of four or the proposed restoration sites are shown in **Appendix B**. At the downstream end, the (now straightened) creek flows through a large wetland area, some of which includes City parkland (west portion of West Medicine Lake Park). The proposed rerouting of Plymouth Creek will move the channel further south and follow a more meandering path through the large wetland area.

4.0 Proposed Improvements

4.1 Description of Proposed Improvements

As described in Section 1.2, the project along this reach of Plymouth Creek consists of rerouting the lower portion of the creek, and a variety of stream stabilization measures to address erosion and sedimentation problems. **Figure 2** shows the 17 stabilization sites and **Table 2** lists the proposed improvements for each site. The following paragraphs describe the proposed rerouting and stream stabilization practices.

Rerouting of Plymouth Creek

The downstream section of Plymouth Creek will be relocated and reconfigured to a more natural stream pattern. This reconfiguration will reduce flooding on the north side of the wetland area and improve ecological function of the stream. The rerouted stream will be in a location approximating its historic location.

Riprap

Riprap is used along the creek edge to protect the toe of the stream bank. In stream systems, riprap typically consists of cobble-sized rock (six inches to 12 inches in diameter). The riprap is keyed in to the streambed and extends up the bank to approximately the bankfull level. The bankfull level is the elevation of the water in the channel during a 1.5-year event. In some areas, this level may be below the top of the stream bank. Also called stone toe protection, riprap is typically used in conjunction with revegetation of the upper banks to provide full bank protection. Riprap is especially effective in heavily shaded areas, where it is difficult to establish vegetation. **Figure 3** illustrates this practice.

Root Wads

Root wads are constructed from sections of root balls with their tree trunks attached. Approximately 20 of the trees removed for this project will be salvaged for their use as root wads. The trunks are buried into the bottom of the stream bank, with the root wad end sticking out into the stream. Supporting “footer logs” and boulders are often used to stabilize the root wads. **Figure 4** illustrates this practice.

Biologs

Biologs are natural fiber rolls made from coir fiber that are laid along the toe of the stream bank slope to stabilize the toe of the stream bank. The biologs are typically 10 – 22 inches in diameter. Because they are made of natural fiber, vegetation can grow on the biologs. When needed, grading of the stream bank slope above the biolog will be performed to achieve a more stable slope (2:1 to 3:1). **Figure 5** illustrates this practice.

Cross Vanes

Cross vanes are drop structures, which are typically constructed of boulders and rocks to flatten the slope of the channel and reduce the velocity of the flow in the channel. Cross vanes, also called constructed riffles, extend across the creek bottom, and are embedded in each bank. Cross vanes direct the main flow to the center of the stream to reduce bank erosion. **Figure 6** illustrates this practice.

J-Vanes

J-vanes (also called rock vanes) are constructed of boulders placed on the creek bottom. The vanes are embedded in the stream bank and are oriented upstream to direct the flow away from that bank. J-vanes typically occupy no more than one-third of the channel width. **Figure 7** illustrates this practice.

Vegetated Reinforced Slope Stabilization (VRSS).

VRSS is a bioengineering method that combines rock, geosynthetics, soil and plants to stabilize steep, eroding banks. VRSS typically involves protecting layers of soil with a blanket or geotextile material creating "soil lifts" (also called "soil pillows") and vegetating the slope. The vegetation's root systems provide long-term slope protection. **Figure 8** illustrates this practice.

Pipe Outlet Stabilization.

Pipe outlet stabilization measures vary according to specific site circumstances. At most sites, additional rock riprap is needed at the pipe outlet. In other cases, pipe realignment and/or lowering of the pipe may be needed to correct existing problems and prevent future erosion. **Figure 9** illustrates this practice.

Table 2 Proposed Improvements

Site #	Downstream Station	Proposed Stream Restoration Practices
1	5+10	Excavate 2,465 feet of new channel to the West Medicine Lake Park pond (reroute Plymouth Creek) Install one cross vane/weir to close old channel Remove 80 trees, salvaging 20 of the removed trees for root wads.
2	30+61	Place riprap along 30 feet of channel length Install three j-vanes Install five root wads.
3	32+36	Place riprap along 90 feet of channel length Install two j-vanes Install six root wads Remove four trees (one very large)

Table 2 Proposed Improvements

Site #	Downstream Station	Proposed Stream Restoration Practices
4	34+06	Install biolog along 50 feet of channel length Install four root wads Remove 7 trees
5	35+36	Place riprap along 140 feet of channel length Install two j-vanes Install three root wads Remove 11 trees Remove debris and buckthorn
6	37+66	Place riprap along 125 feet of channel length Install biolog along 100 feet of channel length, with grading of bank slope above biolog to achieve slopes between 2:1 and 3:1 Install three j-vanes Remove 3 trees Debris removal
7	40+19	Place riprap along 110 feet of channel length Install 180 square feet of vegetated reinforced slop stabilization (VRSS) on channel banks Install biolog (with stakes) along 50 feet of channel length, with grading of bank slope above biolog to achieve slopes between 2:1 and 3:1 Install one j-vane Create low floodplain terrace Redirect outlet to direct flow downstream and protect downstream end of pipe with riprap Remove three trees Clear buckthorn and brush
8	42+51	Place riprap along 95 feet of channel length Install 150 square feet of VRSS on channel banks Install two cross vanes for grade control Install one j-vane Remove five trees (two large) Debris/brush removal
9	44+64	Place riprap along 40 feet of channel length Install two cross vanes for grade control (one on side ravine from 26th Street outlet) Remove five trees (one large)
10	46+53	Install 720 square feet of VRSS on channel banks
11	47+65	Install 600 square feet of VRSS on channel banks Install six root wads Install one cross vane Grade bank slope to achieve slopes between 2:1 and 3:1 Remove 10 trees Brush and debris removal
12	48+91	Install 740 square feet of VRSS on channel banks Install one cross vane for grade control Remove 28 trees
13	50+41	Place riprap along 50 feet of channel length Install one cross vane for grade control Remove six trees (two very large).
14	51+65	Install four j-vanes Replace and redirect two outlet pipes to direct flow downstream and protect downstream end of pipe with riprap (includes installation of one drop structure MH to dissipate energy).

Table 2 Proposed Improvements

Site #	Downstream Station	Proposed Stream Restoration Practices
15	53+28	Regrade 200 feet of east bank to 2:1 Live staking and revegetation
17	60+01	Remove 3,900 cubic yards of sediment from stream above fish barrier Revegetate 0.25 acres of wetland (seeding)

Note: work at site #16 has already been completed so it is not included in this project.

4.2 Project Impacts

4.2.1 Easement Acquisition

Construction easements may need to be acquired since a major portion of the stream channel is currently on private property. The estimated cost for surveys and legal work associated with the easement acquisition is $120,000.

4.2.2 Permits Required for Project

The proposed project will require 1) a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers (COE) and Section 401 certification from the Minnesota Pollution Control Agency (MPCA), 2) an environmental review (Environmental Assessment Worksheet or EAW) under Minnesota Rules, 3) compliance with the Minnesota Wetland Conservation Act, and 4) a Public Waters Work Permit from the Minnesota Department of Natural Resources (MNDNR). The proposed project should also follow the MPCA's guidance document for managing any dredged materials.

Section 404 Permit and EAW

The COE regulates the placement of fill into wetlands, if the wetlands are hydrologically connected to Waters of the United States, under Section 404 of the Clean Water Act (CWA). In addition, the COE may regulate all proposed wetland alterations if any wetland fill is proposed. The MPCA may also be involved in any wetland mitigation requirements as part of the CWA Section 401 water quality certification process for the 404 Permit.

Based upon discussions with staff from the St. Paul District of the COE, the Minnesota Environmental Review process must be completed for the project before the Section 404 permit application is submitted to the COE. The Minnesota Environmental Review Rules (MN Rules 4410) require that an Environmental Assessment Worksheet (EAW) be completed for the project. MN Rules 4410.4300, subpart 26 requires a mandatory EAW for diversion, realignment or channelization projects affecting greater than 500 feet of natural watercourse with a total drainage area of ten or more square miles. The channel relocation part of the proposed project triggers this mandatory EAW. The City of Plymouth would be the Responsible Governmental Unit for the EAW.

The Plymouth Creek project has been included in the *Resource Management Plan for Bassett Creek Watershed Management Commission Water Quality Improvement Projects 2010 – 2016* submitted to the COE in April 2009. The goal of the *Resource Management Plan* (RMP) is to complete on a conceptual level the COE permitting process for all of the projects proposed.

The COE 404 permit requires a Section 106 review for historic and cultural resources. To ensure timely completion of the COE 404 permit application, a literature review and database search for cultural and historic resources within the project area was completed as part of the RMP. If more detailed information is requested by the State Historic Preservation Office (SHPO), then a Phase I Archaeological Survey may need to be completed. A Phase I Archaeological Survey can be completed in 45 days or less during the frost-free period. Even with the information collected as part of the EAW and the RMP, the COE staff anticipates that the 404 permit review and approval process could require 120 days to complete.

Construction of the new stream channel alignment could be designed to minimize the regulatory requirements for wetland mitigation under the Clean Water Act provisions. Design of the new channel configuration such that the bankfull flow (~1.5-year flow) is allowed to discharge into the adjacent wetlands may also lessen any mitigation requirements for the project. Prescriptive specifications for the project that include measures for construction and erosion control limiting temporary and permanent wetland impacts would also reduce the need for mitigation of wetland impacts.

Minnesota Wetland Conservation Act

The Wetland Conservation Act (WCA) regulates the filling and draining of wetlands and excavation within Type 3, 4, and 5 wetlands. In addition, WCA may regulate all types of wetland alteration if any wetland fill is proposed. The WCA is administered by local government units (LGU), which include: cities, counties, watershed management organizations, soil and water conservation districts, and townships. Plymouth is the LGU for the proposed project site. The Minnesota Board of Water and Soil Resources (BWSR) oversees administration of the WCA statewide.

The proposed project will involve excavation within wetlands. The WCA and Section 404 require that anyone proposing wetland impacts conduct a "sequencing analysis," which consists of three general steps:

1. Avoid disturbing wetlands.
2. Minimize impacts to wetlands.
3. Replace any lost wetland functions and values.

When planning for wetland replacement, attempts must be made to replace wetlands on-site before considering other options. Some wetland credits may be obtained for removal of the sediment upstream of the fish barrier and for planting aquatic vegetation. Certain wetland activities are exempt from the WCA, allowing projects with minimal impact, or projects located on land where certain pre-established land uses are present, to proceed without regulation. Design of the new channel configuration such that the bankfull flow (~1.5-year flow) is allowed to discharge into the adjacent wetlands would also lessen the likelihood of any mitigation being required for the project under WCA.

Public Waters Work Permit

The Minnesota Department of Natural Resources (MNDNR) regulates projects constructed below the ordinary high water level of public waters or public waters wetlands, which alter the course, current, or cross section of the water body. Public waters regulated by the MNDNR are identified on published public waters inventory (PWI) maps. Plymouth Creek is a public water/watercourse, so the proposed work will require a MNDNR public waters work permit.

MPCA Guidance for Managing Dredged Materials

The MPCA considers material excavated below the MNDNR's ordinary high water level to be dredged material. Because dredged material is defined as a waste and is regulated by MPCA, the MPCA has developed a guidance document for managing dredged material (document available on the MPCA website: http://www.pca.state.mn.us/water/dredgedmaterials.html).

The MPCA's guidance document provides assistance in determining what type(s) of regulatory oversight and/or permit is required at projects and sites involving the removal and management (storage, treatment, disposal and/or reuse) of dredged materials, once excavated, as well as what is required for discharges from the project site and/or management control site(s), including stormwater.

Because the MPCA's guidance is not mandatory, it does not establish or affect legal rights or obligations. However, should a permit be needed for managing the dredged material, such as in the event of short term or long term storage of dredged material on site, any generation of runoff from the stored materials (including stormwater runoff), dewatering runoff, etc., then following the guidance will help ensure a project is in compliance.

Some types of dredging projects do not require a permit from the MPCA for the management of dredged material; examples include the following:

- Projects involving the removal of less than or equal to 3,000 cubic yards of material with no surface water discharge (i.e., the material is immediately hauled away or any dewatering water infiltrates and does not runoff), and where the material is either:
    - more than 93% sand, as determined by the grain size analysis;
    - characterized as having contaminant values less than the relevant soil reference values (SRV) for the proposed disposal option; or,
    - disposed at a site or landfill that already has an MPCA permit to manage dredged material (industrial waste management plan).
- Projects involving the removal of more than 3,000 cubic yards with no surface water discharge that is disposed at a site or landfill that already has an MPCA permit to manage dredged material (industrial waste management plan).

If not disposed of in a landfill, the dredged material needs to be characterized according to the relevant soil reference values (SRV). A Level 1 SRV is required for the material to be re-used on residential/recreational lands, whereas a Level 2 SRV means the material must be re-used on industrial sites. The guidance document specifies the number and depth of sediment cores that are to be collected. Sediment cores must reach a depth two feet beyond the proposed dredging depth. For a dredged sediment volume of 0 to 30,000 cubic yards, at least three sediment cores must be collected. If more sediment is to be removed, the number of cores increases. Each distinct strata must be analyzed and if no strata exist, then core samples need to be divided into two-foot segments and sampled.

For projects not requiring a permit, information pertaining to the project must be submitted to the MPCA for review prior to initiation of dredge activities. A Notification to Manage Dredged

Materials without a Permit (Notification) is used for this purpose. The MPCA will review the notification within 30 days, and if there's no response otherwise from the MPCA, no permit is required and the project can proceed. Even if no permit is required, sediment cores must be collected and analyzed.

If a permit is required, it needs to be submitted at least 180 days before the anticipated date of dredging. All sediment analysis work would need to be completed before the submission of any permit requests. The testing and reporting related to the sediment characterization has project budget implications and will need to be considered at part of the project design costs.

4.2.3 Other Project Impacts

Tree Loss

The proposed project includes the removal of 160 trees, as estimated from tree inventories and from reviewing aerial photographs. Tree inventories were conducted at Sites 2 – 17, and aerial photographs were reviewed and a visual assessment completed for Site 1. From the aerial photographs and the visual review, it is estimated that 80 of the trees will be removed to allow for the rerouting of Plymouth Creek. From the tree inventories it is estimated that another 80 trees will be removed to allow for the installation of stream stabilization measures. Six of the trees to be removed are very large (diameter greater than 16 inches). Of the estimated 80 trees to be removed for the rerouting of Plymouth Creek, 20 will be salvaged for use as root wads. Once the alignment for the rerouting of Plymouth Creek has been determined, a tree inventory will be conducted and the total tree removal requirements can be further defined.

Water Quality Impacts

The proposed stabilization measures will result in a reduction in the sediment and phosphorus loading to Medicine Lake. Total suspended sediment (TSS) and phosphorus data obtained from the publication *City of Plymouth Water Quality Monitoring 2005 – 2007* (Three Rivers Park District) and from Medicine Lake watershed 2008 water quality data provided by the City of Plymouth indicate that there is a large increase in TSS and phosphorus in Plymouth Creek over the project reach. By comparing the average loads between the upstream monitoring site (Industrial Park -2, IP-2) and the downstream monitoring site (Plymouth Creek, monitored at West Medicine Lake Road) over the years 2004 – 2008, the data shows the following:

Average Annual Nutrient Loading (2004 – 2008)

TSS		
IP-2 Monitoring Site	**Plymouth Creek Monitoring Site**	**Change in Load, from IP-2 to Plymouth Creek**
262,363 pounds	**935,081 pounds**	**672,718 pounds increase**

Total Phosphorus		
IP-2 Monitoring Site	**Plymouth Creek Monitoring Site**	**Change in Load, from IP-2 to Plymouth Creek**
1,667 pounds	**1,998 pounds**	**331 pounds increase**

Particulate Phosphorus		
IP-2 Monitoring Site	**Plymouth Creek Monitoring Site**	**Change in Load, from IP-2 to Plymouth Creek**
942 pounds	**1,200 pounds**	**258 pounds increase**

The increased TSS and particulate phosphorus loads indicate that the stream is picking up a large amount of sediment between the two monitoring stations. Because there is a relatively small increase in the untreated drainage area between the two monitoring stations, it can be assumed that most of the increase in TSS and phosphorus is the result of streambank and streambed erosion. It is estimated that the proposed project will reduce the loadings in TSS and phosphorus due to this streambank and streambed erosion by 50% to 60%. Based on this and the 2004 – 2008 monitoring data, it is estimated that the project will reduce the total phosphorus load between 160 and 200 pounds per year and the TSS load between 170 and 200 tons per year.

The BCWMC estimated the sediment and phosphorus loading to the Bassett Creek Main Stem from channel erosion as part of the *Bassett Creek Main Stem Watershed Management Plan* (2000). Three erosion scenarios were evaluated to illustrate increased loadings resulting from minor, moderate and severe channel erosion. The most likely condition present in the Bassett Creek Main Stem was found to lie between the moderate and severe scenarios, with approximately 10 percent of the stream channel suffering from erosion. Similar scenarios were used to estimate the additional loading of phosphorus to the Bassett Creek Main Stem. The study results indicate that moderate channel erosion could contribute an additional 1,000,000 pounds of suspended sediments annually (from approximately 500,000 pounds to 1,500,000 pounds) and 50 pounds of phosphorus annually (from approximately 2,650 pounds to 2,700 pounds) to the Main Stem of Bassett Creek. Stabilizing the reach was estimated to reduce phosphorus loads by 96 lbs per year and suspended solids loads by 100 tons per year.

It is recommended that monitoring be conducted before and after construction to evaluate the effectiveness of the stream stabilization project. The final project design should take into consideration and allow for the establishment of monitoring sites and access to the sites.

4.3 Cost Estimate

The estimated construction cost for the Plymouth Creek Restoration Project is $845,200. Assuming an additional $120,000 for construction easements brings the total estimated project cost to $965,200. This cost assumes wetland mitigation is not necessary; however, if wetland mitigation is required under WCA for the stream channel realignment, up to 1.7 acres of wetland mitigation may be needed (assuming 1:1 replacement). The mitigation costs for 1.7 acres of wetland are estimated at $50,000 per acre of new wetland totaling $75,000 – $100,000 in additional project construction and related costs. A feasibility-level cost estimate for the project construction is included in **Table 3. Figure 2** shows the corresponding site numbers and stationing referenced in **Table 3**.

The opinion of probable construction costs provided in this report is made on the basis of Barr's experience and qualifications, and represents our best judgment as experienced and qualified professionals familiar with the project. The cost opinion is based on project-related information available to Barr at this time and includes a conceptual-level design of the project.

4.4 Funding Sources

The City of Plymouth proposes to use BCWMC capital improvement program (CIP) funds to pay for this project. BCWMC channel restoration projects are funded through the BCWMC's CIP and are paid for via an ad valorem tax levied by Hennepin County over the entire Bassett Creek watershed.

4.5 Project Schedule

Figure 10 shows the proposed project schedule. The bulk of the construction work is slated to be completed over the winter of 2010-2011, with final stabilization of the old stream channel completed in the spring of 2012. This schedule assumes the new reconstructed channel alignment (Site 1) would be constructed with a temporary diversion and kept offline from stream flow for one growing season. Keeping the new channel offline for one year will allow good vegetation establishment on the shorelines and floodplain areas. This one-year offline phase also requires that restoration of the old stream channel would be completed one year later than the bulk of the restoration construction.

For project construction to occur in 2010, the Commission must hold a public hearing and order the project in time for the Commission's submittal of its 2010 ad valorem tax levy request to Hennepin

County (by October 1, 2009). To allow contractors to acquire plant materials at a reasonable price for the required quantities, the project bidding is recommended to take place in the summer of 2010. In the intervening time, the City will gather public input, conduct the environmental assessment, prepare the final design, obtain permits, and complete the West Medicine Lake Park pond project.

Table 3. Site Locations, Proposed Stream Restoration Practices, and Overall Cost Estimate for Plymouth Creek - Reach 4.

Site #	Downstream station [1]	Site length (feet)	Proposed stream restoration practices	Site Total Cost [2, 3]
1	**5+10**	2465	Excavate 2465' of new channel to the West Medicine Lake Park pond; 1 cross vane/weir to close old channel; remove 80 trees, w/ 20 salvaged for root wads.	$ 216,800.00
2	**30+61**	175	30' riprap: 3 j-vanes; and 5 root wads.	$ 22,800.00
3	**32+36**	170	90' riprap; 2 j-vanes; 6 root wads; remove 4 trees (1 very large).	$ 31,500.00
4	**34+06**	130	50' of biolog; 4 root wads; remove 7 trees.	$ 9,400.00
5	**35+36**	230	140' of riprap; 2 j-vanes; 3 root wads; remove 11 trees; remove debris and buckthorn	$ 40,000.00
6	**37+66**	250	125' of riprap; 100' biolog with grading; 3 j-vanes; remove 3 trees; debris removal	$ 27,300.00
7	**40+19**	230	110' riprap; 180 SF of VRSS; 50' biolog w/ stakes and grade; 1 j-vane; Create low floodplain terrace; Redirect outlet and protect end w/ riprap; remove 3 trees; Clear buckthorn and brush.	$ 45,500.00
8	**42+51**	140	95' riprap; 150' SF VRSS; 2 cross vanes for grade control; 1 j-vane; remove 5 trees (2 large); Debris/brush removal.	$ 44,800.00
9	**44+64**	180	40' of riprap; 2 cross vanes for grade control (one on side ravine from 26th Street outlet); remove 5 trees (1 large);	$ 23,000.00
10	**46+53**	60	720 SF VRSS	$ 40,500.00
11	**47+65**	130	600 SF VRSS; 6 root wads; 1 cross vane; grade slope; remove 10 trees; Brush and debris removal.	$ 70,400.00
12	**48+91**	150	740 SF VRSS; 1 cross vane for grade control; remove 28 trees	$ 83,800.00
13	**50+41**	30	50' riprap; 1 cross vane for grade control; remove 6 trees (2 very large).	$ 16,900.00
14	**51+65**	120	4 j-vanes; Replace, redirect and protect end w/ riprap 2 outlets (need 1 drop structure MH to dissipate energy).	$ 24,600.00
15	**53+28**	200	Regrade 200' of east bank to 2:1; Live staking and revegetate.	$ 8,600.00
17	**60+01**	250	3,900 CY sediment removal above fish barrier; 0.25 acres of wetland vegetation seeding.	$ 139,300.00
--	**--**	--	Easement acquisition	$ 120,000.00
			Summation	**$ 965,200**

[1] Stream stationing: 0+00 at West Medicine Lake Road bridge

[2] All sites include restoration seeding and erosion control blanket for disturbed areas, and a 2:1 tree replacement as needed. Site 1 may require sediment collection and laboratory analysis as per MPCA Guidance.

[3] Construction cost estimates include additional 25% for design, permitting, and contingency

Figures

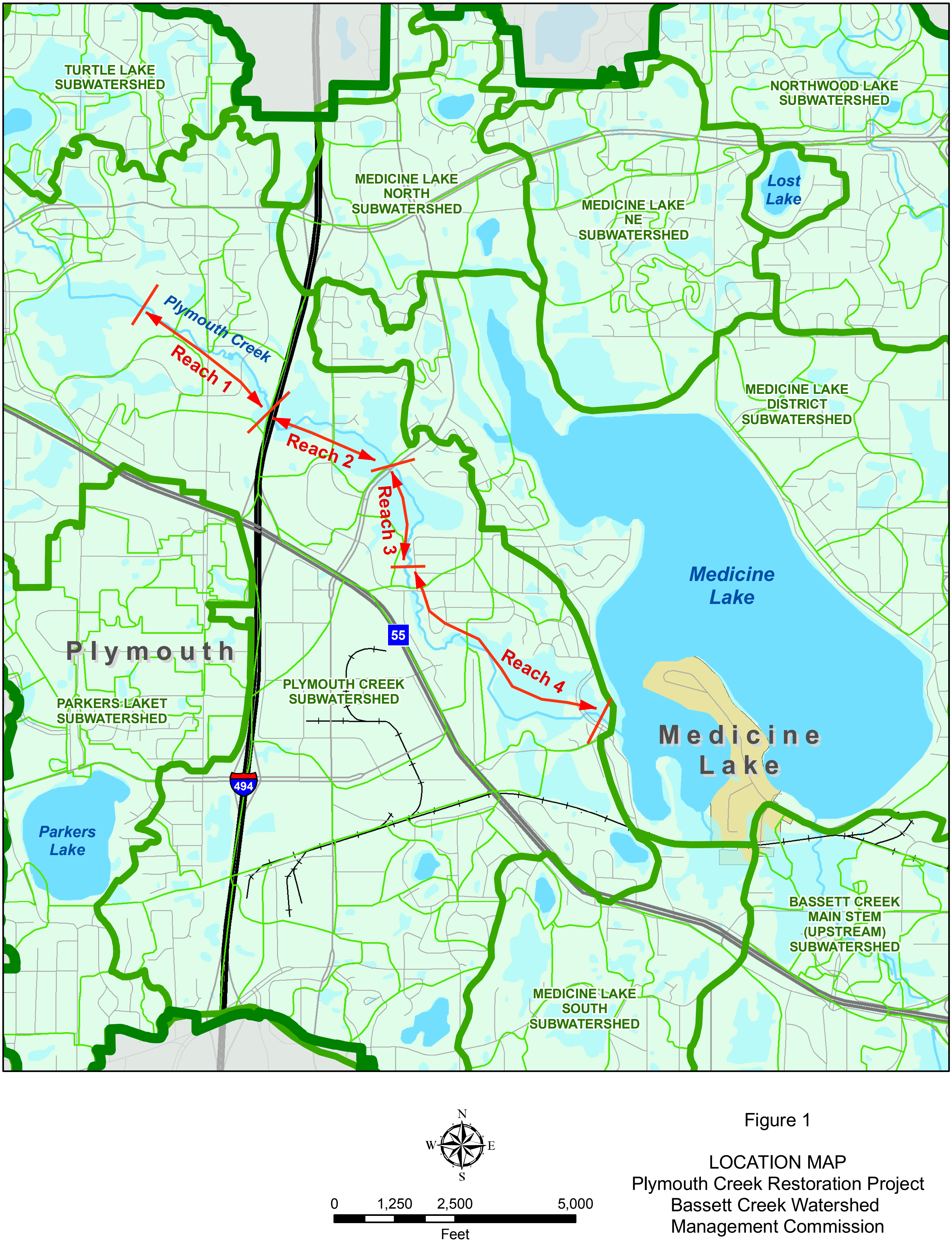
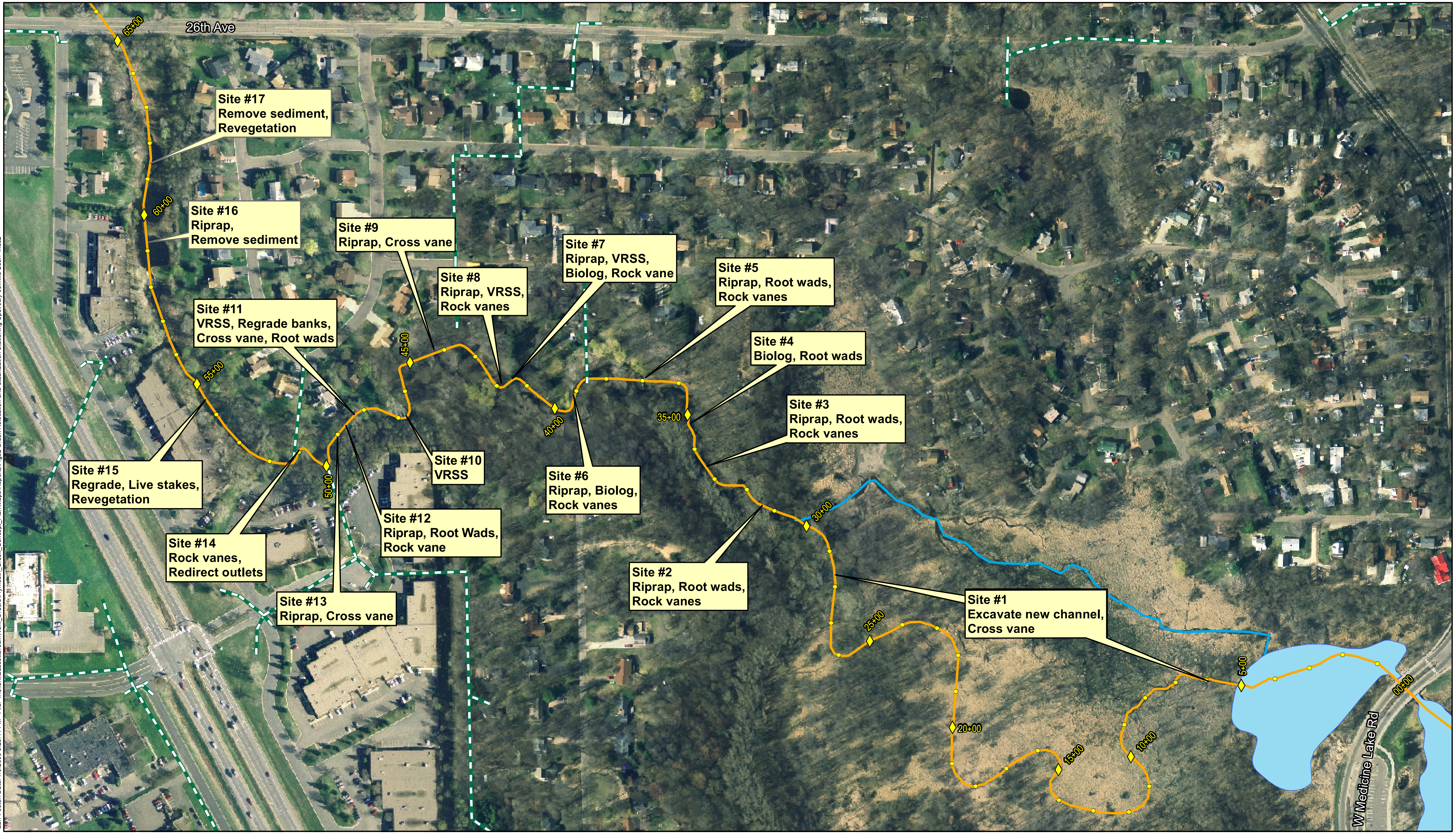


Figure 1

LOCATION MAP
Plymouth Creek Restoration Project
Bassett Creek Watershed Management Commission



Barr Footer: Date: 7/9/2009 3:23:44 PM File: I:\Client\BassettCreek\Work_Orders\Plymouth_Creek_Concept_Plan\Maps\Reports\Fig2 Creek Relocation and Stabilization Stationing Updt July 09.mxd User: mbs2

Station

Storm Sewer

Existing Creek Alignment

Extent of Channel to be Restored and Relocated

Proposed Pond Extent

Note: Stream alignment shown has not been verified by survey. Location will need to be verified with a full survey prior to final design

N

Feet

250 0 250

Figure 2

PLYMOUTH CREEK RELOCATION AND STREAM STABILIZATION SITES

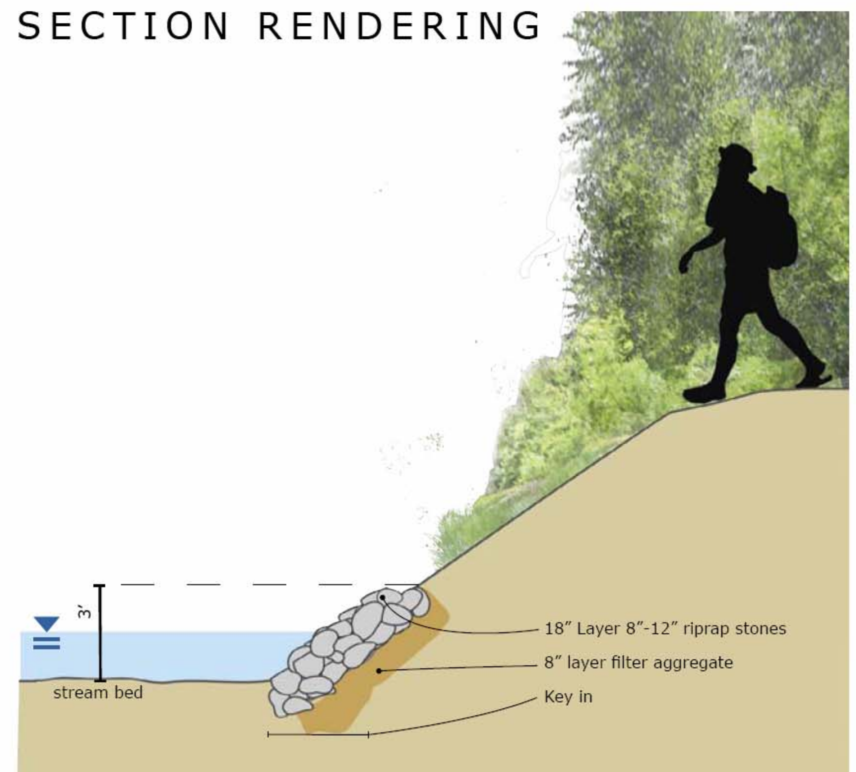
Plymouth Creek Restoration Project

Bassett Creek Watershed Management Commission

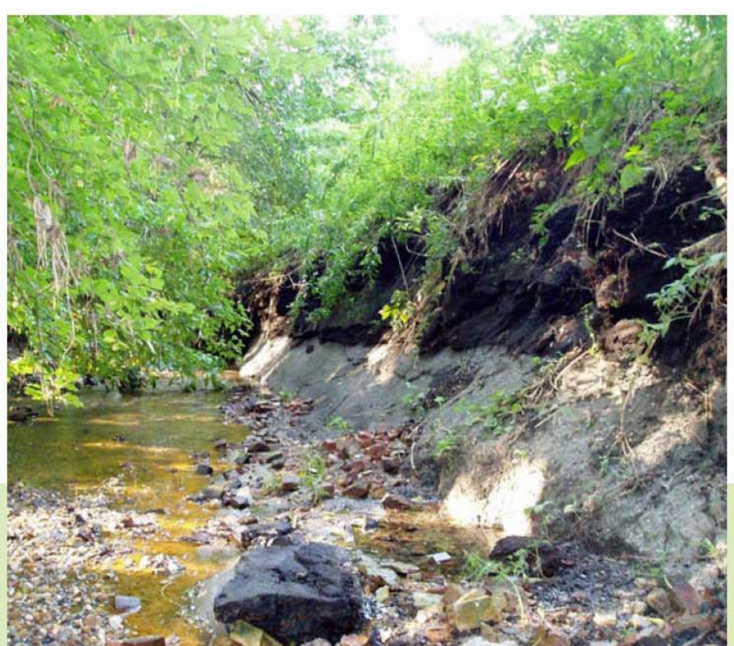
Stream Stabilization Plan

Stone Toe Protection is constructed from cobble-sized rock on the creek edges. It extends to approximately the bankfull level, which will protect the channel banks for flow events that occur every 1 to 2 years or less. The material will extend into the ground to resist scour. Coarse gravel is used to separate the larger rock material from underlying soil. Stone toe protection is typically used in conjunction with revegetation of the upper banks.

SECTION RENDERING

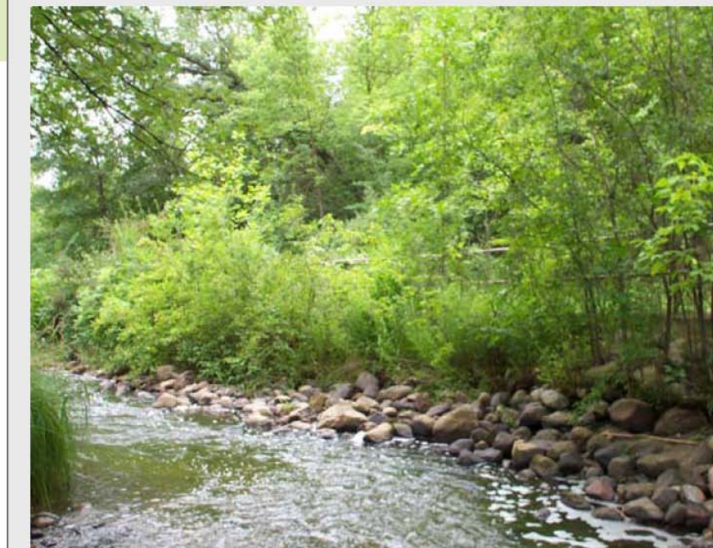


EXISTING CONDITIONS



Fluvial bank erosion is caused by water in the stream moving past the streambanks. The shear stress caused by the flow entrains soil particles into the flow, causing the stream bank to erode away. This is the most common type of erosion that occurs in streams. Virtually all streams experience this type of erosion as their flow path evolves over time. However, the rate of fluvial bank erosion can increase when the stream is out of equilibrium with its watershed. Increased flow from a watershed will increase the rate of fluvial bank erosion. In many cases, it appears to be a part of the natural process of stream evolution. In places where the channel is confined by the valley walls, however, fluvial bank erosion can lead to failure of the high banks. It can also undermine storm sewer inlets.

SIMILAR PROJECTS



Stone toe protection has been used extensively in Nine Mile Creek's Lower Valley, in conjunction with deflector dikes, grade control measures and stabilization of large bank failures. Following the 1987 "super storm," the proposed design allowed the stream to continue its course while taking measures to protect areas where water flow was eroding valley walls. The resulting measures have stabilized the stream channel and valley walls while blending seamlessly with the natural environment.

MATERIALS

Materials will consist of cobble-sized material with coarse gravel filter layer to provide separation from the underlying soil. Natural fieldstone material will be used.

Stone Toe Protection

Bank Protection

BARR

Figure 3

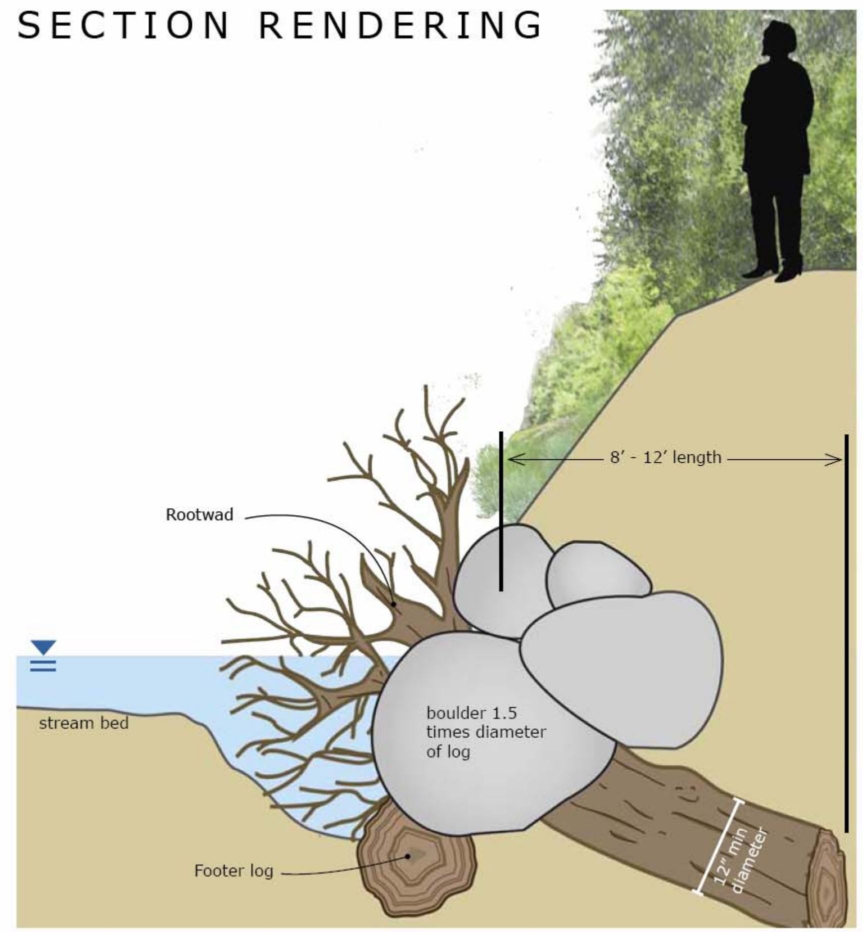
Stream Stabilization Plan

Root wads are constructed using sections of tree trunks with their root balls attached. The trunks extend into the stream bank leaving only the roots exposed, partially submerged. The root wads are spaced to protect a given length of bank. Footer logs and boulders are often used to help stabilize the root wads. Root wads work well where the water is deep, such as on the outside of bends, and where there is adequate sunlight to allow vegetation to grow around the exposed root wads. As the vegetation becomes established, it becomes difficult to distinguish the root wads from their natural surroundings.

EXISTING CONDITIONS

Fluvial bank erosion is caused by water in the stream moving past the streambanks. The shear stress caused by the flow entrains soil particles into the flow, causing the stream bank to erode away. This is the most common type of erosion that occurs in streams. Virtually all streams experience this type of erosion as their flow path evolves over time. However, the rate of fluvial bank erosion can increase when the stream is out of equilibrium with its watershed. Increased flow from a watershed will increase the rate of fluvial bank erosion. In many cases, it appears to be a part of the natural process of stream evolution. In places where the channel is confined by the valley walls, however, fluvial bank erosion can lead to failure of the high banks. It can also undermine storm sewer inlets.

SECTION RENDERING



SIMILAR PROJECTS

Root wads were used to stabilize two sites on the Rum River in Anoka, Minnesota, where severe bank erosion threatened to destroy adjacent trails. Approximately six root wads were placed at each site under difficult, high-water conditions. The banks were then graded, topsoil was added, and native vegetation was planted. Despite the difficult placement, the root wads have protected the lower bank, allowing the vegetation to become well established.

MATERIALS

Materials will consist of 12 to 16 foot long tree trunks, minimum 12-inch diameter, with the root ball attached. Materials should be harvested on-site as much as possible. Smaller logs and boulders are also helpful to stabilize and support the root wads.

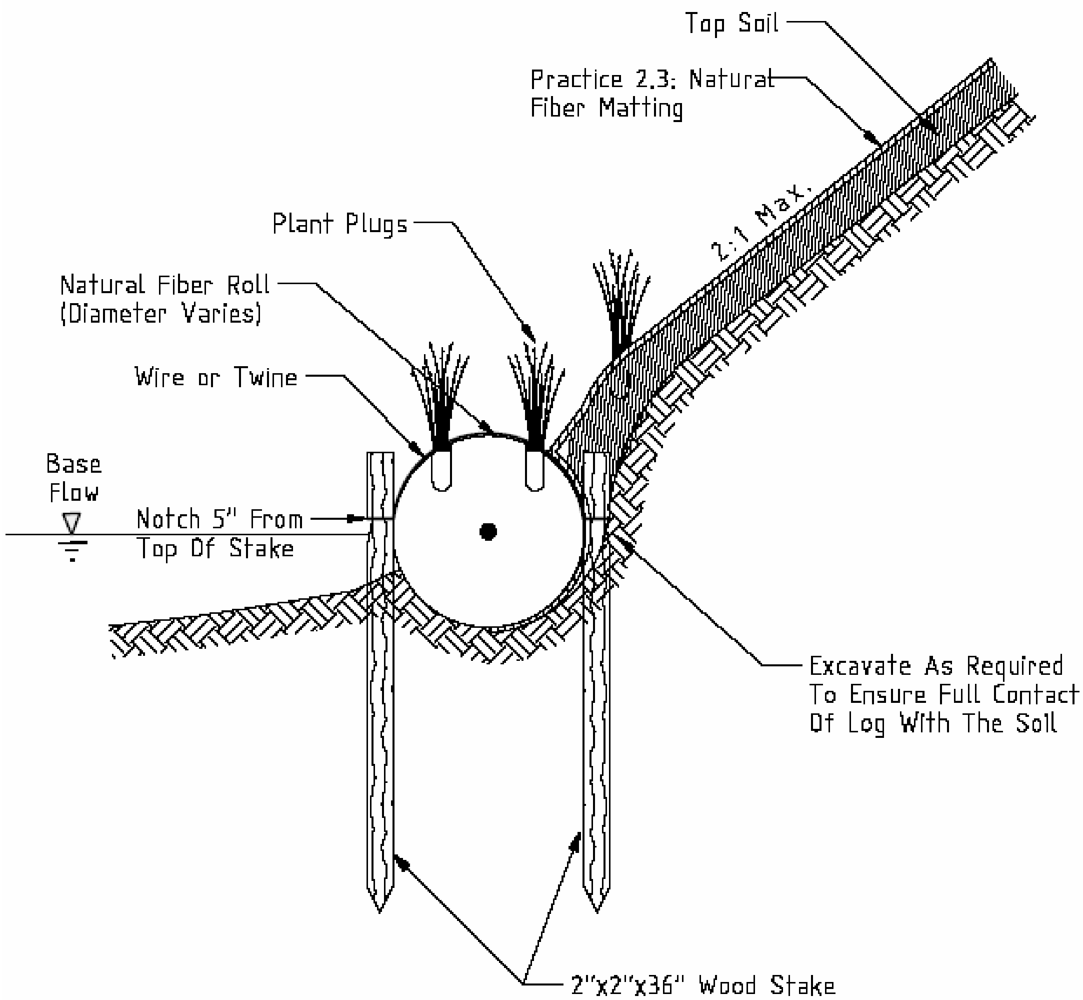


Root Wads

Bank Protection

BARR

Figure 4



Source:
The Virginia Stream Restoration & Stabilization Best Management Practices Guide

Figure 5
Biologs Bank Protection
Plymouth Creek Restoration Project
Bassett Creek Watershed Management Commission

Stream Stabilization Plan

Grade control measures are used where channel downcutting has occurred. Various types of weirs are commonly used to provide grade control on streams, particularly in steeper systems. Weirs can be constructed of sheetpile, concrete, or natural materials such as rock. In most cases, natural rock is used to emulate natural riffles. Large boulders would comprise the core of the structure, with smaller rock material placed on the upstream and downstream sides of the boulders to provide a gradual transition to the channel.

The riffles will serve to raise the surface of the water profile, and will reconnect the stream to its floodplain areas. Following the installation of the riffles, pools will be created upstream of the riffles. However, these pools will fill with sediment over time, which will in effect raise the channel bottom to the desired elevation.

MATERIALS

Materials will consist of various gradations of rock, ranging from large, 3-foot boulders to coarse gravel.

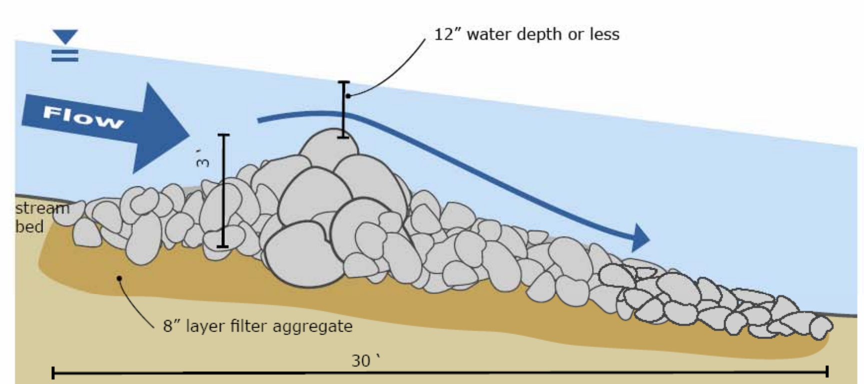
SIMILAR PROJECTS

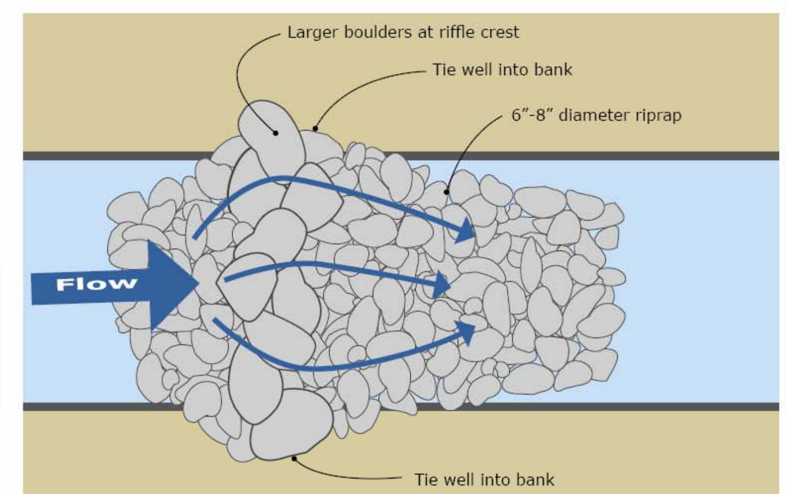
Following the 1987 "super storm," a rapids was constructed on Nine Mile Creek downstream of the 106th Street Bridge. The rapids was one of several grade-control structures that were installed on a three-mile stretch of creek in the lower valley. The proposal allowed the stream to continue its course while taking measures to protect areas where water flow was eroding valley walls. Protection measures included applying porous deflector dikes, burying sheetpile walls parallel to the creek to prevent undercutting of slopes, installing weirs (rock or capped sheetpile) to limit stream-bed degradation, and improving storm-sewer outlets.

EXISTING CONDITIONS

Channel incision occurs when there is an imbalance between the sediment supply and the sediment carrying capacity of the stream. Erosion will occur when the sediment carrying capacity of a stream exceeds the sediment supply. In streams with cohesive banks and steep channel slope, the erosion will first occur primarily on the channel bottom because that is where the erosive forces are the strongest. As the channel deepens, the stream will gradually become wider as the banks eventually fail. The stream will gradually return to equilibrium; however, the process can take many years and significant amounts of erosion will occur during the process.

SECTION/PLAN RENDERING





Constructed Riffle

Grade Control

BARR

Figure 6

Stream Stabilization Plan

Rock vanes are constructed from boulders on the creek bottom. They function by diverting channel flow toward the center and away from the bank. They are typically oriented in the upstream direction and occupy no more than one third of the channel width. Vanes are largely submerged and inconspicuous. The rocks are chosen such that they will be large enough to resist movement during flood flows or by vandalism, with additional smaller rock material to add stability. Rock vanes function in much the same way as root wads in that they push the stream thalweg (zone of highest velocity) away from the outside bend. They also promote sedimentation behind the vane, which adds to the toe protection.

Vanes can also be constructed from both banks, forming an upstream-pointing "V." In this configuration, the vane protects both banks and also provides grade control.

MATERIALS

Materials will consist of various gradations of rock, ranging from large, 3-foot boulders to coarse gravel.

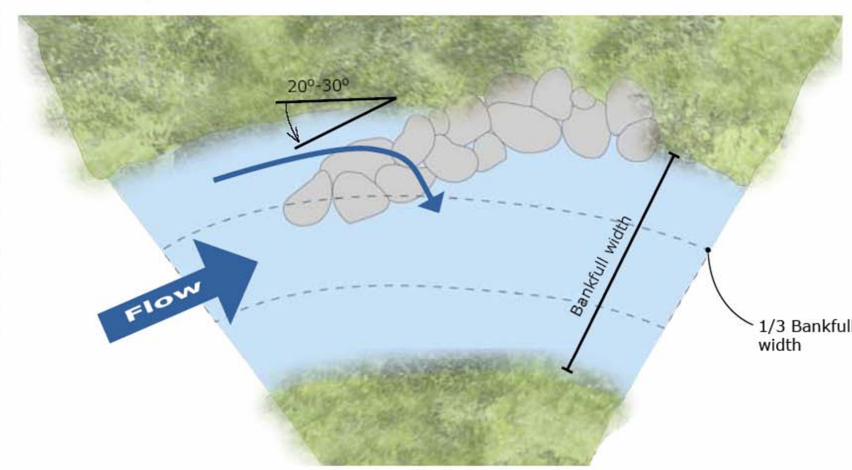
SIMILAR PROJECTS

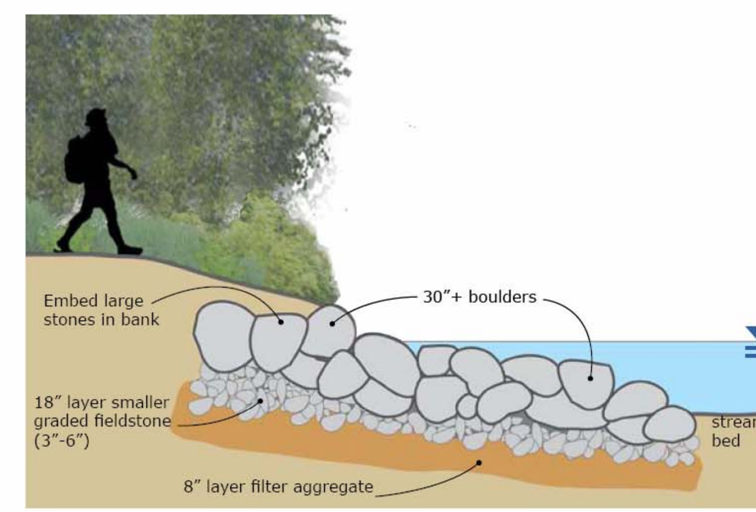
Here is an example of a stabilization project designed for a 1,000-foot long, 20-foot high streambank that was severely eroded. The channel was directed away from the bank toe by installing six rock vanes. The bank was planted with native vegetation and protected with erosion control blanket, while the terrace above the bank was graded to redirect surface runoff to a less vulnerable area. The restored streambank withstood significant flooding during 2001, and has become nicely vegetated (see picture above).

EXISTING CONDITIONS

Fluvial bank erosion is caused by water in the stream moving past the streambanks. The shear stress caused by the flow entrains soil particles into the flow, causing the stream bank to erode away. This is the most common type of erosion that occurs in streams. Virtually all streams experience this type of erosion as their flow path evolves over time. However, the rate of fluvial bank erosion can increase when the stream is out of equilibrium with its watershed. Increased flow from a watershed will increase the rate of fluvial bank erosion. In places where the channel is confined by the valley walls, however, fluvial bank erosion can lead to failure of the high banks. It can also undermine storm sewer inlets.

PLAN/SECTION RENDERING





Rock Vanes

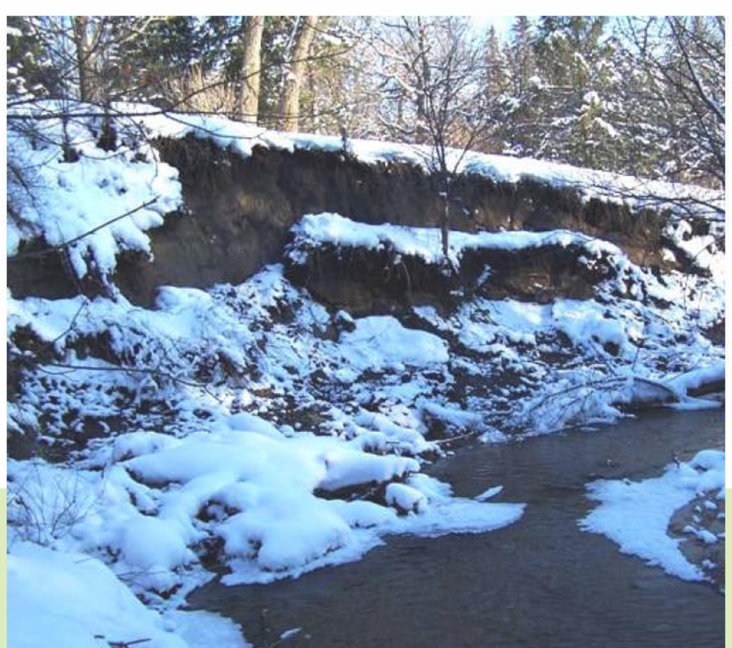
Bank Protection

BARR

Figure 7

Stream Stabilization Plan

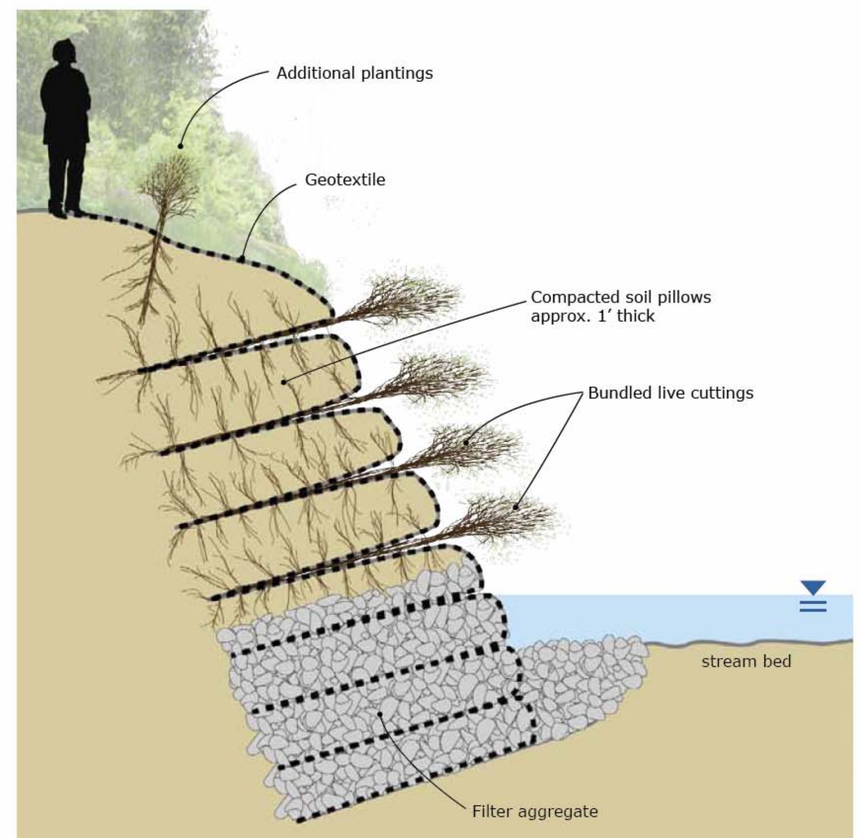
EXISTING CONDITIONS



Fluvial bank erosion is caused by water in the stream moving past the streambanks. The shear stress caused by the flow entrains soil particles into the flow, causing the stream bank to erode away. This is the most common type of erosion that occurs in streams.
Virtually all streams experience this type of erosion as their flow path evolves over time. However, the rate of fluvial bank erosion can increase when the stream is out of equilibrium with its watershed. Increased flow from a watershed will increase the rate of fluvial bank erosion.

Soil Pillows are utilized in a bioengineering method known as Vegetated Reinforced Slope Stabilization (VRSS). The method combines rock, geosynthetics, soil and plants to stabilize steep, eroding slopes in a structurally sound manner. VRSS typically involves protecting layers of soils with a blanket or geotextile material (e.g. erosion control blanket) and vegetating the slope by either planting selected species (often willow or dogwood species) between the soil layers or by seeding the soil with desired species before it is covered by the protective material. In either case, with adequate light and moisture, the vegetation grows quickly and provides significant root structure to strengthen the bank. This method tends to be labor intensive and, therefore, relatively expensive.

SECTION RENDERING



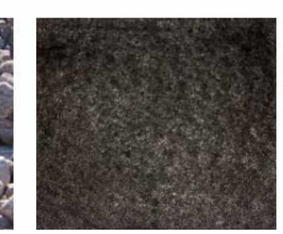
In places where the channel is confined by the steep valley walls, however, fluvial bank erosion can lead to failure of the high banks. It can also undermine storm sewer inlets.
For sites where groundwater seepage is a problem and where it is desirable to maintain steep banks, soil pillows are a feasible solution.

SIMILAR PROJECTS

The Mill Creek Restoration Project utilized soil bioengineering design to stabilize 175 linear feet of severely eroding streambanks within the Caldwell Recreation Park in southeastern Ohio. The work included two 25-foot vegetated reinforced soil slope (VRSS) sections, two 50-foot fill bank sections protected with woven coir and direct woody plantings, and a 12.5-foot tie-in on the upstream and downstream end of streambank work area.

MATERIALS

Materials consist of graded rock for the lower layers of the structure and for internal drainage, if necessary. Geotextile fabric is used to wrap the soil. Plants, such as willow or dogwood, or seed mixture is used for planting in and between the soil pillows.



Soil Pillows

Bank Protection

BARR

Figure 8

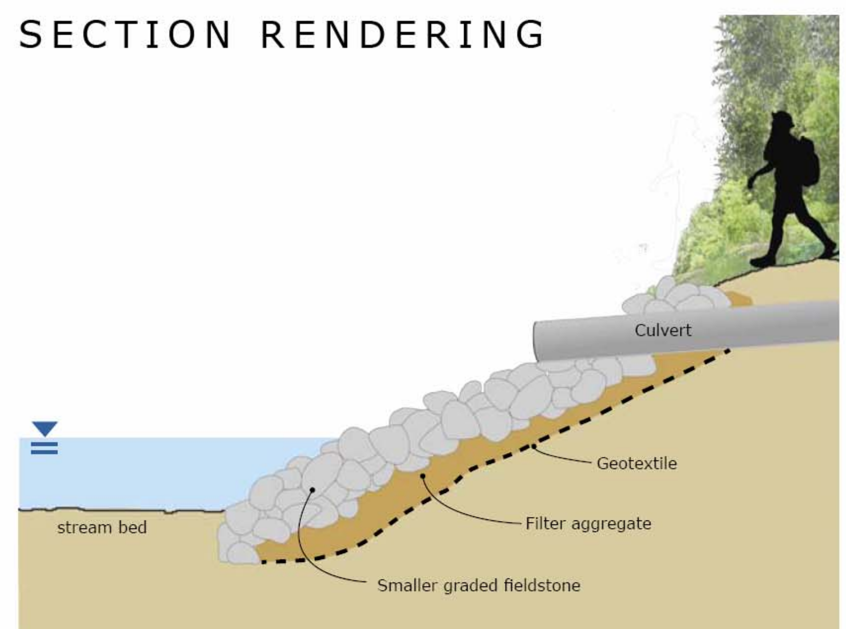
Stream Stabilization Plan

Culvert Stabilization is somewhat unique to each situation, depending on the site circumstances. Most sites require additional rock placement with a granular filter layer (rather than filter fabric). Some cases may require re-alignment and/or lowering of the outlet to better align with the stream channel. Typically, outlets should be aligned in the downstream channel direction so that flow doesn't impinge on the opposite bank. It is usually desireable for the culvert to enter the stream at or just above the normal water level in order to minimze the potential for undercutting.

EXISTING CONDITIONS

Erosion is frequently observed at culvert outlets for a variety of reasons, including insufficient erosion protection at the culvert outlet, streambank erosion, and channel downcutting, which leaves the culvert perched above the channel. Filter fabric is often used at culvert outlets to separate riprap protection from underlying soils, however the fabric provides a slippery surface for the riprap, which commonly slides into the channel.

SECTION RENDERING

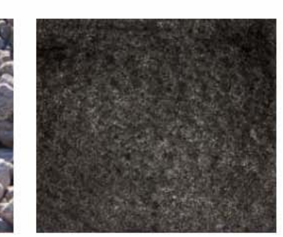


SIMILAR PROJECTS

There are many culvert stabilization designs used on various streams and rivers. Because they are often small projects, the work is often performed by local municipalities or completed as part of a larger project.

MATERIALS

Materials consist of rock materials ranging from graded riprap (either fieldstone, or, for steep slopes, angular) and granular filter material (typically coarse gravel). If necessary, additional pipe, manholes and end sections may be necessary.



Culvert Stabilization

Bank Protection

Figure 9

Project Task	2009						2010												2011						
	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July
Feasibility study to BCWMC & City	■	■																							
BCWMC review of feasibility study		■	■																						
BCWMC hearing & order project for 2010			■																						
BCWMC submit final 2010 tax levy amount to Hennepin County (Due by Oct. 1st)			■																						
City of Plymouth public input process			■	■	■	■	■	■	■	■	■	■													
EAW - preparation to "no EIS" decision (90 days), includes archaeological & reconnaissance study					■	■	■																		
Project final design				■	■	■	■	■	■	■	■	■													
COE and other permits - submit immediately upon EAW decision (120 days for COE permit) - COE permit may be issued as part of Resource Management Plan							■	■	■	■	■	■													
BCWMC re-review of project, if needed											■														
Project bidding and city council approval													■	■											
Project contracting/notice to proceed															■										
BCWMC submit final 2011 tax levy amount to Hennepin County															■										
Project mobilization																■	■								
Streambank restoration																	■	■	■	■					
New channel construction																		■	■	■					
Final stabilization (*new channel - May 2011; old channel - May 2012)																							*& May 2012	■	■

Figure 10

PROJECT SCHEDULE
Plymouth Creek Restoration Project
Bassett Creek Watershed Management Commission

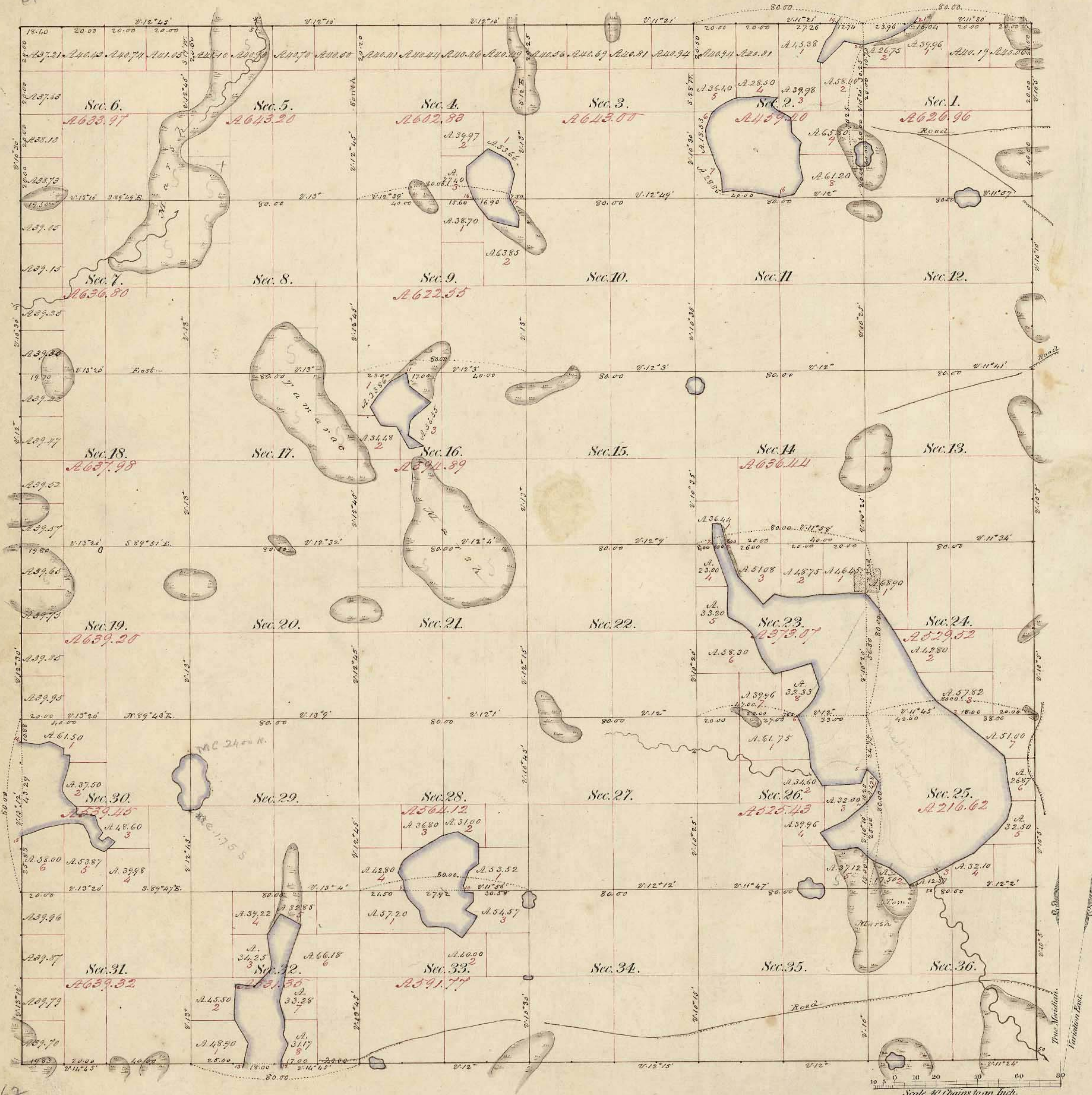
P:\Mpls\23 MN\27\2327051\WorkFiles\Plymouth Creek\Feasibility Report\Figure 10 Project schedule_revised July_24_09

Appendices

Appendix A

1855 Public Land Survey & Historic Aerial Photos

Township No. 118 N., Range No. 22 West of the 5th Mer.



Total number of Acres 21487.87

Meanders of Lakes.

Posts	Courses	Chs. Lks.	Posts	Courses	Chs. Lks.	Posts	Courses	Chs. Lks.
Lake in Sections			Lake in Secs. 28 & 33				S.65° E.	8.00
14.23.24.25 and 26.							South	3.00
			9	N.10° W.	5.00		East	3.00
1	S.39° E.	19.00		N.32° W.	4.00		S.8° W.	5.00
	S.31° E.	13.00		N.21° E.	5.00		S.18° W.	9.00
	S.26° E.	15.00		N.47° E.	6.00		S.11° W.	3.00
	S.37° E.	14.00		N.61° E.	17.00		S.21° E.	4.00
2	S.56° E.	9.44		N.77° E.	8.00		S.49° E.	6.00
				S.61° E.	11.00		South	3.50
	S.53° E.	18.00		South	9.00		East	5.00
	S.44° E.	12.00		S.52° W.	7.00		S.79° E.	4.00
	S.10° E.	22.00		S.20° W.	7.00		S.16° E.	5.00
	S.17° W.	7.00	10	S.10° E.	2.00		S.34° E.	4.00
	S.35° W.	8.00					S.36° W.	3.50
	S.50° W.	16.00		S.21° E.	1.00		S.55° E.	2.50
	S.66° W.	18.00		S.82° E.	4.00		N.53° E.	3.00
	S.70° W.	5.00		South	4.00		S.60° E.	4.00
	S.60° W.	10.00		S.47° W.	5.00		S.46° W.	6.00
	N.42° W.	5.00		S.62° E.	6.00		N.73° W.	4.00
	N.54° W.	7.00		S.28° W.	5.00		N.65° W.	2.00
	N.62° W.	11.00		S.39° W.	8.00		N.37° W.	3.00
3	N.51° W.	1.63		N.55° W.	8.00		N.14° W.	3.00
				N.83° W.	5.00		N.27° W.	5.00
	N.33° W.	3.00		S.88° W.	4.00		N.72° W.	2.50
	N.52° W.	3.00		N.40° W.	5.00		N.88° W.	5.00
	S.84° W.	10.00		N.14° W.	5.00		S.80° W.	10.00
	N.86° W.	3.00		N.44° W.	8.00	15	S.72° W.	13.00
	N.35° W.	9.00	9	N.19° W.	3.47			
	N.64° E.	13.00				Lake in Secs. 4 & 9.		
4	N.52° E.	14.00	Lake in Section 16					
						16	N.20° W.	9.00
	N.35° E.	6.00	11	S.61½° W.	8.00		North	7.00
	N.24° E.	5.00		S.39½° W.	16.00		N.34° E.	13.00
5	N.42½° W.	7.20		S.33° E.	10.00		S.62° E.	8.00
				S.86½° E.	7.50		S.22° E.	12.00
	S.20° W.	7.00		S.30° E.	11.00	17	S.12° W.	8.28
	S.86° W.	18.00		N.78½° E.	7.00			
	N.33° W.	10.00		N.58° W.	8.50		S.28° E.	9.00
	N.5° W.	9.00		N.7½° E.	7.00		South	5.00
	N.21° W.	14.00		N.43° E.	5.00		N.75° W.	15.00
6	N.30° W.	2.00		N.49° E.	8.00	18	N.36° W.	11.29
				N.53½° W.	12.00			
	N.49° E.	7.00	11	N.13½° W.	6.40	Lake in section 2		
	N.37° E.	5.00						
	N.26° E.	6.00	Lake in Section 32.			18	N.81° W.	13.50
	N.17° W.	11.00					West	4.00
	S.75° W.	18.00	12	North	2.00		N.83° W.	4.00
	N.47° W.	9.00		N.23° E.	7.50		S.83½° W.	5.00
	N.21° W.	15.00		N.25° W.	5.00		N.4° W.	9.00
	N.42° W.	4.00		N.14° E.	3.50		N.28° W.	8.00
	N.63° W.	8.00		N.4° W.	4.50		N.20° W.	11.00
	North	14.00		N.17° W.	7.00		N.½° W.	4.00
7	N.19° W.	21.00		N.12° E.	19.00		N.26° E.	8.00
				N.14° E.	19.00		N.50° E.	4.00
	North	9.00		N.62° W.	9.00		N.64° E.	7.50
	East	4.00		S.33° W.	12.00		N.77° E.	4.00
8	S.12½° E.	9.30		S.9° E.	12.00		S.83° E.	4.50
				S.7° W.	4.00		N.78½° E.	5.00
	S.20° E.	16.00		S.45° W.	10.00		S.83° E.	8.00
	S.42° E.	18.00		N.86° W.	10.00		S.50° W.	3.30
	N.47° E.	8.00		S.3° W.	16.00		S.27° E.	3.00
	S.73° E.	5.00		S.28° E.	14.00		S.59½° E.	8.00
	East	11.00	13	S.12° W.	8.38		S.20° E.	7.50
	N.78° E.	4.00					S.43° E.	7.50
	N.87° E.	14.00	Lake in Section 30				S.18° W.	3.00
1	S.86° E.	8.98					S.3° W.	2.50
			14	S.85° E.	8.00		S.2° W.	6.00
				N.75° E.	5.00		S.10½° E.	6.00
							S.36° W.	8.50
		589.55			234.75	18	S.83° W.	6.50
						Lake in Secs. 1 & 2.		
						19	S.26° W.	5.50
							S.43° W.	2.50
							S.24° W.	11.00
							S.73° E.	2.00
							N.49° E.	14.00
						20	S.78° E.	9.00
							N.75° E.	15.00
							N.60½° E.	8.50
						21	N.54° E.	2.30
						Total	Ms. 18. Chs. 21.	Lks. 47

Surveys Designated.	By Whom Surveyed.	Date of Contract.	Amount of Surveys M. Chs. Lks.	When Surveyed.	When Charged in the Sur. Genl. Acc.
Township lines.	John Ryan	July 19th 1854	23 . 78 . 23	May 1855	
Subdivisions.	Hardin Nowlin	June 9th 1855	75 . 20 . 20	August 1855	

The above Map of Township No. 118 N., of Range No. 22 West, 5th Principal Meridian, Minnesota, is strictly conformable to the field notes of the survey thereof on file in this Office which have been examined and approved.

Surveyor General's Office
Dubuque, March 18th 1856.

Warner Lewis
Sur. Genl.

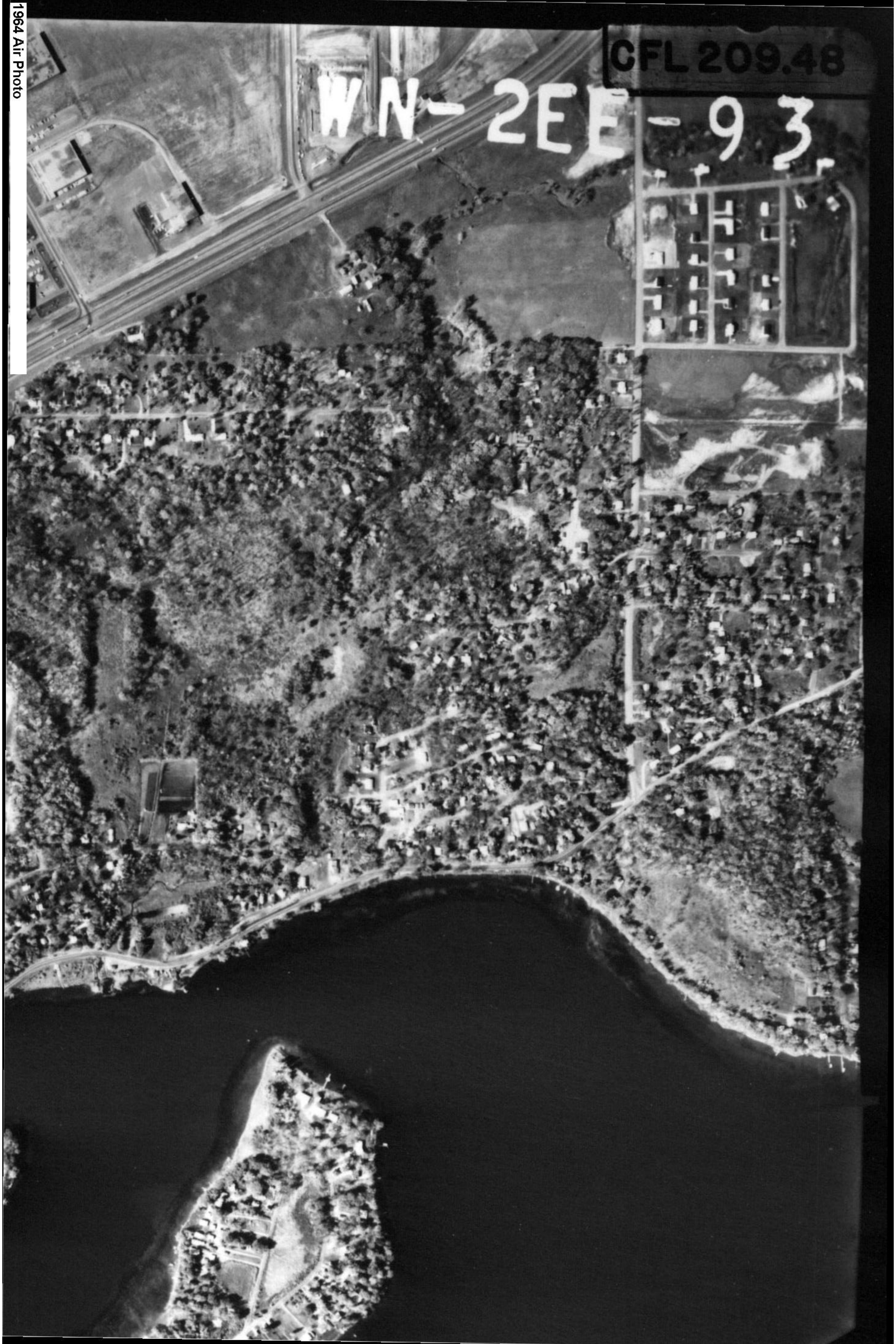
1937 Air Photo

1940 Air Photo

1947 Air Photo

1953 Air Photo

1957 Air Photo



1964 Air Photo

1969 Air Photo

Appendix B

2008 Site Photos

Stream bank erosion and existing vegetation at Site 5.

Stream bank erosion and existing vegetation at Site 8.

Stormsewer outlet and bank erosion at Site 14.

Stream bank erosion and existing vegetation at Site 15.