# STEIGER LAKE WET DETENTION POND FEASIBILITY STUDY

for:

**Minnehaha Creek Watershed District**

**October 7, 2010**

by:

**SRF Consulting Group, Inc.**
**One Carlson Parkway North, Suite 150**
**Minneapolis, MN  55447-4443**

SRF No. 0107087

# TABLE OF CONTENTS

# 1.0 Executive Summary

Steiger Lake is located within the City of Victoria in northeastern Carver County. The lake's water quality historically has been good, with in-lake nutrient concentrations below the threshold's for the 303d Impaired Waters List. However, the average concentration in 2008 was 44 µg/L, which is above goal set for the lake in the District's Water Resources Management Plan (2007) of 30 µg/L. This study is intended to investigate the feasibility, size and scope of a wet detention pond or other best management practice (BMP) to treat the runoff from two areas tributary to Steiger Lake and located immediately south of Trunk Highway 5. The primary focus for the location of such a BMP is a partially drained wetland, identified as D-116-24-022 in the District's wetland inventory. In addition to the subject wetland, this study also looked at the potential to utilize two existing stormwater ponds to assist with the phosphorus removal. The ponds are located immediately north and south of the subject wetland adjacent to Trunk Highway 5 and in the Katy Hills area, respectively. The recommended BMP should be designed to remove at least half of the total phosphorus (TP) load projected to be contributed by two subwatersheds under the ultimate 2020 development conditions.

Five alternatives were identified: 1) use the existing channel with a multi-stage outlet; 2) create a meandering channel with a multi-stage outlet; 3) create a wet detention pond within the subject wetland; 4) construct a multi-stage outlet to allow restoration of the wetland to a hemi-marsh; and 5) construct a multi-stage outlet to allow restoration of the wetland to a hemi-marsh while routing upstream inflows through Katy Hills Pond. Modeling software used in this study includes PLOAD, PondNet, and XP-SWMM. PLOAD data was used to effectively calibrate PondNet to match the phosphorus loading in the District's model. Based on this analysis, the first four alternatives provide the necessary reductions in TP loading from the two subwatersheds, ranging from 52.4% to 55.6%. Three of these options required the use of the existing City pond in order to create BMPs in series to achieve a minimum of 50% removal. Upon completion of the initial study of the first four alternatives, the District requested further investigation of the nutrient loading to account for removals that may occur in the ponds and wetland complex upstream of the subject wetland. This detailed analysis was incorporated into the study of the fifth alternative, which incorporated most existing stormwater ponds and wetlands upstream of the study area, showed that TP reductions of up to 31.8% can be achieved by routing most upstream runoff through Katy Hills Pond and the existing City pond.

XP-SWMM modeling indicates that all alternatives could be designed to provide extended detention for storms up to a 1-inch rainfall without raising the 2-year or 100-year high water levels. The models also indicate that additional active storage would be required surrounding the existing City pond in order to maintain the existing 100-year high water level. The detailed analysis of the fifth alternative shows increased water surface elevations throughout the system due to the refinement of upstream storage capacity.

The additional study also included an analysis of the expected sediment loading to Steiger Lake due to streambank erosion within the channel draining the subject wetland. Five segments of the stream channel showed evidence of erosion, two of which was sever. The estimated soil loss from the stream channel is approximately 157 tons per year. Channel bank stabilization at the two mass wasting locations will reduce soil loss within the channel to approximately 102 tons per year.

## 2.0 Introduction and Background

Steiger Lake is located within the City of Victoria in northeastern Carver County (Figure 1). It falls within the southwestern boundary of the Minnehaha Creek Watershed District (MCWD or District) and is surrounded by the Carver Park Reserve except at the lake's southernmost point. There are large areas of undisturbed or minimally disturbed forest and wetland ringing the lake, which have been designated Regionally Significant Ecological Areas by the Minnesota Department of Natural Resources. The Minnesota County Biological Survey identified several areas of moderate or high biodiversity significance, including a large area of maple-basswood forest and tamarack swamp surrounding Steiger Lake.

Steiger Lake's water quality historically has been good, with in-lake nutrient concentrations below the threshold's for the 303d Impaired Waters List. However, the average concentration in 2008 was 44 µg/L, which is above goal set for the lake in the District's Water Resources Management Plan (2007) of 30 µg/L. To meet the goal, the District has determined that the external phosphorus load to Steiger Lake will need to be reduced by 121 lbs./year.

Furthermore, Steiger Lake is part of a chain of lakes, marshes and channels that flow to Parley Lake before ultimately discharging to Halsted's Bay on Lake Minnetonka. Parley Lake is impaired for excess nutrients, and therefore, a total maximum daily load (TMDL) study including a phosphorus reduction plan is currently being developed for the lake. Specifically, the draft TMDL has identified the need to reduce external loading to Parley Lake by 978 pounds annually through various efforts throughout the watershed as well as through internal load management. Although water quality improvements to Steiger Lake cannot be used in determining the reductions to Parley Lake, the District sees this project as an opportunity to address some of the water quality issues throughout the Six Mile Marsh watershed.

This study is intended to investigate the feasibility, size and scope of a wet detention pond or other best management practice (BMP) to treat the runoff from two areas tributary to Steiger Lake and located immediately south of Trunk Highway 5. The primary focus for the location of such a BMP is a partially drained wetland, identified as D-116-24-022 in the District's wetland inventory. In addition to the subject wetland, this study also looks at the potential to utilize two existing stormwater ponds to assist with the phosphorus removal. The ponds are located adjacent to Trunk Highway 5 north of the subject wetland and adjacent to Narcissus Street south of the subject wetland, in the Katy Hills area. The recommended BMP should be designed to remove at least half of the total phosphorus (TP) load projected to be contributed by the two subwatersheds under the ultimate 2020 development conditions. See Figures 1 and 2 for maps of the general location and the specific study area, respectively.

As shown on Figure 4, the subject wetland falls within three parcels. All of the parcels are each privately owned.

Trunk Highway 5, which runs along the northerly boundary of the subject wetland, has on-going maintenance issues due to the depth of the wetland soils under the road bed. Therefore, the

Minnesota Department of Transportation (Mn/DOT) plans to reconstruct a portion of Trunk Highway 5 to correct this during 2012. Mn/DOT intends to surcharge this area to consolidate the soils prior to reconstructing the roadway.

This study includes an evaluation of the existing conditions and full-build conditions, provides five alternatives in an effort to meet the nutrient removal goal, a comparison of the cost-effectiveness of the alternatives, observations and suggestions for next steps. Resources used for the study include:

- The PLOAD and XP-SWMM models created for the MCWD Hydraulic, Hydrologic, Pollutant Study, 2003
  - PLOAD model data = Six Mile 041702.xls
  - XP-SWMM model = 050722_ALL_Updated2_Upper.xp
- MCWD Functional Assessment of Wetlands, 2003
- MCWD Six Mile Marsh Implementation Plan, 2005
- Carver County 2-foot contour mapping
- Carver County Soil Survey
- HydroCAD output from the Victoria pond permitting (received from MCWD)
- MCWD Permit Numbers 86-71, 87-45 and 88-17 regarding the Katy Hills Development
- City of Victoria BMP Inventory Analysis tabulations

# 3.0 Evaluation of Existing Conditions and Future Proposed Conditions

## *3.1 Subwatershed Hydrology and Nutrient Loading*

As noted above, two subwatersheds drain to Steiger Lake in the study area, SMC-12 and SMC-13. See Figure 2 for their location and relationship to Steiger Lake. The larger of the two subwatersheds, SMC-12, is roughly 180 acres in size. Land uses found within this subwatershed consist primarily of single family residential, upland soils that are maintained/planted/cropland, vacant/agricultural, and park or public/semi public uses. The majority of SMC-12 drains to a large wetland complex at the west boundary. This wetland drains via a culvert and an open channel to the subject wetland within subwatershed SMC-13. By 2020, the land uses are expected to shift such that 71.4 percent of subwatershed will be low-density residential, increased from 30.5 percent in the existing condition. The anticipated TP loadings for 2020 reflect this change in land use, with a 35.8 percent increase in TP. [1]

Subwatershed SMC-13 is approximately 71 acres and surrounds the subject wetland. Land use within this subwatershed is predominately single family residential, with a relatively large portion of the subwatershed being the subject wetland. Vacant/agricultural land and upland areas that are maintained or cropland also make up a relatively significant percentage of the drainage area. The subject wetland is partially drained, with a straightened channel flowing

[1] Existing, future 2020 land uses, and their associated nutrient loadings are taken from the MCWD PLOAD data.

through the middle of the wetland. Discharge from SMC-13 flows through a series of culverts and a small stream channel prior to reaching Steiger Lake. Compared to SMC-12, this subwatershed shows only a moderate change in land use by 2020, with a slight increase in low-density residential. Therefore, the expected TP loadings from SMC-13 will not increase significantly over the existing loads. [2]

Table 1 summarizes the existing hydraulic and nutrient loading from the two subwatersheds in comparison with the anticipated loading for the assumed 2020 land use conditions. Based upon our review of the PLOAD data, it does not appear that any phosphorus reductions were attributed to the existing wetlands or stormwater ponds in the two subwatersheds.

**Table 1: Subwatershed Loading**

| Subwatershed ID | Acreage | Hydraulic Loading (ac-ft) | | TP Loading (lbs/year) | |
|---|---|---|---|---|---|
| | | Existing | 2020 | Existing | 2020 |
| SMC-12 | 179.9 | 79.3 | 91.1 | 73.2 | 99.4 |
| SMC-13 | 71.4 | 32.9 | 33.9 | 31.1 | 33.1 |
| ***Total*** | ***251.3*** | ***112.2*** | ***125.0*** | ***104.3*** | ***132.5*** |

## 3.2 Soils Information

According to the Carver County Soil Survey, soils in the study area are generally loamy with moderate infiltration rates. At the particular location identified for the proposed pond, the soil survey indicates the predominant soil type to be muck with very shallow groundwater. Roughly 70% of the wetland is mapped as muck or peat soils (Houghton, Muskego, and Klossner series). As noted in Section 2, the depth of muck is very deep in some locations, affecting the performance of Trunk Highway 5.

Given that the subject wetland had been drained, there was the possibility that permanent inundation of the wetland soils could release trapped phosphorus into the water column. High levels of bio-available phosphorus could preclude the use of BMPs that rely on permanent pools of water or inundation periods longer than a few days. On May 14, 2010, SRF staff took six soil samples from the subject wetland and the upland area adjacent to a stormwater pond immediately north of Trunk Highway 5. Figure 3 depicts the mapped soil polygons and the approximate locations of the six samples, labeled A through F. Soil Samples A through D were taken from the portion of the wetland that lies southeast of Highway 5. Soil Samples E through F were taken from the portion of the wetland that lies northwest of Highway 5. Locations of Samples A and B were close to residences with mowed lawns that sloped to the wetland. Samples B and C were taken from near the toe-of-slope of the easterly side of the Trunk Highway 5 road embankment. Samples E and F were from near the toe-of-slope of the westerly embankment of Trunk Highway 5.

[2] Existing, future 2020 land uses, and their associated nutrient loadings are taken from the MCWD PLOAD data.

The samples were collected with a sharpshooter shovel. Soil was mixed from a soil depth of 4 inches to 15 inches for each sample. The top 4 inches of soil was discarded as it was mostly stems and roots of reed canary grass. Samples were taken to the Research Analytical Laboratory at the University of Minnesota (St. Paul Campus) hours after samples were taken. In all six sampling pits, soils were saturated at a depth of 4 inches from the soil surface and the water table was observed to be at a depth of 9-12 inches.

The soil samples were immediately and thoroughly dried upon arrival at the lab in preparation for phosphorus analysis. Total phosphorus (expressed as percent) and bio-available phosphorus (using the Bray 1 method and expressed as parts per million) were analyzed for each sample. Total phosphorus is an extraction of all of the phosphorus in the soil sample including ortho-phosphates, meta-phosphates, and poly-phosphates that may be bound to various metals in the soil such as iron or aluminum. Bio-available phosphorus is that portion of phosphorus in solution that can be readily used by plants or easily carried via streamflow to receiving water bodies. The Bray 1 method of extraction is commonly used for soils with neutral to slightly acidic pH. Table 2 gives the lab analytical data (TP and bio-available phosphorus, the latter listed as Bray P) for each of the six soil samples.

Results from the Bray 1 test show bio-available phosphorus to be quite low. For comparison, optimal plant growth typically requires 25-30 ppm P; whereas, the highest value measured in soils at the subject wetland was 14 ppm P. Therefore, the soils within the subject wetland are not likely to be a source of phosphorus release with implementation of increased water residence time.

**Table 2: TP and Bio-available P in Soil Samples from the Subject Wetland Site**

| **Sample ID** | **TP ( % )** | **Bray P ( ppm )** |
|---|---|---|
| A | 0.147 / 0.150 | 8 / 9 |
| B | 0.067 | 14 |
| C | 0.105 | 1 |
| D | 0.084 | 1 |
| E | 0.100 | 1 |
| F | 0.070 | 2 |

## *3.3 Additional Observations*

We have the following additional observations of the existing conditions:

- As noted above, the study area flows through a small stream channel prior to discharging to Steiger Lake. Downstream of SMC-13, the channel becomes very deep as it flows through a wooded area within the Three Rivers Park District property. Despite the steep banks, the channel appears to be relatively stable with only two or three areas of bank erosion noted on an April 15, 2010 site visit. Photographs taken during this site visit can be found in Appendix B.

- During the May 14, 2010 fieldwork, a sanitary sewer line was noted to run north-south along the east side of the subject wetland. It appears to be located in the backyards of the adjacent residential properties and outside the wetland boundary. Its approximate location is shown on Figure 4.

- The City of Victoria constructed a stormwater pond in the parcel immediately north of the Trunk Highway 5 across from the subject wetland. This pond provides treatment and rate control for a portion of downtown Victoria. The pond drains into the channel and appears to act in concert with the channel during high flow events, providing additional flood storage. The existing drainage area to the pond is roughly 14 acres and consists primarily of the downtown commercial district, as well as a portion of Trunk Highway 5. Use of this pond either as the sole BMP or as part of the treatment train was discussed with the City's Community Development Director (Holly Kreft), their engineering consultant (Cara Geheren, TKDA), and MCWD staff (Nat Kale and Ellen Heine) during the April 15, 2010 site visit.

# 4.0 Alternatives Analysis

Five alternatives are proposed:

1. Existing Wetland Channel with Multi-Stage Outlet (Figure 5). Construct a multi-stage outlet for the subject wetland that causes smaller storms to fill the wetland to an elevation of 962.0 feet, allowing the water level to slowly drawdown to an elevation of 961.0 feet. This modification will increase the detention time and make better use of the ability of the existing wetland vegetation to filter and treat the flows in the channel. Specifics of this alternative include:

   - The existing channel would be maintained.

   - Two forebays are recommended to provide pre-treatment for the larger offsite areas entering the subject wetland. In one case, this may involve realignment of a small portion of the Trunk Highway 5 ditch.

   - The typical water level in the wetland would increase slightly over the existing condition, but not change the 100-year high water level (965.6 ft.[3]).

   - A new culvert, with an invert elevation of 961.0 feet, would direct flows from the lower to middle of the water column to the existing regional City pond for additional water quality treatment.

[3] The 100-year high water level was based upon the XP-SWMM model received from the District with the modifications described in Section 4.2.

- A 50-foot long weir would be constructed with a spillcrest of 962.0 feet. The weir is proposed to be sheet pile with a concrete cap in order to minimize maintenance. However, a timber weir could be used. Flow from the weir discharges to the existing outlet from the subject wetland.

- Any change in appearance of the wetland from the existing condition is expected to be minimal, with minor changes to vegetation patterns depending on annual rainfall patterns.

2. <u>Meandering Channel with Multi-Stage Outlet (Figure 6).</u> Create a meandered channel within the subject wetland to make better use of all parts of the existing wetland to treat the flows in the channel. All other specifics of the design would be similar to Alternative 1, and as with Alternative 1, a multi-stage outlet would also be utilized to increase the detention time for smaller storms, filling the wetland to an elevation of 962.0 feet before slowly draining down to an elevation of 961.0 feet. However, this alternative could be expected to provide a slight to moderate change in the appearance of the wetland as the meandering channel might provide more hydrology to supply a different vegetative community in portions of the wetland that are farther away from the existing channel.

3. <u>Wetland Pond (Figure 7)</u>. Excavate a large wet detention pond within the subject wetland to provide a large sedimentation basin to settle out suspended solids and the attached nutrients. Although the wet detention pond could achieve the minimum treatment goal for the project, this alternative also includes routing the lower to middle portion of the flows to the existing regional City pond for additional water quality treatment. Specifics of this alternative include:

   - A new culvert, with an invert elevation of 961.0 feet, would direct flows from the lower to middle of the water column to the existing City pond for additional water quality treatment.

   - A 50-foot long weir would be constructed with a spillcrest of 962.0 feet in order to provide extended detention for smaller storm events and to maintain the existing 100-year high water level. The weir is proposed to be sheet pile with a concrete cap in order to minimize maintenance. However, a timber weir could be used. Flow from the weir discharges to the existing outlet from the subject wetland.

   - This alternative will change the nature of the existing wetland through a large open-water feature with wetland vegetation fringing the pond. The pond is proposed to range from four to six feet in depth, with an undulating bottom and shoreline to create a natural, organic appearance.

   - The two forebays would not be needed. However, realigning a small portion of the Trunk Highway 5 ditch may still be desirable to improve water quality.

4. <u>Wetland Restoration (Mosaic of Wetland Types) (Figure 8)</u>. Restore the wetland using a mosaic of intertwined emergent and open water wetland types also known as a hemi-marsh, which is a shallow water wetland complex with a closely interspersed composition of about 50% emergent vegetation and 50% open water. Such a wetland mosaic provides habitat

diversity for wildlife and can provide a circuitous flow of surface hydrology for effective water quality improvements. Wetland types proposed are described as follows:

- ***Deep Areas of Type 3 Wetland***: Deep areas would be graded to support surface water depths of 9 inches to 1 foot for much of the growing season. Continuously wet conditions throughout much of the growing season would provide suitable habitat for amphibians. Also, deep areas would allow more sediment-bound phosphorus settling. Native vegetation that could potentially thrive in the deep areas are wide-leaved cattail (*Typha latifolia*), river bulrush (*Scirpus fluviatilis*), hard stem bulrush (*Scirpus acutus*), and soft stem bulrush (*Schoenoplectus tabernaemontani*).

- ***Shallow Areas of Type 3 Wetland***: Shallow areas of Type 3 wetland would be graded to support surface water depths of 3 to 9 inches throughout a significant portion of the growing season. Such a hydrologic regime would provide nesting and loafing habitat for a variety of wildlife and opportunities to settle sediment-bound phosphorus during high water events. Shallow Type 3 wetlands are composed of several plant communities including shallow emergent marsh and a small component of sedge meadows at the slightly drier perimeter. Dominant native vegetation species suitable for Shallow Type 3 wetland areas include wide-leaved cattail, various bulrush species, and various rush species (*Juncus* spp.). Dominant species in sedge meadows would be several *Carex* species, mostly hummock sedge (*Carex stricta*). Spring 2010 fieldwork at the subject wetland revealed several remnant hummocks of *Carex stricta* an indicator of likely plant communities in pre-European settlement times. The hummocks are now completely infested with the invasive reed canary grass (*Phalaris arundinacea*).

- ***Undulating Type 2/1 Wetland***: Areas proposed as Undulating Type 2/1 Wetland would be graded to have saturated soils within the rooting zones (0 to 12 inches below the soil surface) for a week or two during the early growing season. Such habitat provides nesting, foraging, and migration habitat for a variety of wildlife and provides some buffering and sediment filtering capacity. Native vegetation suitable for such a hydrologic regime include a variety of hydrophytic grasses such as Canada bluejoint (*Calamagrostis canadensis*), a variety of sedges (*Carex* spp.), and forbs. For aesthetic appeal and wildlife habitat, wet shrubs such as red-osier dogwood (*Cornus stolonifera*) and elderberry (*Sambucus canadensis*) can be scattered throughout the wetter portions of the Undulating Type 2/1 Wetland areas.

As the existing roadside ditch and culvert draining the wetland are quite low, the alternative also includes modification of the existing outlet from the wetland to create a multi-stage outlet. The multi-stage outlet will allow the hydrologic regime to be restored to the wetland and provide an overflow to the existing regional pond for additional water quality treatment.

5. <u>Wetland Restoration (Mosaic of Wetland Types) with Katy Hills Pond Modification (Figure 9)</u>. This alternative is the same as Alternative 4, but runoff generated from subwatershed SMC-12 that is currently conveyed directly into the subject wetland via a culvert crossing Narcissus Street will be routed into Katy Hills Pond. Katy Hills Pond is an existing stormwater pond that currently treats the adjacent residential area and roadways within a 13.9 acre watershed. The pond can be expanded to provide an additional 0.3 acre-

feet of deadpool storage within the existing footprint without encroaching upon the subject wetland or adjacent sanitary sewer. Specifics of this alternative include:

- In general, the northeast portion of the pond will be extended to include the existing channel section, forcing flow into the pond.
- The existing outlet structure, which consists of a 15-inch PVC culvert with a wood baffle skimming structure, appears to have settled and may no longer be functioning properly. Therefore, this alternative includes reconstruction of the outlet control with a concrete structure, submerged skimmer and overflow grate. The outlet structure was assumed to function during low flow periods for proposed conditions.
- Since the hydraulic loading of the pond is high due to the added drainage area, a reinforced berm will be implemented such that overflows will occur over a broad area without erosion.
- The treatment efficiency of the existing pond will be analyzed as Alternative 5A, while the expanded Katy Hills Pond will be analyzed as Alternative 5B.

Streambank Stabilization (Figure 10): Separate from the five alternatives listed above, the feasibility study also includes an assessment of the effectiveness of stabilizing the areas of bank erosion noted in Section 3. Streambank stabilization has been proposed for the stream channel connecting the subject wetland and existing City regional pond to Steiger Lake. Along the stream channel there are two segments (Segments 4 and 5 in Appendix F) with approximately 35 feet and 65 feet in length of severe erosion. In both cases, the stream channel has migrated into the steep bank causing mass wasting to occur. The resultant stream bank is highly unstable with a vertical face.

Stabilization of the two bank segments will be best attained by filling in the eroded void with suitable fill material, moving the stream back to its original location. Once filled, stabilization of these segments will occur by armoring the toe of the slope with riprap and establishing permanent vegetation on the rehabilitated streambank that will hold the soil and slow runoff from running directly down the slope. The existing tree canopy within the ravine requires the use of specific trees and shrubs that will flourish under shady conditions. Some examples of trees and shrubs that will grow in shady conditions include the Bitternut Hickory, Pagoda Dogwood, American Hazel and American Elder.

## 4.1 Nutrient Modeling

PondNet was chosen to assess the relative efficiencies of the alternatives. The data from the District's PLOAD model was used in the PondNet analysis as follows:

- The hydraulic loading for the future 2020 developed condition of SMC-12 and SMC-13 was used to determine the runoff coefficient in PondNet such that the same hydraulic loading in acre-feet was generated for the 251.3 acres.

- Once the runoff coefficient was determined, the "Runoff Total P" concentration in ppb was modified to produce as close to the same TP loading for the 2020 condition from SMC-12 and SMC-13 as determined in PLOAD for the 251.3 acres.

The following hydrologic data was used for the four alternatives:

- Drainage Area = 251.3 acres
- Runoff Coefficient = 0.3836
- Runoff Total P = 390 ppb

A comprehensive analysis of Alternative 5 was performed in which most stormwater ponds and the major wetland within SMC-12 were analyzed in conjunction with the study area to establish the treatment efficiency of the entire system. Instead of using average parameters for the entire system for the input to each BMP, as documented previously, average parameters for each major drainage area, i.e. SMC-12 and SMC-13, were utilized individually. The following hydrologic data was used for Alternative 5 within SMC-12 and SMC-13:

- SMC-12
  - Drainage Area = 179.9 acres
  - Runoff Coefficient = 0.3904
  - Runoff Total P = 402 ppb

- SMC-13
  - Drainage Area = 71.4 acres
  - Runoff Coefficient = 0.3662
  - Runoff Total P = 360 ppb

Runoff coefficients and runoff total phosphorus concentrations were held constant for each BMP such that hydraulic and total phosphorus loading would remain the same for each alternative analyzed.

Because the existing regional City pond will be used as part of the treatment system for all alternatives, hydrologic data was needed to include in PondNet. The pond and its direct drainage area fall within the SMC-14 subwatershed, which includes Steiger Lake. SRF received output from the HydroCAD model created by TKDA to document the pond's performance with the addition of stormwater runoff from the City of Victoria fire station. According to this model, the total drainage area to the pond is 137.7 acres; however, this appears much larger than what would likely drain to the pond directly based upon the county's 2-foot contour mapping and aerial photography. A revised drainage area of 13.9 acres, which was determined using the aforementioned data, was then utilized. The average hydraulic loading and corresponding runoff coefficient were determined from PLOAD for the commercial land uses that fall within SMC-14. The TP runoff concentration was taken directly from PLOAD for commercial districts. The following hydrologic data was used in PondNet to represent the direct drainage area to the existing City pond:

- Drainage area = 13.9 acres
- Runoff Coefficient = 0.8
- Runoff Total P = 280 ppb

PondNet relies on the surface area of the proposed treatment basin and its mean depth. Basins in series can be analyzed by including the outflow from the upstream basin as one of the inputs, along with the local drainage area, to the next basin downstream. The five alternatives each would provide extended detention of the runoff to an elevation of 962.0 feet. In all three cases, the 962 foot contour remains the same, with a surface area of just over 5.3 acres. However, the storage below this elevation varies according to the amount of excavation proposed, and therefore, the mean depth varies between the alternatives.

Stage-storage information for the existing City pond was not included in the permit information for the pond's construction. Based upon the 2-foot contours and aerial mapping, it was determined that the pond's normal water level (NWL) is approximately 958.0 feet, with a surface area of 0.8 acres. The mean depth for the existing pond was determined assuming the following:

- Depth of permanent pool = 6 feet
- 10-foot bench below the NWL at 1V:10H
- Slopes below the bench = 1V:3H

In total, five stormwater ponds and one wetland was incorporated into the PondNet model for analysis of Alternative 5. The input data necessary for the stormwater ponds was obtained from the City of Victoria BMP Inventory Analysis tabulation, which provided direct and tributary drainage area to the stormwater pond, as well as pond surface area and dead pool volume. Mean depth was calculated from the dead pool volume and surface area. Grading plans and outlet structure details were obtained from MCWD for the characteristics of Katy Hills Pond. Since no previous analysis was performed on the wetland upstream of the study area, surface area was determined from aerial photographs and a mean depth of two feet was assumed.

Table 3 compares the hydraulic and TP loading between the values from PLOAD and PondNET based upon the above inputs for the 2020 future condition. Based on the good correlation between the data, the runoff coefficients and TP concentration used in PondNet were deemed appropriate to this analysis.

**Table 3: Comparison of PLOAD to PondNet**

| | **Hydraulic Loading (acre-feet)** | **TP Loading (pounds)** |
|---|---|---|
| **PLOAD Data** | 125.021 | 132.513 |
| **PondNet Results** | 125.037 | 132.549 |

Table 4 provides the anticipated results for each of the alternatives. Preliminary analysis indicated that neither Alternative 1 nor Alternative 2 could provide the desired TP removal within the subject wetland alone. Therefore, a secondary outlet from the subject wetland was added to route the middle portion of the water column to the existing City pond for additional treatment. Note that Alternative 4 was added after the completion of the draft analysis. Given that its anticipated stage-storage volume will be similar to, or slightly larger than, that of Alternative 2, it is expected that results for Alternative 4 will be very similar to those of Alternative 2, including the need to route a portion of the stormwater to the existing regional pond for further treatment. When looking at settling mechanisms for TP removal, two-cell systems generally provide a higher level of removal. As shown in Table 4, if Alternative 3 is also routed to the pond, the overall TP removal is expected to be 63.7%. These results can be compared with each alternative's performance if the existing regional City pond is not used, as shown in Table 5. However, this analysis does not take into account the soluble phosphorus that is removed via plant uptake mechanisms. PondNet spreadsheets can be found in Appendix C.

The results of Alternative 5A (route to existing Katy Hills Pond) and Alternative 5B (route to expanded Katy Hills Pond) are also shown in Tables 4 and 5, but represent the more comprehensive analysis. The analysis shows that the four stormwater ponds (P-39, P-25, P-17 and P-18) and wetland located within SMC-12 remove a substantial amount of phosphorus prior to discharging to the subject wetland. Routing runoff from SMC-13 through Katy Hills Pond removes 8.5 pounds and 9.6 pounds of phosphorus for Alternatives 5A and 5B, respectively. The limited expansion of the Katy Hills pond has a negligible effect on the total phosphorus removal. Use of the existing regional City pond produces removal efficiencies over 70%.

**Table 4: BMP Removal Efficiency – With Use of the Existing Regional City Pond[4]**

| Alternative | Inflow TP Loading (pounds) | Outflow TP Loading (pounds) | TP Captured (pounds) | Removal Efficiency |
|---|---|---|---|---|
| Alternative 1 | 143.5 | 66.9 | 76.6 | 53.4% |
| Alternative 2 and 4 | 143.5 | 63.7 | 79.8 | 55.6% |
| Alternative 3 | 143.5 | 52.1 | 91.4 | 63.7% |
| Alternative 5A | 143.5 | 42.6 | 101.0 | 70.3% |
| Alternative 5B | 143.5 | 42.2 | 101.4 | 70.6% |

[4] Inflow TP loading includes the contribution from the direct drainage area to the existing City pond. Outflow TP loading and corresponding removal efficiency is from the overall system.

**Table 5: BMP Removal Efficiency – Without Use of the Existing Regional City Pond**

| Alternative | Inflow TP Loading (pounds) | Outflow TP Loading (pounds) | TP Captured (pounds) | Removal Efficiency |
|---|---|---|---|---|
| Alternative 1 | 132.5 | 92.1 | 40.4 | 30.5% |
| Alternative 2 and 4 | 132.5 | 85.5 | 47.0 | 35.5% |
| Alternative 3 | 132.5 | 63.1 | 69.4 | 52.4% |
| Alternative 5A | 132.5 | 46.3 | 86.3 | 65.1% |
| Alternative 5B | 132.5 | 45.7 | 86.9 | 65.5% |

## *4.2 XP-SWMM Modeling*

The District's XP-SWMM was used as the starting point for the hydraulic analysis of the four alternatives in comparison with the existing condition. As with the water quality analysis, Alternative 4 was not modeled separately; its performance is expected to be similar to that of Alternative 2 given the similar stage-storage curves. Nodes and links outside of the study area were eliminated from the model in order to improve its running time. The model received from the District was also modified as follows:

- The existing regional City pond and subject wetland had been modeled in one storage area. The hydrologic information for the node was consistent with the drainage area for SMC-13, but did not include the direct drainage area to the existing pond. For the purposes of this study, the stage-storage for the existing City pond was separated into a distinct node according to the 2-foot county contours. As noted in Section 4.1, the direct drainage area to the existing pond was delineated based upon the 2-foot contours and was used in the runoff layer for the new storage node. The impervious percentage, slope and width were also determined based upon the contours and aerial photography.

- The stage-storage information for the subject wetland was modified to include volume above the normal water elevation and below the 962.0 contour, which was not in the original model.

- The outlet from the subject wetland crossing Trunk Highway 5 was not included in the original model. Based upon photos from the April 15, 2010 field walk, it was modeled assuming a 24" RCP with an invert of 958.0 feet. Because the culvert appeared to be approximately one foot submerged during the field walk, the starting water elevation was then assumed to be 959.0 feet, which appears to coincide with contour mapping.

- The channel downstream of the Trunk Highway 5 culvert was modeled assuming a trapezoidal channel, with a Manning's n of 0.035.

- An outlet from the existing pond was added to the model as a 10-foot long, broad-crested weir to represent the surface overflow that was noted in the field walk and apparent from the 2-foot contours.

- A comprehensive modeling approach was utilized for Alternatives 5A and 5B. Where Alternatives 1 through 4 used one storage node for each watershed, Alternatives 5A and 5B incorporated Pond P-18 and associated wetland located within SMC-12, as well as Katy Hills Pond and connecting upstream conveyance system within SMC-13. Because the models are not consistent in detail, the corresponding results are not directly comparable.

Specific items to note for the modeling of the alternatives include:

- Alternative 1 – The stage-storage data for the subject wetland matches that of the existing condition. A 12-inch diameter culvert was added to route flows from the wetland to the existing pond (invert elevation = 961.0) and a 50-foot long weir at 962.0. A weir was also added to represent flow over the berm between the subject wetland and the existing channel downstream of the 50-foot weir.

- Alternative 2 – The stage-storage was increased for the volume below the 962.0-foot contour to reflect the grading that would occur with the meandering channel. The multi-stage outlet matches that of Alternative 1.

- Alternative 3 – The stage-storage was further increased for the volume below the 962.0-foot contour. The multi-stage matches that of the other two alternatives.

- The 1-inch, 24-hour storm was modeled to test that the multi-stage outlet was providing extended detention for storms up to that rainfall depth. Other storm events modeled include the SCS 2-year and 100-year, 24-hour/Type II storms.

Results from the XP-SWMM models are included in Appendix D along with model schematics and a CD-ROM containing the models. It should be noted that once storage for the existing City pond was separated from that of the subject wetland, the 100-year high water level (HWL) for the pond in the existing condition appears to encroach on the adjacent parking lot based upon the two-foot contours. The HydroCAD model output indicates that expected 100-year HWL is approximately one foot higher than found in the XP-SWMM model, also encroaching on the parking lot. (The discrepancy in HWL is likely due to differences in the stage-storage curves used by the two models.)

In general, the 100-year HWL in the subject wetland decreases slightly from that in the existing condition with each of the alternatives. None of the alternatives are expected to increase the water levels upstream of the subject wetland. However, all would increase the 2-year and 100-year HWLs of the existing regional City pond by approximately 0.4 and 0.3 feet, respectively. Therefore, additional active storage surrounding the pond should be considered. Roughly 4,600 cubic feet of additional storage volume would need to be excavated from the area surrounding the pond in order to maintain the HWL at the existing condition.

As modeled without additional active storage surrounding the existing City pond, the maximum flow rates in the channel and culvert downstream of the pond are expected to increase by roughly 2.5 to 3.1 cfs over that of the existing condition for both the 2-year and 100-year storm events, as seen in Link 26 and SMC-13US5. Maximum velocities in the channel remain roughly the same in all alternatives when compared to the existing condition for both storm events, but increase slightly in SMC-13US5.

### 4.3 Streambank Erosion

The stream channel that connects the subject wetland and existing City regional pond to Steiger Lake has cut a deep ravine and continues to erode over time. Observation of the stream channel along with existing contour data revealed five stream segments experiencing erosion to some degree. In general, the upper three segments appeared relatively stable with no active erosion, while the lower two segments had fresh bank erosion with vertical faces. A map indicating these five segments has been included in Appendix F.

An estimate of sediment loading to Steiger Lake on an annual basis was determined using a method developed by the NRCS that assumes a constant lateral recession rate that is depended upon soil conditions and streambank conditions for silt loam soils. Based on the field observations, the upper three segments were assigned a lateral recession rate of 0.1 feet per year, while the lower two segments were assigned a lateral recession rate of 0.4 feet per year. The corresponding annual sediment loading for the five segments is approximately 157 tons per year.

Because of the severity of the two lower stream segments, efforts have been proposed to stabilize those areas. Stabilization of those areas will greatly reduce the sediment loading to Steiger Lake. Assuming the lateral recession rate of 0.4 feet per year is reduced to 0.1 feet per year, the annual sediment loading becomes 102 tons per year. Since sediment is known to bind phosphorus, reduction of this sediment load will help to improve the water quality of Steiger Lake.

## 5.0 Estimate of Probable Construction Costs

Details for the cost analysis of each alternative can be found in Appendix E. A summary of the probable construction and engineering costs is included in Table 6. It should be noted that these costs do not include right-of-way acquisition. Temporary construction access will likely be required from Mn/DOT or adjacent property owners. Permanent easements and/or partial property acquisition will also be required.

**Table 6: Summary of Cost Analysis**

| Alternative | Construction Cost | Contingency (25%) | Engineering (20%) | Total Design and Construction |
|---|---|---|---|---|
| Alternative 1 | $107,264 | $27,036 | $26,860 | $161,160 |
| Alternative 2 | $140,159 | $35,041 | $35,040 | $210,240 |
| Alternative 3 | $226,589 | $56,611 | $56,640 | $339,840 |
| Alternative 4 | $184,664 | $46,170 | $46,166 | $276,970 |
| Alternative 5 | $244,959 | $48,992 | $48,992 | $293,951 |
| Streambank Stabilization | $33,407 | $6,681 | $6,681 | $40,090 |

# 6.0 Observations and Recommendations

Based upon our analysis, we have the following observations and recommendations:

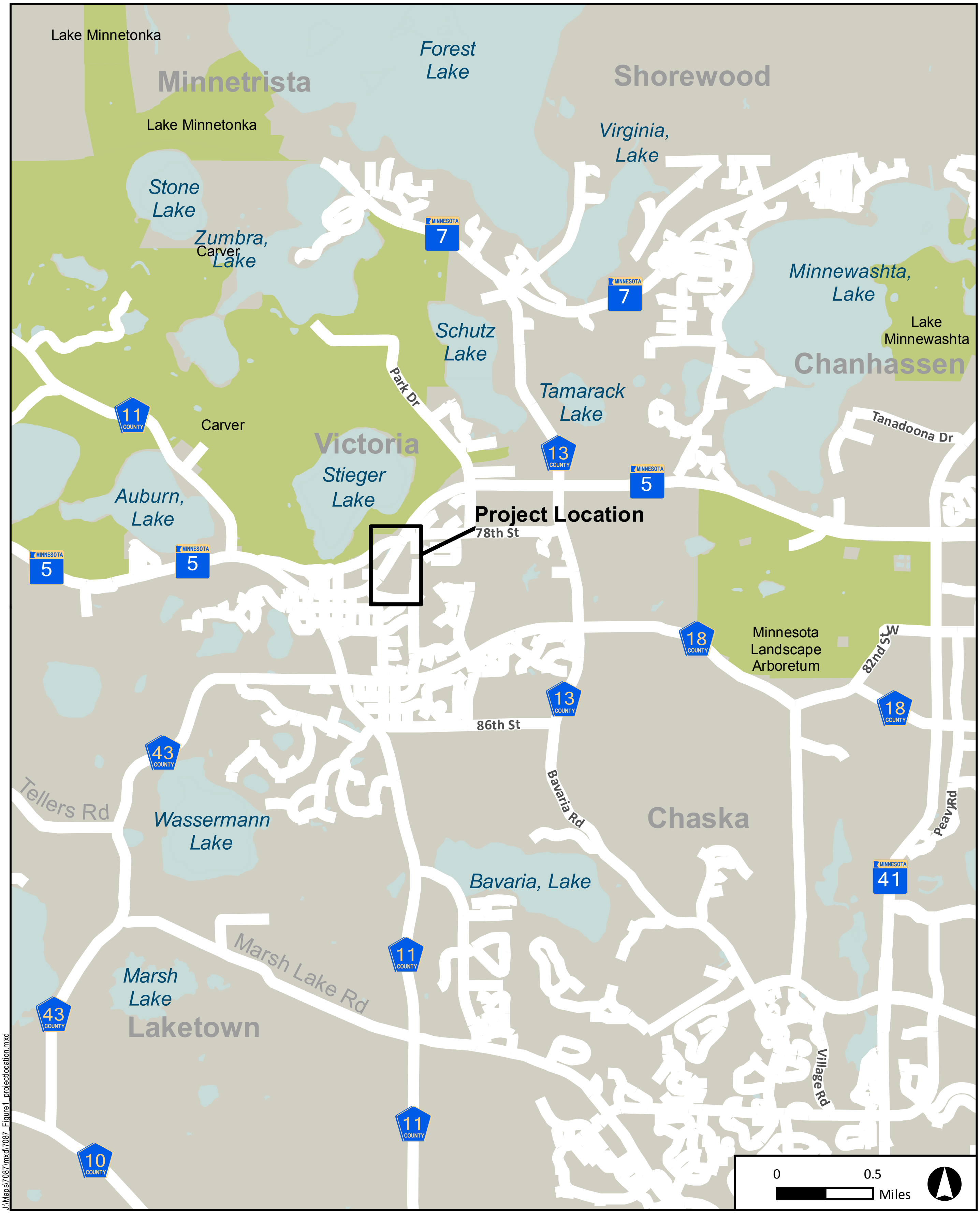
- Based upon the ability of each alternative to remove phosphorus by settling mechanisms, each of the alternatives meet the District's goal to remove at least 50 percent of the TP contributed by the two subwatersheds.
- All of the alternatives except Alternative 3 will maintain a greater percentage of vegetation. In that regard, these alternatives are likely to maintain the existing water balance to Steiger Lake via similar evapotranspiration processes. These alternatives may even provide a slight reduction in the hydraulic loading to Steiger Lake following smaller storm events in that more of the vegetated areas of the subject wetland will be utilized. Therefore, these alternatives may also have a greater ability to take up soluble phosphorus.
- Alternative 4 will result in a restored wetland with the highest level of ecological diversity when assessed base upon plant communities, followed by Alternative 2.
- Alternative 1 will result in the least amount of construction-related disturbance to the existing wetland, followed by Alternative 2. However, given the predominance of reed canary grass and narrow-leaved cattail, it may be desirable to eliminate these species, either through flooding or appropriate herbicide, in order to establish a diverse native plant community.
- A long-term wetland restoration management plan may want to be considered to maximize the likelihood that the desired plant community will become established.
- If flow is routed to the existing regional City pond, it is highly recommended that additional flood storage be provided adjacent to the pond between the 958-foot and 961-foot contours. Based upon observations during the April 15th field walk and verified by the 2-foot contours,

it appears that there are opportunities to create adequate storage surrounding the pond. It may be desirable to investigate providing additional dead pool storage and modifications to the pond's outlet at that time to increase its stormwater treatment capacity.

- Access to the forebays and weir will need to be considered for maintenance purposes.
- An additional project the District may want to consider in conjunction with the Three Rivers Park District and City of Victoria is the restoration of the banks along the channel where erosion was noted during the April 15, 2010 field walk.
- Soil borings should be taken within the subject wetland, near the proposed weir, and by the existing regional City pond to verify soil types, depth of muck, and foundation design for the weir.
- As well as performing a topographic survey of the subject wetland during the initial stages of final design, it is recommended that the following items be surveyed:
  - The existing culvert draining the subject wetland across Trunk Highway 5.
  - The edge of the parking lot, as well as the low area within the parking lot.
  - The overflow berm between the existing City pond and the channel.
  - The berm between Trunk Highway 5 and the subject wetland.
  - The outlet and berm surrounding the Katy Hills pond. If Alternative 5 is not selected, it will also be important to ensure changes in water levels do not affect this pond's performance during small events.
  - Low openings for the buildings surrounding the subject wetland.
  - The location of the existing sanitary sewer that runs along the easterly edge of the subject wetland.
- The inflow and outflow from the subject channel could be monitored to determine the actual phosphorus concentrations entering and leaving the subject wetland in the existing condition.

# APPENDIX A

# FIGURES

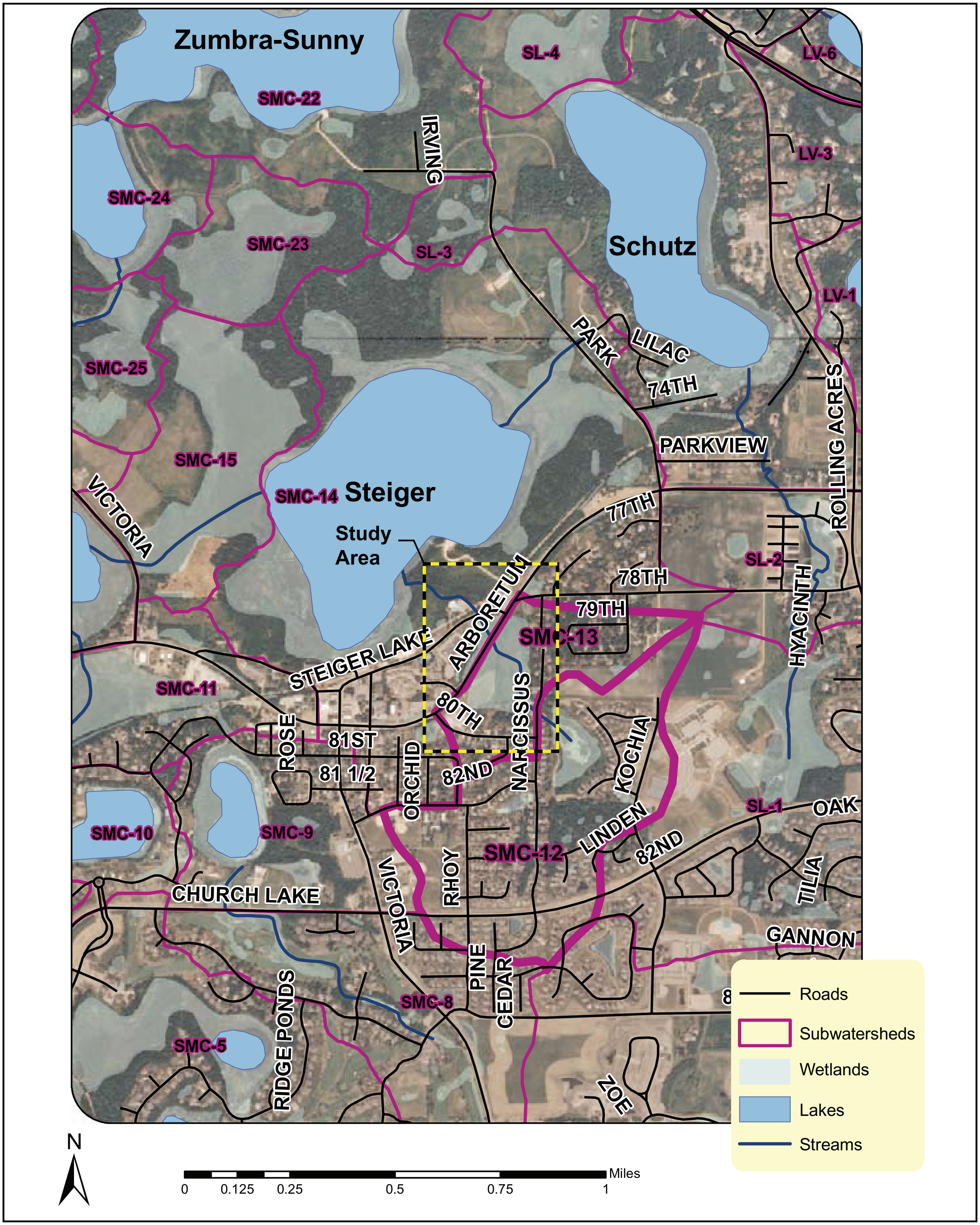



## Project Location Map

Steiger Lake Wet Detention Pond

Minnehaha Creek Watershed District

**Figure 1**




Support/7087/Figures/

**Steiger Lake Study Area and Subwatershed Map**

Steiger Lake Wet Detention Pond

Minnehaha Creek Watershed District

**Figure 2**


Support/ 7087 Steiger Lake Wet Detention Pond/Figures 11x17

**Soils Sampling Locations and Soil Types**

Steiger Lake Wet Detention Pond

Minnehaha Creek Watershed District

Figure 3

7087
6/18/2010


Support/ 7087 Steiger Lake Wet Detention Pond/Figures 11x17

**Stormwater Overview**

Steiger Lake Wet Detention Pond

Minnehaha Creek Watershed District

7087
6/18/2010

**Figure 4**


H:\Projects\7087\WR\Graphics\illustrative graphics\Indesign layout\7087_SteigerLake_Options.indd

**Stieger Lake Pond Option 1- Existing Wetland Channel**

Figure 5

Steiger Lake Wet Detention Pond
Minnehaha Creek Watershed District
7087
6/17/2010


H:\Projects\7087\WR\Graphics\Illustrative graphics\Indesign layout\7087_SteigerLake_Options.indd

**Stieger Lake Pond Option 2- Proposed Wetland Channel**

**Figure 6**

Steiger Lake Wet Detention Pond

Minnehaha Creek Watershed District

7087

6/17/2010


H:\Projects\7087\WR\Graphics\Illustrative graphics\Indesign layout\7087_SteigerLake_Options.indd

**Stieger Lake Pond Option 3- Propsoed Wetland Pond**

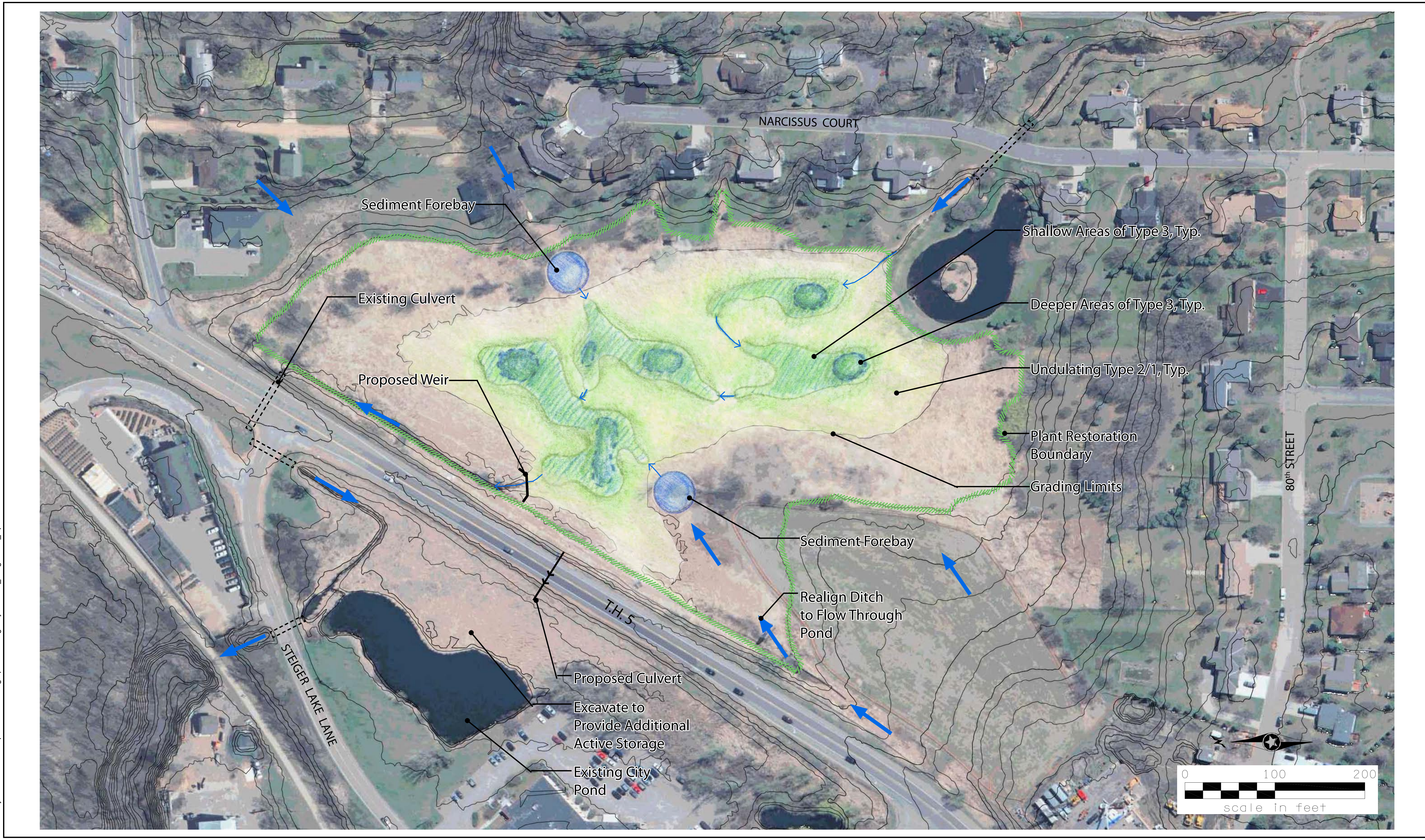
Steiger Lake Wet Detention Pond

Minnehaha Creek Watershed District

7087

6/17/2010

**Figure 7**




H:\Projects\7087\WR\Graphics\illustrative graphics\indesign layout\7087_SteigerLake_Options.indd

**Stieger Lake Pond Option 4- Wetland Restoration (Mosaic of Wetland Types)**

**Figure 8**

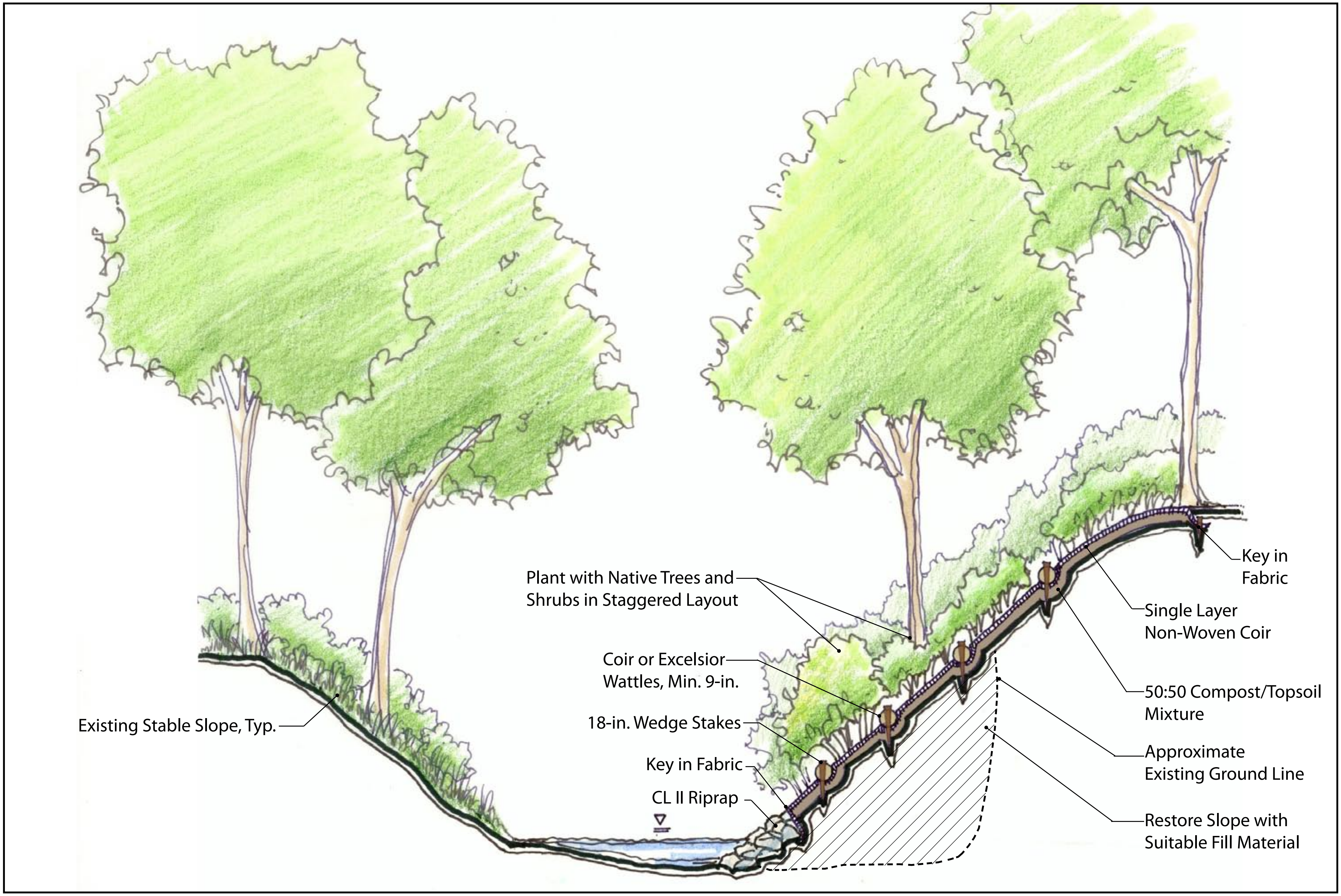
Steiger Lake Wet Detention Pond
Minnehaha Creek Watershed District
7087
7/14/2010


H:\Projects\7087\WR\Graphics\Illustrative graphics\Indesign layout\7087_SteigerLake_Options.indd

**Stieger Lake Pond Option 5- Wetland Restoration (Mosaic of Wetland Types) with Katy Hills Pond Modification**

**Figure 9**

Steiger Lake Wet Detention Pond
Minnehaha Creek Watershed District
7087
10/06/2010




H:\Projects\7087\WR\Graphics\illustrative graphics\Indesign layout\7087_HardwoodCreek)Section.indd

## Steiger Lake- Creek Stabilization Typical Section

Figure 10

Steiger Lake Wet Detention Pond
Minnehaha Creek Watershed District
7087
10/06/10

# APPENDIX B

# SITE PHOTOGRAPHS

Photo 1: Southwest inlet to regional City pond and available expansion area.

Photo 2: Northeast outlet from regional City pond and available expansion area.

Photo 3: Southwest inlet to regional City pond with adjacent parking lot.

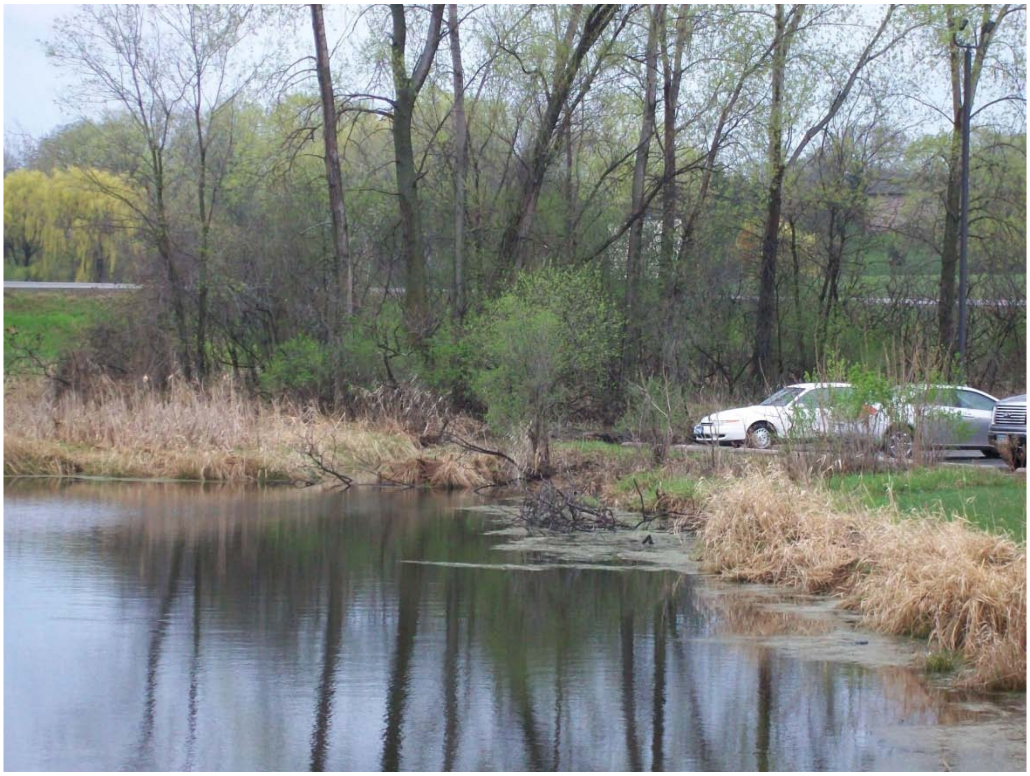


Photo 4: Available expansion area along north side of regional City pond.

Photo 5:  Available expansion area on north side of regional City Pond along Stieger Lake Lane.

Photo 6:  SW Regional LRT bridge crossing creek upstream of Stieger Lake/downstream of Steiger Lake Lane.

Photo 7: Drainage ditch and regional City pond upstream of outlet crossing Stieger Lake Lane.

Photo 8: Regional City pond and adjacent commercial property.

Photo 9: Drainage ditch and regional City pond outlet crossing Stieger Lake Lane.

Photo 10: Regional City pond and adjacent commercial property.

Photo 11:  Drainage ditch located on north side of TH 5 upstream of regional City Pond.


Photo 12:  Culvert crossing Stieger Lake Lane upstream of regional City pond.

Photo 13: Drainage ditch located on south side of TH 5 upstream of culvert crossing. Subject wetland is shown to the left.

Photo 14: Drainage ditch located on south side of TH 5 upstream of culvert crossing.

Photo 15:  Drainage ditch culvert crossing entrance on south side of TH 5.

Photo 16:  Drainage ditch located on south side of TH 5 upstream of culvert crossing with subject wetland in background.

Photo 17: Drainage ditch located on south side of TH 5 upstream of culvert crossing.

Photo 18: Homes located on southeast side of subject wetland near inlet to wetland.

Photo 19: Regional City pond and drainage ditch.

Photo 20: SW Regional LRT bridge crossing creek upstream of Stieger Lake.

Photo 21: Stieger Lake Lane culvert crossing outlet upstream of SW Regional LRT bridge.

Photo 22: Creek channel immediately downstream of SW Regional LRT bridge.

Photo 23:  Channel upstream of Stieger Lake, immediately downstream of SW Regional LRT.

Photo 24:  Debris/trash along channel upstream of Stieger Lake.

Photo 25:  Garbage dump area along creek channel upstream of Stieger Lake.

Photo 26:  First slough area along creek channel upstream of Stieger Lake.

Photo 27:  Tires found within the creek channel upstream of Stieger Lake.

Photo 28:  Second slough area along creek channel upstream of Stieger Lake.

Photo 29: Debris blocking conveyance within creek channel upstream of Stieger Lake.

Photo 30: Second slough area along creek channel upstream of Stieger Lake.

Photo 31:  Outlet of creek channel into Stieger Lake.

Photo 32:  Southeast shore of Stieger Lake near creek channel outlet.

Photo 33: Southeast shoreline of Stieger Lake near creek channel outlet.

Photo 34: Drainage ditch downstream of Narcissuss Street and upstream of subject wetland.

Photo 35:  Drainage ditch culvert outlet on north side of Narcissuss Street.

Photo 36:  Drainage ditch located within the southeast side of subject wetland.

Photo 37: Wildlife spotted within the subject wetland.

Photo 38: Outlet control structure located within residential pond south of subject wetland.

Photo 39: Channel located downstream of residential pond outlet within subject wetland.

Photo 40: Channel located downstream of residential pond outlet within subject wetland.

Photo 41:  Stieger Lake Lane roadway ditch draining to creek above SW Regional LRT bridge.

Photo 42:  Second slough area along creek channel upstream of Stieger Lake.

Photo 43: Creek channel upstream of Stieger Lake.

Photo 44: First slough area along creek channel upstream of Stieger Lake.

# APPENDIX C

# PONDNET CALCULATIONS

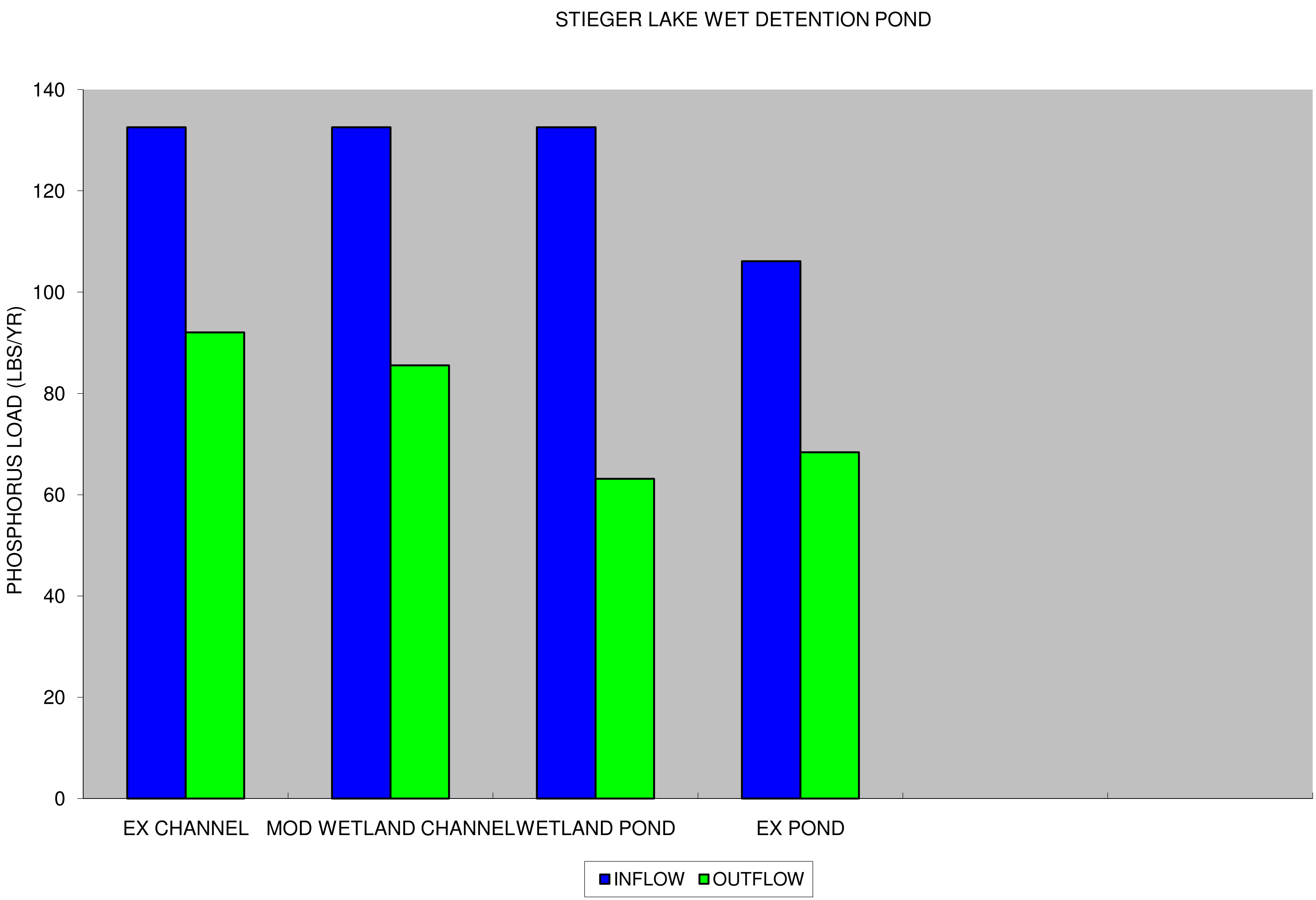
SRF COMM. # 7087
BY JAD 6/10/10
CHECKED LAG 6/10/10

PONDNET 2.1 FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 Press ALT-G for Graphs
TITLE--> **STIEGER LAKE WET DETENTION POND**

| INPUT VARIABLES.... | UNITS | | | | |
|---|---|---|---|---|---|
| case labels | | EX CHANNEL | MOD WETLAND CHANNEL | WETLAND POND | EX POND |
| watershed area | acres | 251.3 | 251.3 | 251.3 | 265.18 |
| runoff coefficient | - | 0.3836 | 0.3836 | 0.3836 | 0.4054 |
| pond surface area | acres | 5.31 | 5.31 | 5.31 | 0.81 |
| pond mean depth | feet | 0.6 | 0.8 | 2.1 | 3.5 |
| upstream pond p load | lbs/yr | 0 | 0 | 0 | 0 |
| upstream pond outflow | ac-ft/yr | 0 | 0 | 0 | 0 |
| OUTPUT VARIABLES........ | | | | | |
| outflow p load | lbs/yr | 92.06929707 | 85.530994 | 63.1316454 | 68.35940455 |
| outflow volume | ac-ft/yr | 125.0371212 | 125.0371212 | 125.0371212 | 139.4416103 |
| outflow p conc | ppb | 270.9108563 | 251.6721161 | 185.762775 | 180.3667289 |
| pond removal | % | 30.53935791 | 35.47210687 | 52.37104263 | 35.58672373 |
| total removal | % | 30.53567788 | 35.46868818 | 52.36851924 | 35.5833111 |
| ASSUMED EXPORT FACTORS............. | | | | | |
| period length | yrs | 1 | 1 | 1 | 1 |
| period precipitation | inches | 15.565 | 15.565 | 15.565 | 15.565 |
| **runoff total p** | **ppb** | **390** | **390** | **390** | **280** |
| runoff ortho p/total p | - | 0.3 | 0.3 | 0.3 | 0.3 |
| relative decay rate | - | 1 | 1 | 1 | 1 |
| unit runoff | in/yr | 5.970734 | 5.970734 | 5.970734 | 6.310051 |
| unit export | lbs/ac-y | 0.527452731 | 0.527452731 | 0.527452731 | 0.400204636 |
| POND WATER BUDGETS...................... | | | | | |
| runoff | ac-ft/yr | 125.0371212 | 125.0371212 | 125.0371212 | 139.4416103 |
| upstream pond | ac-ft/yr | 0 | 0 | 0 | 0 |
| total inflow | ac-ft/yr | 125.0371212 | 125.0371212 | 125.0371212 | 139.4416103 |
| outflow | ac-ft/yr | 125.0371212 | 125.0371212 | 125.0371212 | 139.4416103 |
| POND PHOSPHORUS BUDGETS.................. | | | | | |
| runoff | lbs/yr | 132.5488713 | 132.5488713 | 132.5488713 | 106.1262654 |
| upstream pond | lbs/yr | 0 | 0 | 0 | 0 |
| total inflow | lbs/yr | 132.5488713 | 132.5488713 | 132.5488713 | 106.1262654 |
| net sedimentation | lbs/yr | 40.47957421 | 47.01787728 | 69.41722589 | 37.76686088 |
| outflow | lbs/yr | 92.06929707 | 85.530994 | 63.1316454 | 68.35940455 |
| HYDRAULIC PARAMETERS............ | | | | | |
| pond volume | acre-ft | 3.10104 | 4.17366 | 11.3103 | 2.868108 |
| vlawmo pond volume | acre-ft | 20.08305833 | 20.08305833 | 20.08305833 | 22.39666083 |
| relative volume | inches | 0.386026863 | 0.519549853 | 1.407940441 | 0.320149064 |
| residence time | years | 0.024800955 | 0.033379367 | 0.090455537 | 0.020568523 |
| residence time | days | 9.052348529 | 12.18346908 | 33.01627118 | 7.507510975 |
| overflow rate | ft/yr | 23.54748045 | 23.54748045 | 23.54748045 | 172.1076405 |
| inflow phos conc | ppb | 390.0206623 | 390.0206623 | 390.0206623 | 280.0148344 |
| outflow phos conc | ppb | 270.9108563 | 251.6721161 | 185.762775 | 180.3667289 |
| p reaction rate | - | 0.632968816 | 0.85190666 | 2.308602018 | 0.85770359 |
| 1-rp | - | 0.694606421 | 0.645278931 | 0.476289574 | 0.644132763 |



ALTERNATIVES WITHOUT USE OF EX. POND
EX. POND INCLUDED FOR REFERENCE ONLY


STIEGER LAKE WET DETENTION POND
PHOSPHORUS LOAD (LBS/YR)
0
20
40
60
80
100
120
140
EX CHANNEL
MOD WETLAND CHANNEL
WETLAND POND
EX POND
INFLOW
OUTFLOW

SRF COMM. # 7087
BY JAD 6/10/2010
CHECKED LAG 6/10/10

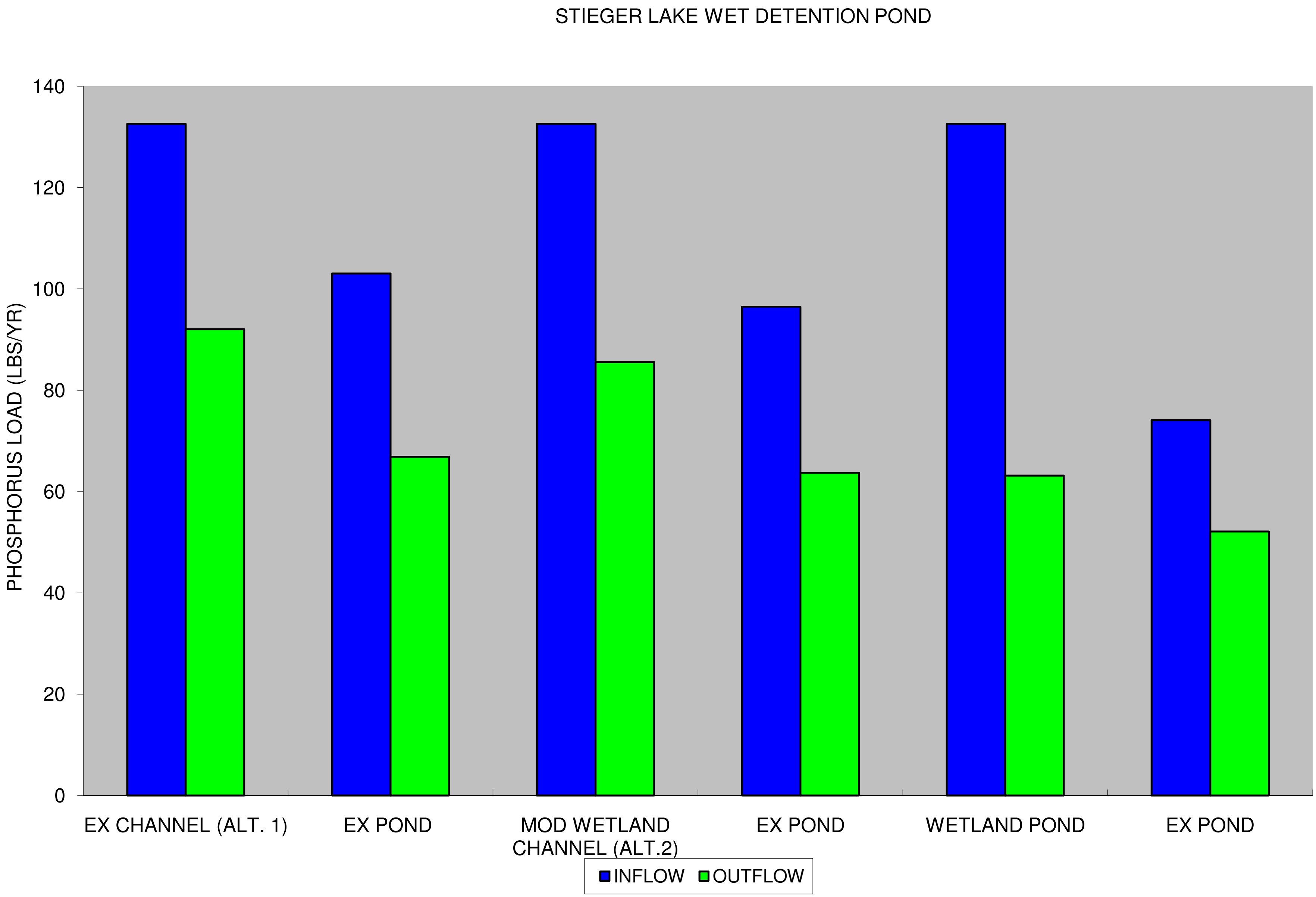
PONDNET 2.1 FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 Press ALT-G for Graphs

TITLE--> **STIEGER LAKE WET DETENTION POND**

| INPUT VARIABLES.... | UNITS | STIEGER LAKE WET DETENTION POND | | | |
|---|---|---|---|---|---|
| case labels | | EX CHANNEL (ALT. 1) | EX POND | MOD WETLAND CHANNEL (ALT.2) | EX POND |
| watershed area | acres | 251.3 | 13.88 | 251.3 | 13.88 |
| runoff coefficient | - | 0.3836 | 0.8 | 0.3836 | 0.8 |
| pond surface area | acres | 5.31 | 0.81 | 5.31 | 0.81 |
| pond mean depth | feet | 0.6 | 3.5 | 0.8 | 3.5 |
| upstream pond p load | lbs/yr | 0 | 92.0692971 | 0 | 85.530994 |
| upstream pond outflow | ac-ft/yr | 0 | 125.037121 | 0 | 125.037121 |
| **OUTPUT VARIABLES........** | | | | | |
| outflow p load | lbs/yr | 92.06929707 | 66.8801598 | 85.530994 | 63.6990503 |
| outflow volume | ac-ft/yr | 125.0371212 | 139.439935 | 125.0371212 | 139.439935 |
| outflow p conc | ppb | 270.9108563 | 176.465853 | 251.6721161 | 168.072374 |
| pond removal | % | 30.53935791 | 35.0873396 | 35.47210687 | 33.985622 |
| total removal | % | 30.53567788 | 36.9764811 | 35.46868818 | 39.9741521 |
| **ASSUMED EXPORT FACTORS.............** | | | | | |
| period length | yrs | 1 | 1 | 1 | 1 |
| period precipitation | inches | 15.565 | 15.565 | 15.565 | 15.565 |
| **runoff total p** | **ppb** | **390** | **280** | **390** | **280** |
| runoff ortho p/total p | - | 0.3 | 0.3 | 0.3 | 0.3 |
| relative decay rate | - | 1 | 1 | 1 | 1 |
| unit runoff | in/yr | 5.970734 | 12.452 | 5.970734 | 12.452 |
| unit export | lbs/ac-y | 0.527452731 | 0.78974768 | 0.527452731 | 0.78974768 |
| **POND WATER BUDGETS......................** | | | | | |
| runoff | ac-ft/yr | 125.0371212 | 14.4028133 | 125.0371212 | 14.4028133 |
| upstream pond | ac-ft/yr | 0 | 125.037121 | 0 | 125.037121 |
| total inflow | ac-ft/yr | 125.0371212 | 139.439935 | 125.0371212 | 139.439935 |
| outflow | ac-ft/yr | 125.0371212 | 139.439935 | 125.0371212 | 139.439935 |
| **POND PHOSPHORUS BUDGETS...................** | | | | | |
| runoff | lbs/yr | 132.5488713 | 10.9616978 | 132.5488713 | 10.9616978 |
| upstream pond | lbs/yr | 0 | 92.0692971 | 0 | 85.530994 |
| total inflow | lbs/yr | 132.5488713 | 103.030995 | 132.5488713 | 96.4926918 |
| net sedimentation | lbs/yr | 40.47957421 | 36.1508351 | 47.01787728 | 32.7936415 |
| outflow | lbs/yr | 92.06929707 | 66.8801598 | 85.530994 | 63.6990503 |
| **HYDRAULIC PARAMETERS............** | | | | | |
| pond volume | acre-ft | 3.10104 | 2.868108 | 4.17366 | 2.868108 |
| vlawmo pond volume | acre-ft | 20.08305833 | 2.31333333 | 20.08305833 | 2.31333333 |
| relative volume | inches | 0.386026863 | 3.09954035 | 0.519549853 | 3.09954035 |
| residence time | years | 0.024800955 | 0.02056877 | 0.033379367 | 0.02056877 |
| residence time | days | 9.052348529 | 7.5076012 | 12.18346908 | 7.5076012 |
| overflow rate | ft/yr | 23.54748045 | 172.105572 | 23.54748045 | 172.105572 |
| inflow phos conc | ppb | 390.0206623 | 271.85121 | 390.0206623 | 254.599648 |
| outflow phos conc | ppb | 270.9108563 | 176.465853 | 251.6721161 | 168.072374 |
| p reaction rate | - | 0.632968816 | 0.83270586 | 0.85190666 | 0.7798627 |
| 1-rp | - | 0.694606421 | 0.6491266 | 0.645278931 | 0.66014378 |

PONDNET 2.1 FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 Press ALT-G for Graphs
TITLE--> **STIEGER LAKE WET DETENTION POND**

| INPUT VARIABLES.... | UNITS | | |
|---|---|---|---|
| case labels | | WETLAND POND | EX POND |
| | | | |
| watershed area | acres | 251.3 | 13.88 |
| runoff coefficient | - | 0.3836 | 0.8 |
| pond surface area | acres | 5.31 | 0.81 |
| pond mean depth | feet | 2.1 | 3.5 |
| upstream pond p load | lbs/yr | 0 | 63.1316454 |
| upstream pond outflow | ac-ft/yr | 0 | 125.0371212 |
| | | | |
| OUTPUT VARIABLES........ | | | |
| outflow p load | lbs/yr | 63.1316454 | 52.12997991 |
| outflow volume | ac-ft/yr | 125.0371212 | 139.4399345 |
| outflow p conc | ppb | 185.762775 | 137.5469406 |
| pond removal | % | 52.37104263 | 29.64282934 |
| total removal | % | 52.36851924 | 50.87609264 |
| | | | |
| ASSUMED EXPORT FACTORS............. | | | |
| period length | yrs | 1 | 1 |
| period precipitation | inches | 15.565 | 15.565 |
| **runoff total p** | **ppb** | **390** | **280** |
| runoff ortho p/total p | - | 0.3 | 0.3 |
| relative decay rate | - | 1 | 1 |
| unit runoff | in/yr | 5.970734 | 12.452 |
| unit export | lbs/ac-y | 0.527452731 | 0.789747679 |
| | | | |
| POND WATER BUDGETS...................... | | | |
| runoff | ac-ft/yr | 125.0371212 | 14.40281333 |
| upstream pond | ac-ft/yr | 0 | 125.0371212 |
| total inflow | ac-ft/yr | 125.0371212 | 139.4399345 |
| outflow | ac-ft/yr | 125.0371212 | 139.4399345 |
| | | | |
| POND PHOSPHORUS BUDGETS................... | | | |
| runoff | lbs/yr | 132.5488713 | 10.96169778 |
| upstream pond | lbs/yr | 0 | 63.1316454 |
| total inflow | lbs/yr | 132.5488713 | 74.09334318 |
| net sedimentation | lbs/yr | 69.41722589 | 21.96336327 |
| outflow | lbs/yr | 63.1316454 | 52.12997991 |
| | | | |
| HYDRAULIC PARAMETERS........... | | | |
| pond volume | acre-ft | 11.3103 | 2.868108 |
| vlawmo pond volume | acre-ft | 20.08305833 | 2.313333333 |
| relative volume | inches | 1.407940441 | 3.099540346 |
| residence time | years | 0.090455537 | 0.02056877 |
| residence time | days | 33.01627118 | 7.507601202 |
| overflow rate | ft/yr | 23.54748045 | 172.1055721 |
| inflow phos conc | ppb | 390.0206623 | 195.4981124 |
| outflow phos conc | ppb | 185.762775 | 137.5469406 |
| p reaction rate | - | 2.308602018 | 0.598829133 |
| 1-rp | - | 0.476289574 | 0.703571707 |


STIEGER LAKE WET DETENTION POND
PHOSPHORUS LOAD (LBS/YR)
140
120
100
80
60
40
20
0
EX CHANNEL (ALT. 1)
EX POND
MOD WETLAND CHANNEL (ALT.2)
EX POND
WETLAND POND
EX POND
INFLOW
OUTFLOW

SRF COMM. # 7087
BY TRE 10/6/10
CHECKED RTJ 10/6/10

PONDNET 2.1 — FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 — Press ALT-G for Graphs
TITLE--> **STIEGER LAKE WET DETENTION POND**

| INPUT VARIABLES.... | UNITS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| case labels | | P-39 | P-25 | P-17 | P-18 | Wetland US | K-Hills Pond Ex | Alt - 5 |
| watershed area | acres | 22.0 | 8.7 | 47.2 | 21.3 | 80.7 | 13.9 | 57.5 |
| runoff coefficient | - | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3662 | 0.3662 |
| pond surface area | acres | 0.90 | 0.10 | 0.90 | 0.60 | 3.67 | 0.46 | 5.31 |
| pond mean depth | feet | 3.56 | 7.00 | 4.11 | 4.67 | 2.00 | 2.80 | 0.786 |
| upstream pond p load | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 33.4128 |
| upstream pond outflow | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 |
| **OUTPUT VARIABLES........** | | | | | | | | |
| outflow p load | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 33.4128 | 46.33578 |
| outflow volume | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 |
| outflow p conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 125.8251 | 136.3684 |
| pond removal | % | 63.49452 | 66.6306 | 54.47629 | 65.93526 | 43.87595 | 20.34952 | 22.95156 |
| total removal | % | 63.49259 | 66.62883 | 66.02527 | 65.93346 | 64.30187 | 65.04859 | 62.11988 |
| **ASSUMED EXPORT FACTORS.............** | | | | | | | | |
| period length | yrs | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| period precipitation | inches | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 |
| **runoff total p** | **ppb** | **401.5** | **401.5** | **401.5** | **401.5** | **401.5** | **360** | **360** |
| runoff ortho p/total p | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| relative decay rate | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| unit runoff | in/yr | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 5.699903 | 5.699903 |
| unit export | lbs/ac-y | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.464795 | 0.464795 |
| **POND WATER BUDGETS......................** | | | | | | | | |
| runoff | ac-ft/yr | 11.14039 | 4.405518 | 23.9012 | 10.78592 | 40.86497 | 6.602388 | 27.31204 |
| upstream pond | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 |
| total inflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 |
| outflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 |
| **POND PHOSPHORUS BUDGETS..................** | | | | | | | | |
| runoff | lbs/yr | 12.15789 | 4.807895 | 26.08421 | 11.77105 | 44.59737 | 6.460647 | 26.7257 |
| upstream pond | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 33.4128 |
| total inflow | lbs/yr | 12.15789 | 4.807895 | 32.12687 | 11.77105 | 63.23249 | 41.94928 | 60.1385 |
| net sedimentation | lbs/yr | 7.719597 | 3.203529 | 17.50153 | 7.761275 | 27.74386 | 8.536479 | 13.80272 |
| outflow | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 33.4128 | 46.33578 |
| **HYDRAULIC PARAMETERS............** | | | | | | | | |
| pond volume | acre-ft | 3.204 | 0.7 | 3.699 | 2.802 | 7.34 | 1.2796 | 4.17366 |
| vlawmo pond volume | acre-ft | 1.789333 | 0.7076 | 3.838933 | 1.7324 | 6.5636 | 1.060454 | 4.386771 |
| relative volume | inches | 4.476528 | 2.473149 | 2.408872 | 4.043523 | 2.795722 | 3.016632 | 2.378549 |
| residence time | years | 0.287602 | 0.158892 | 0.093771 | 0.259783 | 0.080573 | 0.013097 | 0.033386 |
| residence time | days | 104.9748 | 57.99546 | 34.22647 | 94.82082 | 29.40899 | 4.780472 | 12.18588 |
| overflow rate | ft/yr | 12.37821 | 44.05518 | 43.83012 | 17.97654 | 24.82234 | 213.7864 | 23.54283 |
| inflow phos conc | ppb | 401.5213 | 401.5213 | 299.6428 | 401.5213 | 255.3771 | 157.9715 | 176.9905 |
| outflow phos conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 125.8251 | 136.3684 |
| p reaction rate | - | 4.764531 | 5.983798 | 2.628647 | 5.682085 | 1.392927 | 0.320758 | 0.38662 |
| 1-rp | - | 0.365055 | 0.333694 | 0.455237 | 0.340647 | 0.561241 | 0.796505 | 0.770484 |

ALTERNATIVE 5 WITHOUT
USE OF EX. POND

H:\Projects\7087\WR\Excel\
Stieger PondNet Analysis (Stand Alone Alt 5).xlsx

SRF COMM. # 7087
BY TRE 10/6/10
CHECKED RTJ 10/6/10

PONDNET 2.1 FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 Press ALT-G for Graphs
TITLE--> **STIEGER LAKE WET DETENTION POND**

| INPUT VARIABLES.... | UNITS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| case labels | | P-39 | P-25 | P-17 | P-18 | Wetland US | K-Hills Pond PR | Alt - 5 |
| watershed area | acres | 22.0 | 8.7 | 47.2 | 21.3 | 80.7 | 13.9 | 57.5 |
| runoff coefficient | - | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3662 | 0.3662 |
| pond surface area | acres | 0.90 | 0.10 | 0.90 | 0.60 | 3.67 | 0.56 | 5.31 |
| pond mean depth | feet | 3.56 | 7.00 | 4.11 | 4.67 | 2.00 | 2.86 | 0.786 |
| upstream pond p load | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 32.3286 |
| upstream pond outflow | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 |
| | | | | | | | | |
| OUTPUT VARIABLES........ | | | | | | | | |
| outflow p load | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 32.3286 | 45.65448 |
| outflow volume | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 |
| outflow p conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 121.7422 | 134.3633 |
| pond removal | % | 63.49452 | 66.6306 | 54.47629 | 65.93526 | 43.87595 | 22.93409 | 22.69066 |
| total removal | % | 63.49259 | 66.62883 | 66.02527 | 65.93346 | 64.30187 | 66.18272 | 62.67685 |
| | | | | | | | | |
| ASSUMED EXPORT FACTORS............ | | | | | | | | |
| period length | yrs | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| period precipitation | inches | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 |
| **runoff total p** | **ppb** | **401.5** | **401.5** | **401.5** | **401.5** | **401.5** | **360** | **360** |
| runoff ortho p/total p | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| relative decay rate | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| unit runoff | in/yr | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 5.699903 | 5.699903 |
| unit export | lbs/ac-y | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.464795 | 0.464795 |
| | | | | | | | | |
| POND WATER BUDGETS..................... | | | | | | | | |
| runoff | ac-ft/yr | 11.14039 | 4.405518 | 23.9012 | 10.78592 | 40.86497 | 6.602388 | 27.31204 |
| upstream pond | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 |
| total inflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 |
| outflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 |
| | | | | | | | | |
| POND PHOSPHORUS BUDGETS.................. | | | | | | | | |
| runoff | lbs/yr | 12.15789 | 4.807895 | 26.08421 | 11.77105 | 44.59737 | 6.460647 | 26.7257 |
| upstream pond | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 32.3286 |
| total inflow | lbs/yr | 12.15789 | 4.807895 | 32.12687 | 11.77105 | 63.23249 | 41.94928 | 59.05429 |
| net sedimentation | lbs/yr | 7.719597 | 3.203529 | 17.50153 | 7.761275 | 27.74386 | 9.620685 | 13.39981 |
| outflow | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 32.3286 | 45.65448 |
| | | | | | | | | |
| HYDRAULIC PARAMETERS........... | | | | | | | | |
| pond volume | acre-ft | 3.204 | 0.7 | 3.699 | 2.802 | 7.34 | 1.59874 | 4.17366 |
| vlawmo pond volume | acre-ft | 1.789333 | 0.7076 | 3.838933 | 1.7324 | 6.5636 | 1.060454 | 4.386771 |
| relative volume | inches | 4.476528 | 2.473149 | 2.408872 | 4.043523 | 2.795722 | 3.768998 | 2.378549 |
| residence time | years | 0.287602 | 0.158892 | 0.093771 | 0.259783 | 0.080573 | 0.016364 | 0.033386 |
| residence time | days | 104.9748 | 57.99546 | 34.22647 | 94.82082 | 29.40899 | 5.972751 | 12.18588 |
| overflow rate | ft/yr | 12.37821 | 44.05518 | 43.83012 | 17.97654 | 24.82234 | 174.7771 | 23.54283 |
| inflow phos conc | ppb | 401.5213 | 401.5213 | 299.6428 | 401.5213 | 255.3771 | 157.9715 | 173.7996 |
| outflow phos conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 121.7422 | 134.3633 |
| p reaction rate | - | 4.764531 | 5.983798 | 2.628647 | 5.682085 | 1.392927 | 0.386151 | 0.37965 |
| 1-rp | - | 0.365055 | 0.333694 | 0.455237 | 0.340647 | 0.561241 | 0.770659 | 0.773093 |

ALTERNATIVE 5 WITHOUT
USE OF EX. POND

PONDNET 2.1 FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 Press ALT-G for Graphs
TITLE--> **STIEGER LAKE WET DETENTION POND**

| INPUT VARIABLES.... | UNITS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| case labels | | P-39 | P-25 | P-17 | P-18 | Wetland US | K-Hills Pond EX | Alt - 4 | Alt - 4 Pond |
| watershed area | acres | 22.0 | 8.7 | 47.2 | 21.3 | 80.7 | 13.9 | 57.5 | 13.88 |
| runoff coefficient | - | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3662 | 0.3662 | 0.8 |
| pond surface area | acres | 0.90 | 0.10 | 0.90 | 0.60 | 3.67 | 0.46 | 5.31 | 0.81 |
| pond mean depth | feet | 3.56 | 7.00 | 4.11 | 4.67 | 2.00 | 2.80 | 0.786 | 3.54 |
| upstream pond p load | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 33.4128 | 46.33578 |
| upstream pond outflow | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 | 125.0124 |
| | | | | | | | | | |
| OUTPUT VARIABLES........ | | | | | | | | | |
| outflow p load | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 33.4128 | 46.33578 | 42.61696 |
| outflow volume | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 | 139.4152 |
| outflow p conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 125.8251 | 136.3684 | 112.4664 |
| pond removal | % | 63.49452 | 66.6306 | 54.47629 | 65.93526 | 43.87595 | 20.34952 | 22.95156 | 25.62158 |
| total removal | % | 63.49259 | 66.62883 | 66.02527 | 65.93346 | 64.30187 | 65.04859 | 62.11988 | 59.83343 |
| | | | | | | | | | |
| ASSUMED EXPORT FACTORS............. | | | | | | | | | |
| period length | yrs | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| period precipitation | inches | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 |
| **runoff total p** | **ppb** | **401.5** | **401.5** | **401.5** | **401.5** | **401.5** | **360** | **360** | **280** |
| runoff ortho p/total p | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| relative decay rate | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| unit runoff | in/yr | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 5.699903 | 5.699903 | 12.452 |
| unit export | lbs/ac-y | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.464795 | 0.464795 | 0.789748 |
| | | | | | | | | | |
| POND WATER BUDGETS...................... | | | | | | | | | |
| runoff | ac-ft/yr | 11.14039 | 4.405518 | 23.9012 | 10.78592 | 40.86497 | 6.602388 | 27.31204 | 14.40281 |
| upstream pond | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 | 125.0124 |
| total inflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 | 139.4152 |
| outflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 | 139.4152 |
| | | | | | | | | | |
| POND PHOSPHORUS BUDGETS.................. | | | | | | | | | |
| runoff | lbs/yr | 12.15789 | 4.807895 | 26.08421 | 11.77105 | 44.59737 | 6.460647 | 26.7257 | 10.9617 |
| upstream pond | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 33.4128 | 46.33578 |
| total inflow | lbs/yr | 12.15789 | 4.807895 | 32.12687 | 11.77105 | 63.23249 | 41.94928 | 60.1385 | 57.29748 |
| net sedimentation | lbs/yr | 7.719597 | 3.203529 | 17.50153 | 7.761275 | 27.74386 | 8.536479 | 13.80272 | 14.68052 |
| outflow | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 33.4128 | 46.33578 | 42.61696 |
| | | | | | | | | | |
| HYDRAULIC PARAMETERS........... | | | | | | | | | |
| pond volume | acre-ft | 3.204 | 0.7 | 3.699 | 2.802 | 7.34 | 1.2796 | 4.17366 | 2.8674 |
| vlawmo pond volume | acre-ft | 1.789333 | 0.7076 | 3.838933 | 1.7324 | 6.5636 | 1.060454 | 4.386771 | 2.313333 |
| relative volume | inches | 4.476528 | 2.473149 | 2.408872 | 4.043523 | 2.795722 | 3.016632 | 2.378549 | 3.098775 |
| residence time | years | 0.287602 | 0.158892 | 0.093771 | 0.259783 | 0.080573 | 0.013097 | 0.033386 | 0.020567 |
| residence time | days | 104.9748 | 57.99546 | 34.22647 | 94.82082 | 29.40899 | 4.780472 | 12.18588 | 7.507078 |
| overflow rate | ft/yr | 12.37821 | 44.05518 | 43.83012 | 17.97654 | 24.82234 | 213.7864 | 23.54283 | 172.1176 |
| inflow phos conc | ppb | 401.5213 | 401.5213 | 299.6428 | 401.5213 | 255.3771 | 157.9715 | 176.9905 | 151.2084 |
| outflow phos conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 125.8251 | 136.3684 | 112.4664 |
| p reaction rate | - | 4.764531 | 5.983798 | 2.628647 | 5.682085 | 1.392927 | 0.320758 | 0.38662 | 0.46314 |
| 1-rp | - | 0.365055 | 0.333694 | 0.455237 | 0.340647 | 0.561241 | 0.796505 | 0.770484 | 0.743784 |

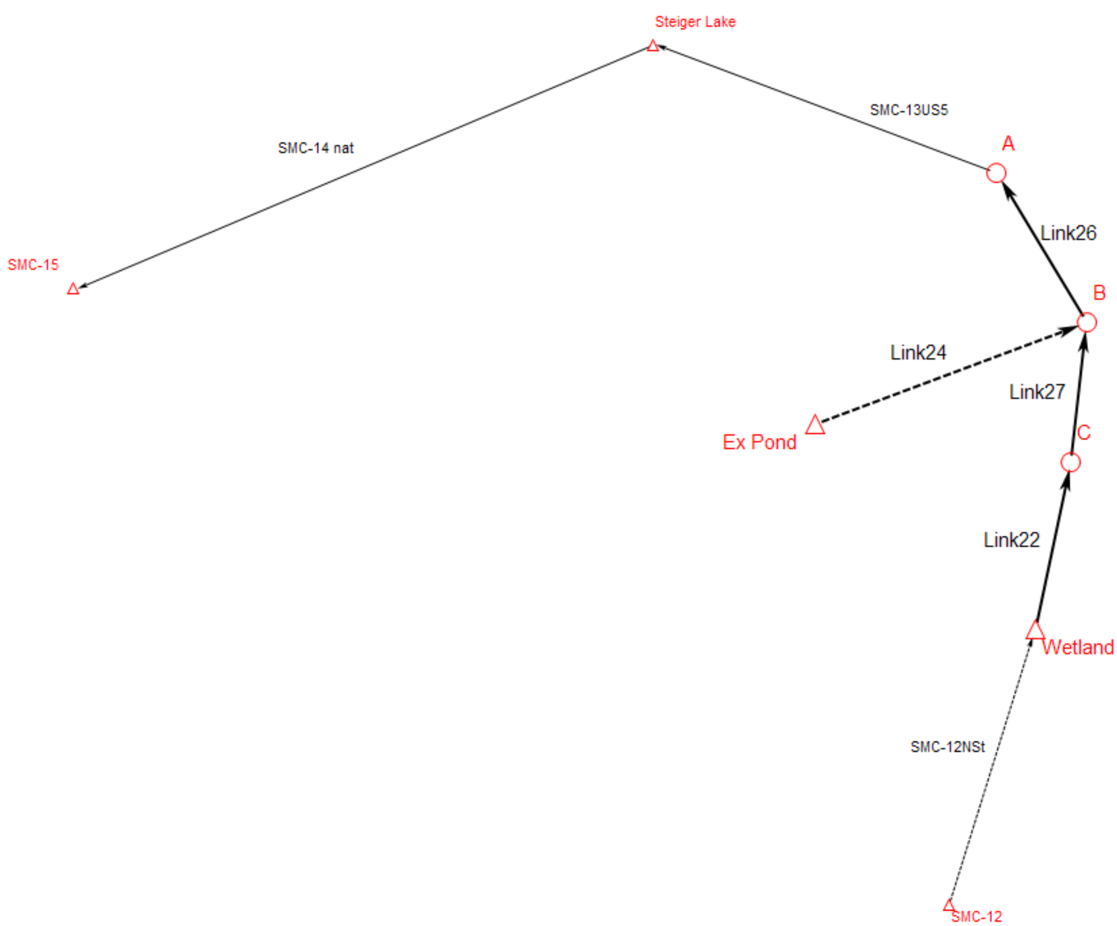
PONDNET 2.1 FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 Press ALT-G for Graphs
TITLE--> **STIEGER LAKE WET DETENTION POND**

| INPUT VARIABLES.... | UNITS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| case labels | | P-39 | P-25 | P-17 | P-18 | Wetland US | K-Hills Pond PR | Alt - 5 | Alt - 5 Pond |
| watershed area | acres | 22.0 | 8.7 | 47.2 | 21.3 | 80.7 | 13.9 | 57.5 | 13.88 |
| runoff coefficient | - | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3904 | 0.3662 | 0.3662 | 0.8 |
| pond surface area | acres | 0.90 | 0.10 | 0.90 | 0.60 | 3.67 | 0.56 | 5.31 | 0.81 |
| pond mean depth | feet | 3.56 | 7.00 | 4.11 | 4.67 | 2.00 | 2.86 | 0.786 | 3.54 |
| upstream pond p load | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 32.3286 | 45.65448 |
| upstream pond outflow | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 | 125.0124 |
| **OUTPUT VARIABLES........** | | | | | | | | | |
| outflow p load | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 32.3286 | 45.65448 | 42.21279 |
| outflow volume | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 | 139.4152 |
| outflow p conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 121.7422 | 134.3633 | 111.3998 |
| pond removal | % | 63.49452 | 66.6306 | 54.47629 | 65.93526 | 43.87595 | 22.93409 | 22.69066 | 25.44041 |
| total removal | % | 63.49259 | 66.62883 | 66.02527 | 65.93346 | 64.30187 | 66.18272 | 62.67685 | 60.21436 |
| **ASSUMED EXPORT FACTORS.............** | | | | | | | | | |
| period length | yrs | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| period precipitation | inches | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 | 15.565 |
| **runoff total p** | **ppb** | **401.5** | **401.5** | **401.5** | **401.5** | **401.5** | **360** | **360** | **280** |
| runoff ortho p/total p | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| relative decay rate | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| unit runoff | in/yr | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 6.076576 | 5.699903 | 5.699903 | 12.452 |
| unit export | lbs/ac-y | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.552632 | 0.464795 | 0.464795 | 0.789748 |
| **POND WATER BUDGETS.....................** | | | | | | | | | |
| runoff | ac-ft/yr | 11.14039 | 4.405518 | 23.9012 | 10.78592 | 40.86497 | 6.602388 | 27.31204 | 14.40281 |
| upstream pond | ac-ft/yr | 0 | 0 | 15.54591 | 0 | 50.23303 | 91.098 | 97.70039 | 125.0124 |
| total inflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 | 139.4152 |
| outflow | ac-ft/yr | 11.14039 | 4.405518 | 39.44711 | 10.78592 | 91.098 | 97.70039 | 125.0124 | 139.4152 |
| **POND PHOSPHORUS BUDGETS..................** | | | | | | | | | |
| runoff | lbs/yr | 12.15789 | 4.807895 | 26.08421 | 11.77105 | 44.59737 | 6.460647 | 26.7257 | 10.9617 |
| upstream pond | lbs/yr | 0 | 0 | 6.042663 | 0 | 18.63512 | 35.48864 | 32.3286 | 45.65448 |
| total inflow | lbs/yr | 12.15789 | 4.807895 | 32.12687 | 11.77105 | 63.23249 | 41.94928 | 59.05429 | 56.61618 |
| net sedimentation | lbs/yr | 7.719597 | 3.203529 | 17.50153 | 7.761275 | 27.74386 | 9.620685 | 13.39981 | 14.40339 |
| outflow | lbs/yr | 4.438298 | 1.604366 | 14.62535 | 4.009778 | 35.48864 | 32.3286 | 45.65448 | 42.21279 |
| **HYDRAULIC PARAMETERS...........** | | | | | | | | | |
| pond volume | acre-ft | 3.204 | 0.7 | 3.699 | 2.802 | 7.34 | 1.59874 | 4.17366 | 2.8674 |
| vlawmo pond volume | acre-ft | 1.789333 | 0.7076 | 3.838933 | 1.7324 | 6.5636 | 1.060454 | 4.386771 | 2.313333 |
| relative volume | inches | 4.476528 | 2.473149 | 2.408872 | 4.043523 | 2.795722 | 3.768998 | 2.378549 | 3.098775 |
| residence time | years | 0.287602 | 0.158892 | 0.093771 | 0.259783 | 0.080573 | 0.016364 | 0.033386 | 0.020567 |
| residence time | days | 104.9748 | 57.99546 | 34.22647 | 94.82082 | 29.40899 | 5.972751 | 12.18588 | 7.507078 |
| overflow rate | ft/yr | 12.37821 | 44.05518 | 43.83012 | 17.97654 | 24.82234 | 174.7771 | 23.54283 | 172.1176 |
| inflow phos conc | ppb | 401.5213 | 401.5213 | 299.6428 | 401.5213 | 255.3771 | 157.9715 | 173.7996 | 149.4104 |
| outflow phos conc | ppb | 146.5773 | 133.9852 | 136.4085 | 136.7772 | 143.328 | 121.7422 | 134.3633 | 111.3998 |
| p reaction rate | - | 4.764531 | 5.983798 | 2.628647 | 5.682085 | 1.392927 | 0.386151 | 0.37965 | 0.457633 |
| 1-rp | - | 0.365055 | 0.333694 | 0.455237 | 0.340647 | 0.561241 | 0.770659 | 0.773093 | 0.745596 |

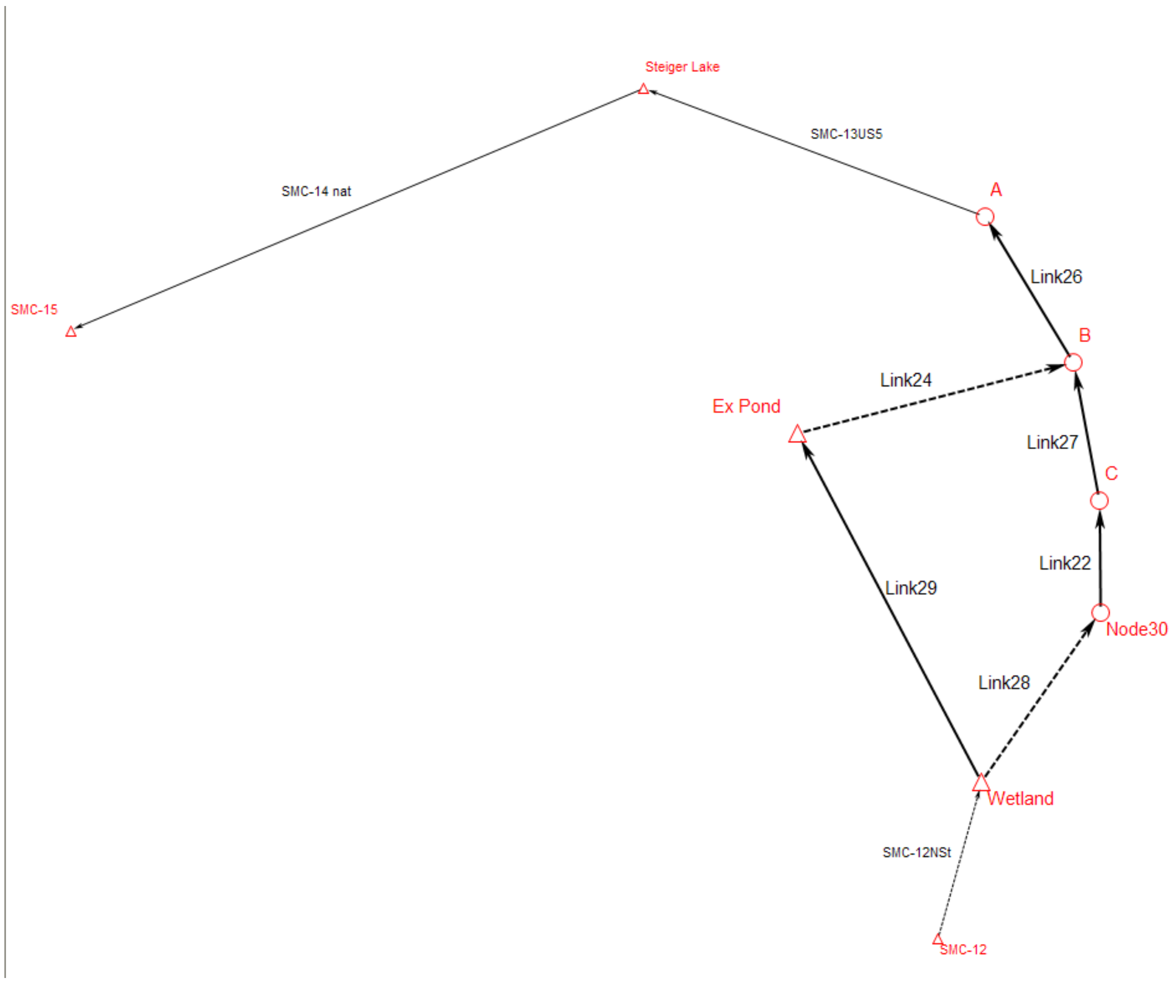
# APPENDIX D

# XP-SWMM DATA AND MODELS

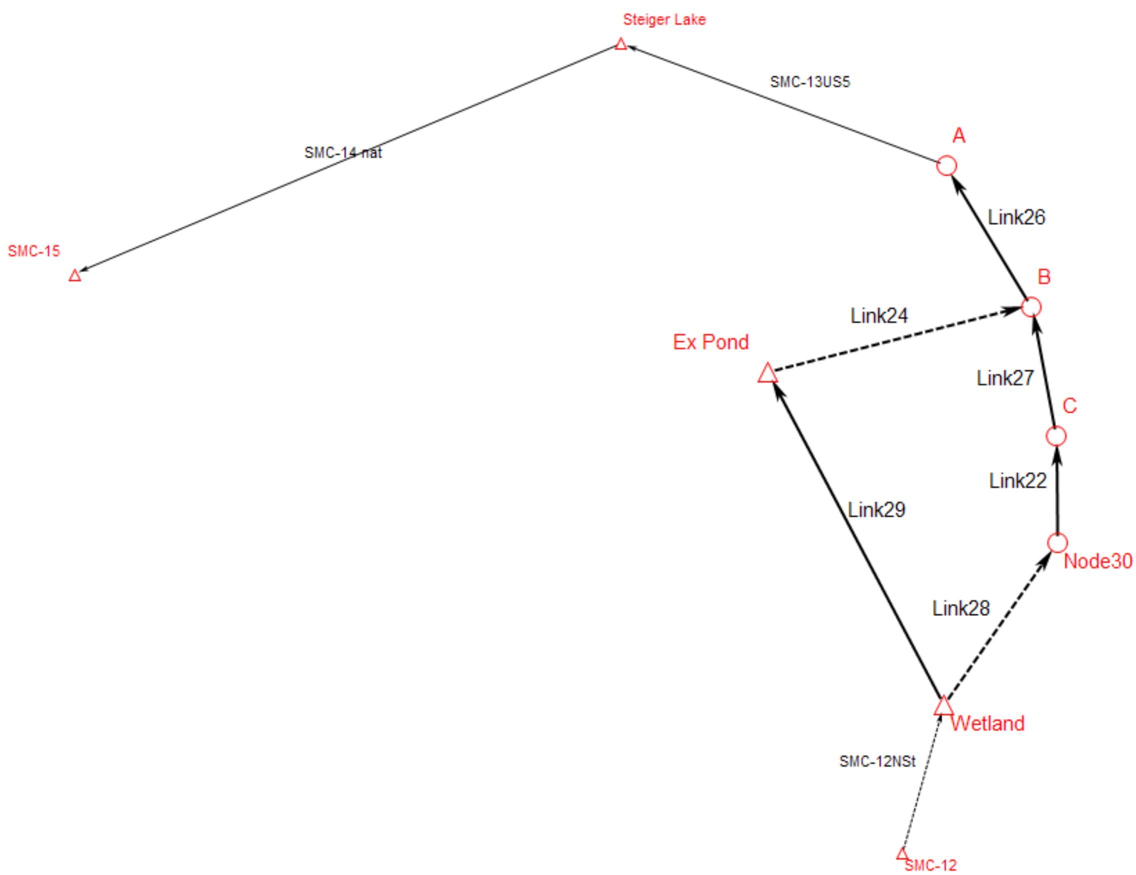
**STEIGER LAKE WETLAND POND**
**EXISTING CONDITION**
SRF COMM. # 7087
SCS TYPE II – 24 HOUR STORMS
BY JAD 6/10/10
CHECKED BY JLN 6/10/10



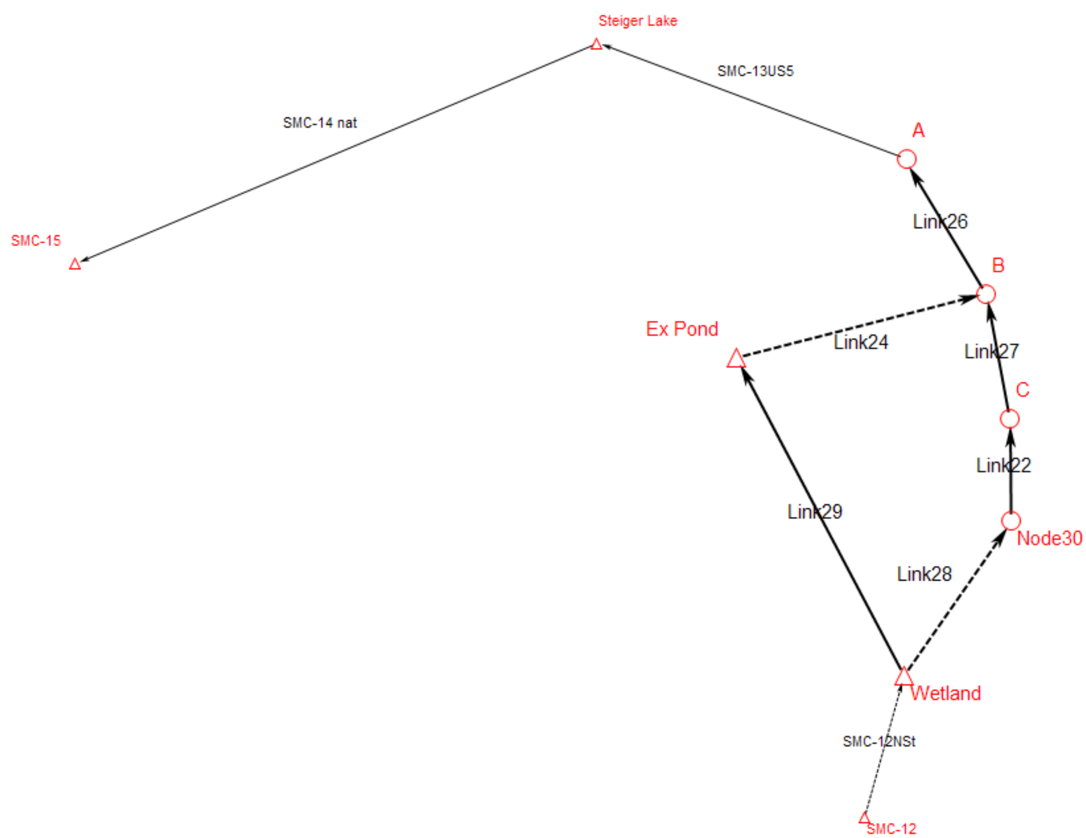
**STEIGER LAKE WETLAND POND**
**ALTERNATIVE 1**
SRF COMM. # 7087
SCS TYPE II – 24 HOUR STORMS
BY JAD 6/10/10
CHECKED BY JLN 6/10/10



**STEIGER LAKE WETLAND POND**
**ALTERNATIVE 2**
SRF COMM. # 7087
SCS TYPE II – 24 HOUR STORMS
BY JAD 6/10/10
CHECKED BY JLN 6/10/10



**STEIGER LAKE WETLAND POND**
**ALTERNATIVE 3**
SRF COMM. # 7087
SCS TYPE II – 24 HOUR STORMS
BY JAD 6/10/10
CHECKED BY JLN 6/10/10



SRF COMM. # 7087
BY JAD 6/10/10
MODEL CHECKED JLN 6/10/10

**Runoff Results**

| Link Name | Drainage Area (ac) | Impervious Percentage | Storm Event | Maximum Water Elevation (ft) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Existing | Alt. 1 | Alt. 2 | Alt. 3 |
| SMC-12 | 179.9 | 34.5% | 1" | - | 963.04 | 963.04 | 963.05 |
| | | | 2 Year | 964.26 | 964.25 | 964.25 | 964.26 |
| | | | 100 Year | 966.27 | 966.28 | 966.28 | 966.28 |
| Wetland | 71.4 | 44.0% | 1" | - | 962.06 | 962.04 | 961.95 |
| | | | 2 Year | 963.02 | 963.09 | 963.07 | 963.02 |
| | | | 100 Year | 965.62 | 965.45 | 965.44 | 965.43 |
| Existing Pond | 13.9 | 64.0% | 1" | - | 958.43 | 958.36 | 958.34 |
| | | | 2 Year | 959.90 | 960.28 | 960.27 | 960.23 |
| | | | 100 Year | 961.00 | 961.33 | 961.33 | 961.32 |
| Steiger Lake | 578.0 | 53.7% | 1" | - | - | - | - |
| | | | 2 Year | 942.99 | 942.99 | 942.99 | 942.99 |
| | | | 100 Year | 943.84 | 943.84 | 943.84 | 943.84 |

Note: The 1-inch storm event was used to evaluate performance for smaller events.

SRF COMM. # 7087
BY JAD 6/10/10
MODEL CHECKED JLN 6/10/10

| Link Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Link Name | Link Description | Storm Event | Maximum Flow (cfs) | | | | Maximum Velocity (ft/s) | | | |
| | | | Existing | Alt. 1 | Alt. 2 | Alt. 3 | Existing | Alt. 1 | Alt. 2 | Alt. 3 |
| SMC-12NSt | Circular 48" RC Pipe | 1" | - | 9.37 | 9.44 | 9.59 | - | 5.46 | 5.56 | 5.78 |
| | | 2 Year | 47.44 | 46.87 | 46.93 | 47.23 | 7.89 | 7.74 | 7.76 | 7.81 |
| | | 100 Year | 117.26 | 115.41 | 115.66 | 116.42 | 9.72 | 9.59 | 9.59 | 9.62 |
| SMC-12NSt | Natural Section | 1" | - | 0.00 | 0.00 | 0.00 | - | 0.00 | 0.00 | 0.00 |
| | | 2 Year | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 100 Year | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Link 29 | Circular 12" RC Pipe | 1" | N/A | 3.10 | 3.06 | 2.966 | N/A | 3.92 | 3.92 | 3.92 |
| | | 2 Year | N/A | 4.09 | 4.07 | 4.027 | N/A | 5.22 | 5.20 | 5.15 |
| | | 100 Year | N/A | 5.64 | 5.64 | 5.669 | N/A | 7.04 | 7.04 | 7.07 |
| Link 22 | Circular 24" RC Pipe | 1" | - | 2.26 | 1.41 | 0.00 | - | 2.80 | 2.52 | 0.00 |
| | | 2 Year | 23.46 | 23.34 | 23.29 | 23.12 | 7.42 | 7.37 | 7.35 | 7.30 |
| | | 100 Year | 31.38 | 29.61 | 29.62 | 29.62 | 9.85 | 9.30 | 9.31 | 9.31 |
| Link 27 | Trapezoidal Channel | 1" | - | 2.26 | 1.40 | 0.00 | - | 1.17 | 0.97 | 0.00 |
| | | 2 Year | 23.46 | 23.33 | 23.27 | 23.11 | 2.29 | 2.48 | 2.49 | 2.52 |
| | | 100 Year | 31.38 | 29.60 | 29.60 | 29.61 | 2.26 | 2.36 | 2.38 | 2.39 |
| Link 26 | Trapezoidal Channel | 1" | - | 5.00 | 4.26 | 3.99 | - | 1.33 | 1.28 | 1.47 |
| | | 2 Year | 23.95 | 27.03 | 26.91 | 26.72 | 1.89 | 1.82 | 1.82 | 1.83 |
| | | 100 Year | 33.10 | 35.64 | 35.62 | 35.53 | 1.86 | 1.84 | 1.86 | 1.91 |
| SMC-13US5 | Circular 36" CMP | 1" | - | 5.00 | 4.26 | 4.00 | - | 2.23 | 2.12 | 2.07 |
| | | 2 Year | 23.95 | 27.03 | 26.91 | 26.72 | 3.82 | 3.98 | 3.98 | 3.98 |
| | | 100 Year | 32.93 | 35.64 | 35.62 | 35.53 | 4.81 | 5.20 | 5.19 | 5.18 |

Note: The 1-inch storm event was used to evaluate performance for smaller events.

SRF COMM. # 7087
BY JAD 10/6/10
MODEL CHECKED TRE 10/6/10

| Runoff Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Link Name | Drainage Area (ac) | Impervious Percentage | Storm Event | Maximum Water Elevation (ft) | | | | | |
| | | | | Existing | Alt. 1 | Alt. 2 | Alt. 3 | Alt. 5A | Alt. 5B |
| P-18 | 21.3 | 40.6% | 1" | - | - | - | - | 974.66 | 974.66 |
| | | | 2 Year | - | - | - | - | 976.31 | 976.31 |
| | | | 100 Year | - | - | - | - | 978.37 | 978.37 |
| Wetland US | 158.6 | 40.4% | 1" | - | - | - | - | 968.34 | 968.33 |
| | | | 2 Year | - | - | - | - | 970.09 | 970.09 |
| | | | 100 Year | - | - | - | - | 972.59 | 972.59 |
| Katy Hills Pond | 13.9 | 45.9% | 1" | - | - | - | - | 963.07 | 963.07 |
| | | | 2 Year | - | - | - | - | 963.35 | 963.35 |
| | | | 100 Year | - | - | - | - | 966.31 | 966.29 |
| SMC-12 | 179.9 | 34.5% | 1" | - | 963.04 | 963.04 | 963.05 | - | - |
| | | | 2 Year | 964.26 | 964.25 | 964.25 | 964.26 | - | - |
| | | | 100 Year | 966.27 | 966.28 | 966.28 | 966.28 | - | - |
| Wetland | 71.4 | 44.0% | 1" | - | 962.06 | 962.04 | 961.95 | 962.03 | 962.02 |
| | | | 2 Year | 963.02 | 963.09 | 963.07 | 963.02 | 963.32 | 963.31 |
| | | | 100 Year | 965.62 | 965.45 | 965.44 | 965.43 | 966.30 | 966.29 |
| Existing Pond | 13.9 | 64.0% | 1" | - | 958.43 | 958.36 | 958.34 | 958.35 | 958.34 |
| | | | 2 Year | 959.90 | 960.28 | 960.27 | 960.23 | 960.38 | 960.38 |
| | | | 100 Year | 961.00 | 961.33 | 961.33 | 961.32 | 961.60 | 961.60 |
| Steiger Lake | 578.0 | 53.7% | 1" | - | - | - | - | - | - |
| | | | 2 Year | 942.99 | 942.99 | 942.99 | 942.99 | 942.99 | 942.99 |
| | | | 100 Year | 943.84 | 943.84 | 943.84 | 943.84 | 943.84 | 943.84 |

Note: The 1-inch storm event was used to evaluate performance for smaller events.

**Link Results**

| Link Name | Link Description | Storm Event | Maximum Flow (cfs) | | | | | | Maximum Velocity (ft/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Existing | Alt. 1 | Alt. 2 | Alt. 3 | Alt. 5A | Alt. 5B | Existing | Alt. 1 | Alt. 2 | Alt. 3 | Alt. 5A | Alt. 5B |
| Link 35 | Circular 42" RC Pipe | 1" | - | - | - | - | 8.5 | 8.4 | - | - | - | - | 4.2 | 4.2 |
| | | 2 Year | - | - | - | - | 58.4 | 58.4 | - | - | - | - | 6.5 | 6.5 |
| | | 100 Year | - | - | - | - | 123.1 | 123.1 | - | - | - | - | 12.7 | 12.7 |
| SMC-12NSt | Circular 48" RC Pipe | 1" | - | 9.4 | 9.4 | 9.6 | - | - | - | 5.46 | 5.56 | 5.78 | - | - |
| | | 2 Year | 47.4 | 46.9 | 46.9 | 47.2 | - | - | 7.89 | 7.74 | 7.76 | 7.81 | - | - |
| | | 100 Year | 117.3 | 115.4 | 115.7 | 116.4 | - | - | 9.72 | 9.59 | 9.59 | 9.62 | - | - |
| Link 29 | Circular 12" RC Pipe | 1" | N/A | 3.1 | 3.1 | 3.0 | 3.0 | 3.0 | N/A | 3.92 | 3.92 | 3.92 | 3.9 | 3.92 |
| | | 2 Year | N/A | 4.1 | 4.1 | 4.0 | 4.3 | 4.3 | N/A | 5.22 | 5.20 | 5.15 | 5.5 | 5.46 |
| | | 100 Year | N/A | 5.6 | 5.6 | 5.7 | 6.1 | 6.1 | N/A | 7.04 | 7.04 | 7.07 | 7.6 | 7.56 |
| Link 22 | Circular 24" RC Pipe | 1" | - | 2.3 | 1.4 | 0.0 | 0.6 | 0.45 | - | 2.80 | 2.52 | 0.00 | 2.0 | 1.83 |
| | | 2 Year | 23.5 | 23.3 | 23.3 | 23.1 | 24.2 | 24.16 | 7.42 | 7.37 | 7.35 | 7.30 | 7.6 | 7.61 |
| | | 100 Year | 31.4 | 29.6 | 29.6 | 29.6 | 32.1 | 32.03 | 9.85 | 9.30 | 9.31 | 9.31 | 10.1 | 10.04 |
| Link 27 | Trapezoidal Channel | 1" | - | 2.3 | 1.4 | 0.0 | 0.6 | 0.5 | - | 1.17 | 0.97 | 0.00 | 0.7 | 0.56 |
| | | 2 Year | 23.5 | 23.3 | 23.3 | 23.1 | 24.2 | 24.1 | 2.29 | 2.48 | 2.49 | 2.52 | 2.5 | 2.51 |
| | | 100 Year | 31.4 | 29.6 | 29.6 | 29.6 | 32.0 | 32.0 | 2.26 | 2.36 | 2.38 | 2.39 | 2.4 | 2.43 |
| Link 26 | Trapezoidal Channel | 1" | - | 5.0 | 4.3 | 4.0 | 4.1 | 4.1 | - | 1.33 | 1.28 | 1.47 | 1.5 | 1.47 |
| | | 2 Year | 24.0 | 27.0 | 26.9 | 26.7 | 28.2 | 28.1 | 1.89 | 1.82 | 1.82 | 1.83 | 1.8 | 1.82 |
| | | 100 Year | 33.1 | 35.6 | 35.6 | 35.5 | 37.7 | 37.7 | 1.86 | 1.84 | 1.86 | 1.91 | 1.9 | 1.90 |
| SMC-13US5 | Circular 36" CMP | 1" | - | 5.0 | 4.3 | 4.0 | 4.1 | 4.1 | - | 2.23 | 2.12 | 2.07 | 2.1 | 2.09 |
| | | 2 Year | 24.0 | 27.0 | 26.9 | 26.7 | 28.2 | 28.1 | 3.82 | 3.98 | 3.98 | 3.98 | 4.1 | 4.07 |
| | | 100 Year | 32.9 | 35.6 | 35.6 | 35.5 | 37.7 | 37.7 | 4.81 | 5.20 | 5.19 | 5.18 | 5.5 | 5.48 |

Note: The 1-inch storm event was used to evaluate performance for smaller events.

# APPENDIX E

# COST ANALYSIS

**STEIGER LAKE WET DETENTION POND COST ESTIMATE**
**ALTERNATIVE 1 - Existing Wetland Channel**

| NOTES | ITEM DESCRIPTION | UNITS | QUANTITY | UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | MOBILIZATIN/CLEARING/GRUBBING | LUMP SUM | 1 | **$ 7,483.54** | $ 7,484 |
| | EXCAVATION AT EXISTING POND (MUCK) | CU YD | 750 | **$ 10.00** | $ 7,500 |
| | FOREBAY EXCAVATION (MUCK) | CU YD | 3500 | **$ 10.00** | $ 35,000 |
| | 24" RC PIPE CULVERT | LIN FT | 120 | **$ 41.00** | $ 4,920 |
| | 24" RC PIPE CULVERT APRON | EACH | 2 | **$ 540.00** | $ 1,080 |
| | CLASS II RIPRAP | CU YD | 5.5 | **$ 51.00** | $ 281 |
| | OUTLET CONTROL FOR 24" RC PIPE | EACH | 1 | **$ 1,000.00** | $ 1,000 |
| **(1)** | 50' WEIR (CONCRETE CAP SHEET PILE) | LUMP SUM | 1 | **$ 30,000.00** | $ 30,000 |
| | SEEDING AND RESTORATION | LUMP SUM | 1 | **$ 15,000.00** | $ 15,000 |
| | EROSION CONTROL | LUMP SUM | 1 | **$ 5,000.00** | $ 5,000 |
| | | | | | |
| | **OPTIONAL ITEMS** | | | | **$ 15,000** |
| | 50' TIMBER WEIR | LUMP SUM | 1 | **$15,000.00** | $ 15,000 |
| | | | | | |
| | | | | **Sub-total** | **$ 107,264** |
| **CONTINGENCY (25%)** | | | | | $ 27,036 |
| | | | | **ESTIMATED TOTAL CONSTRUCTION COST** | **$ 134,300** |
| ENGINEERING (20%) | | | | | $ 26,860 |
| | | | | **ESTIMATED TOTAL COST** | **$ 161,160** |

NOTES: DOES NOT INCLUDE R/W COSTS
**(1)** OPTIONAL TIMBER WEIR DESIGN

**STEIGER LAKE WET DETENTION POND COST ESTIMATE**
**ALTERNATIVE 2 - Meandering Channel**

| ITEM NO. | ITEM DESCRIPTION | UNITS | QUANTITY | UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | MOBILIZATIN/CLEARING/GRUBBING | LUMP SUM | 1 | $ 9,778.54 | $ 9,779 |
| | EXCAVATION AT EXISTING POND (MUCK) | CU YD | 750 | $ 10.00 | $ 7,500 |
| | MEANDERED WETLAND CHANNEL EXCAVATION (MUCK) | CU YD | 1800 | $ 12.00 | $ 21,600 |
| | FOREBAY EXCAVATION (MUCK) | CU YD | 3500 | $ 10.00 | $ 35,000 |
| | 24" RC PIPE CULVERT | LIN FT | 120 | $ 41.00 | $ 4,920 |
| | 24" RC PIPE CULVERT APRON | EACH | 2 | $ 540.00 | $ 1,080 |
| | CLASS II RIPRAP | CU YD | 5.5 | $ 51.00 | $ 281 |
| | OUTLET CONTROL FOR 24" RC PIPE | EACH | 1 | $ 1,000.00 | $ 1,000 |
| **(1)** | 50' WEIR (CONCRETE CAP SHEET PILE) | LUMP SUM | 1 | $ 30,000.00 | $ 30,000 |
| | SEEDING AND RESTORATION | LUMP SUM | 1 | $ 24,000.00 | $ 24,000 |
| | EROSION CONTROL | LUMP SUM | 1 | $ 5,000.00 | $ 5,000 |
| | | | | | |
| | **OPTIONAL ITEMS** | | | | **$ 15,000** |
| | 50' TIMBER WEIR | LUMP SUM | 1 | $15,000.00 | $ 15,000 |
| | | | | | |
| | | | | **Sub-total** | **$ 140,159** |
| **CONTINGENCY (25%)** | | | | | $ 35,041 |
| | | | | **ESTIMATED TOTAL CONSTRUCTION COST** | **$ 175,200** |
| ENGINEERING (20%) | | | | | $ 35,040 |
| | | | | **ESTIMATED TOTAL COST** | **$ 210,240** |

NOTES: DOES NOT INCLUDE R/W COSTS
**(1)** OPTIONAL TIMBER WEIR DESIGN

**STEIGER LAKE WET DETENTION POND COST ESTIMATE**
**ALTERNATIVE 3 - Wetland Pond**

| ITEM NO. | ITEM DESCRIPTION | UNITS | QUANTITY | UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | MOBILIZATIN/CLEARING/GRUBBING | LUMP SUM | 1 | **$ 15,808.54** | $ 15,809 |
| | EXCAVATION AT EXISTING POND (MUCK) | CU YD | 750 | **$ 10.00** | $ 7,500 |
| | WETLAND POND EXCAVATION (MUCK) | CU YD | 13500 | **$ 11.00** | $ 148,500 |
| | 24" RC PIPE CULVERT | LIN FT | 120 | **$ 41.00** | $ 4,920 |
| | 24" RC PIPE CULVERT APRON | EACH | 2 | **$ 540.00** | $ 1,080 |
| | CLASS II RIPRAP | CU YD | 5.5 | **$ 51.00** | $ 281 |
| | OUTLET CONTROL FOR 24" RC PIPE | EACH | 1 | **$ 1,000.00** | $ 1,000 |
| **(1)** | 50' WEIR (CONCRETE CAP SHEET PILE) | LUMP SUM | 1 | **$ 30,000.00** | $ 30,000 |
| | SEEDING AND RESTORATION | LUMP SUM | 1 | **$ 10,000.00** | $ 10,000 |
| | EROSION CONTROL | LUMP SUM | 1 | **$ 7,500.00** | $ 7,500 |
| | | | | | |
| | **OPTIONAL ITEMS** | | | | **$ 15,000** |
| | 50' TIMBER WEIR | LUMP SUM | 1 | **$ 15,000.00** | $ 15,000 |
| | | | | | |
| | | | | **Sub-total** | **$ 226,589** |
| **CONTINGENCY (25%)** | | | | | $ 56,611 |
| | | | | **ESTIMATED TOTAL CONSTRUCTION COST** | **$ 283,200** |
| ENGINEERING (20%) | | | | | $ 56,640 |
| | | | | **ESTIMATED TOTAL COST** | **$ 339,840** |

NOTES: DOES NOT INCLUDE R/W COSTS
**(1)** OPTIONAL TIMBER WEIR DESIGN

**STEIGER LAKE WET DETENTION POND COST ESTIMATE**
**ALTERNATIVE 4 - Wetland Restoration**

| NOTES | ITEM DESCRIPTION | UNITS | QUANTITY | UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | MOBILIZATIN/CLEARING/GRUBBING | LUMP SUM | 1 | **$ 12,883.54** | $ 12,884 |
| | EXCAVATION AT EXISTING POND (MUCK) | CU YD | 750 | **$ 10.00** | $ 7,500 |
| **(1)** | WETLAND RESTORATION EXCAVATION (MUCK) | CU YD | 6000 | **$ 12.00** | $ 72,000 |
| | FOREBAY EXCAVATION (MUCK) | CU YD | 3500 | **$ 10.00** | $ 35,000 |
| | 24" RC PIPE CULVERT | LIN FT | 120 | **$ 41.00** | $ 4,920 |
| | 24" RC PIPE CULVERT APRON | EACH | 2 | **$ 540.00** | $ 1,080 |
| | CLASS II RIPRAP | CU YD | 5.5 | **$ 51.00** | $ 281 |
| | OUTLET CONTROL FOR 24" RC PIPE | EACH | 1 | **$ 1,000.00** | $ 1,000 |
| **(2)** | 50' WEIR (CONCRETE CAP SHEET PILE) | LUMP SUM | 1 | **$ 30,000.00** | $ 30,000 |
| | SEEDING AND RESTORATION | LUMP SUM | 1 | **$ 15,000.00** | $ 15,000 |
| | EROSION CONTROL | LUMP SUM | 1 | **$ 5,000.00** | $ 5,000 |
| | | | | | |
| | **OPTIONAL ITEMS** | | | | **$ 15,000** |
| | 50' TIMBER WEIR | LUMP SUM | 1 | **$15,000.00** | $ 15,000 |
| | | | | | |
| | | | | **Sub-total** | **$ 184,664** |
| **CONTINGENCY (25%)** | | | | | $ 46,170 |
| | | | | **ESTIMATED TOTAL CONSTRUCTION COST** | **$ 230,834** |
| ENGINEERING (20%) | | | | | $ 46,166 |
| | | | | **ESTIMATED TOTAL COST** | **$ 277,000** |

NOTES: DOES NOT INCLUDE R/W COSTS

**(1)** ASSUMES THE TOP 6" WITHIN THE 962-FT CONTOUR WILL BE HAULED OFFSITE DUE TO INFESTATION WITH INVASIVE PLANT SPECIES. ALSO ASSUMES A PORTION OF THE EXCAVATED MATERIAL WILL BE USED TO FILL THE EXISTING CHANNEL.

**(2)** OPTIONAL TIMBER WEIR DESIGN

**STEIGER LAKE WET DETENTION POND COST ESTIMATE**
**ALTERNATIVE 5 - Wetland Restoration with Modification of Katy Hills Pond**

| NOTES | ITEM DESCRIPTION | UNITS | QUANTITY | UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | MOBILIZATIN/CLEARING/GRUBBING | LUMP SUM | 1 | $ 13,672.13 | $ 13,672 |
| | EXCAVATION AT EXISTING POND (MUCK) | CU YD | 1250 | $ 10.00 | $ 12,500 |
| (1) | WETLAND RESTORATION EXCAVATION (MUCK) | CU YD | 6000 | $ 12.00 | $ 72,000 |
| | FOREBAY EXCAVATION (MUCK) | CU YD | 3500 | $ 10.00 | $ 35,000 |
| | 24" RC PIPE CULVERT | LIN FT | 120 | $ 41.00 | $ 4,920 |
| | 24" RC PIPE CULVERT APRON | EACH | 2 | $ 540.00 | $ 1,080 |
| | CLASS II RIPRAP | CU YD | 45 | $ 51.00 | $ 2,295 |
| | OUTLET CONTROL STRUCTURE (KATY HILLS POND) | LUMP SUM | 1 | $ 3,500.00 | $ 3,500 |
| | OUTLET CONTROL FOR 24" RC PIPE | EACH | 1 | $ 1,000.00 | $ 1,000 |
| (2) | 50' WEIR (CONCRETE CAP SHEET PILE) | LUMP SUM | 1 | $ 30,000.00 | $ 30,000 |
| | SEEDING AND RESTORATION | LUMP SUM | 1 | $ 15,000.00 | $ 15,000 |
| | EROSION CONTROL | LUMP SUM | 1 | $ 5,000.00 | $ 5,000 |
| | | | | | $ - |
| | **OPTIONAL ITEMS** | | | | **$ 15,000** |
| | 50' TIMBER WEIR | LUMP SUM | 1 | $15,000.00 | $ 15,000 |
| | | | | | |
| | | | | **Sub-total** | **$ 195,967** |
| **CONTINGENCY (25%)** | | | | | $ 48,992 |
| | | | | **ESTIMATED TOTAL CONSTRUCTION COST** | **$ 244,959** |
| ENGINEERING (20%) | | | | | $ 48,992 |
| | | | | **ESTIMATED TOTAL COST** | **$ 293,951** |

NOTES: DOES NOT INCLUDE R/W COSTS

**(1)** ASSUMES THE TOP 6" WITHIN THE 962-FT CONTOUR WILL BE HAULED OFFSITE DUE TO INFESTATION WITH INVASIVE PLANT SPECIES. ALSO ASSUMES A PORTION OF THE EXCAVATED MATERIAL WILL BE USED TO FILL THE EXISTING CHANNEL.

**(2)** OPTIONAL TIMBER WEIR DESIGN

**STEIGER LAKE WET DETENTION POND COST ESTIMATE**
**STREAMBANK RESTORATION**

| NOTES | ITEM DESCRIPTION | UNITS | QUANTITY | UNIT PRICE | COST |
|---|---|---|---|---|---|
| | | | | | |
| | MOBILIZATIN/CLEARING/GRUBBING | LUMP SUM | - | **$ 7,500.00** | $ 7,500 |
| | COMMON BORROW | CU YD | 270 | **$ 15.00** | $ 4,050 |
| | RIPRAP CL II | CU YD | 30 | **$ 51.00** | $ 1,530 |
| | 50:50 COMPOST/TOPSOIL MIXTURE | CU YD | 50 | **$ 45.00** | $ 2,250 |
| | EROSION CONTROL BLANKET (CATEGORY 7) | SQ YD | 265 | **$ 3.50** | $ 928 |
| | FILTER LOG | LIN FT | 400 | **$ 3.00** | $ 1,200 |
| | DECIDUOUS TREES | EACH | 6 | **$ 400.00** | $ 2,400 |
| | DECIDUOUS SHRUBS LARGE | EACH | 14 | **$ 42.00** | $ 588 |
| | DECIDUOUS SHRUBS SMALL | EACH | 90 | **$ 42.00** | $ 3,780 |
| | SITE EROSION CONTROL | LUMP SUM | - | **$ 2,500.00** | $ 2,500 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | **Sub-total** | **$ 26,726** |
| **CONTINGENCY (25%)** | | | | | $ 6,681 |
| | | | | **ESTIMATED TOTAL CONSTRUCTION COST** | **$ 33,407** |
| ENGINEERING (20%) | | | | | $ 6,681 |
| | | | | **ESTIMATED TOTAL COST** | **$ 40,088** |

NOTES: ACCESS TO SITE WAS ASSUMED FROM THE BOAT LANDING.

# APPENDIX F

# STREAMBANK EROSION COMPUTATIONS

## NRCS Streambank Erosion Estimator (Direct Volume Method)

| | | | |
|---|---|---|---|
| Farmer / Cooperator Name: | SRF Consulting Group, Inc. | Evaluated By: | Troy Erickson |
| Project Name: | Steiger Lake Streambank Erosion | Evaluation Date: | September 28, 2010 |

| Field Number | Eroding Streambank Reach Number | Eroding Bank Length (Feet) | Eroding Bank Height * (Feet) | Area of Eroding Streambank ($FT^2$) | Lateral Recession Rate (Estimated) (FT / Year) | Estimated Volume ($FT^3$) Eroded Annually | Soil Texture | Approximate Pounds of Soil per $FT^3$ | Estimated Soil Loss (Tons/Year) |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 60.0 | 44.0 | 2,640 | 0.10 | 264.0 | Silt Loam | 85 | 11.2 |
| | 2 | 85.0 | 57.0 | 4,845 | 0.10 | 484.5 | Silt Loam | 85 | 20.6 |
| | 3 | 220.0 | 56.0 | 12,320 | 0.10 | 1,232.0 | Silt Loam | 85 | 52.4 |
| | | | | Total Estimated Annual Streambank Erosion Soil Loss (Tons): | | | | | 84.2 |

| Field Number | Eroding Streambank Reach Number | Eroding Bank Length (Feet) | Eroding Bank Height * (Feet) | Area of Eroding Streambank ($FT^2$) | Lateral Recession Rate (Estimated) (FT / Year) | Estimated Volume ($FT^3$) Eroded Annually | Soil Texture | Approximate Pounds of Soil per $FT^3$ | Estimated Soil Loss (Tons/Year) |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 50.0 | 35.0 | 1,750 | 0.40 | 700.0 | Silt Loam | 85 | 29.8 |
| | 5 | 60.0 | 42.0 | 2,520 | 0.40 | 1,008.0 | Silt Loam | 85 | 42.8 |
| | | | | | | | | | |
| | | | | Total Estimated Annual Streambank Erosion Soil Loss (Tons): | | | | | 72.6 |

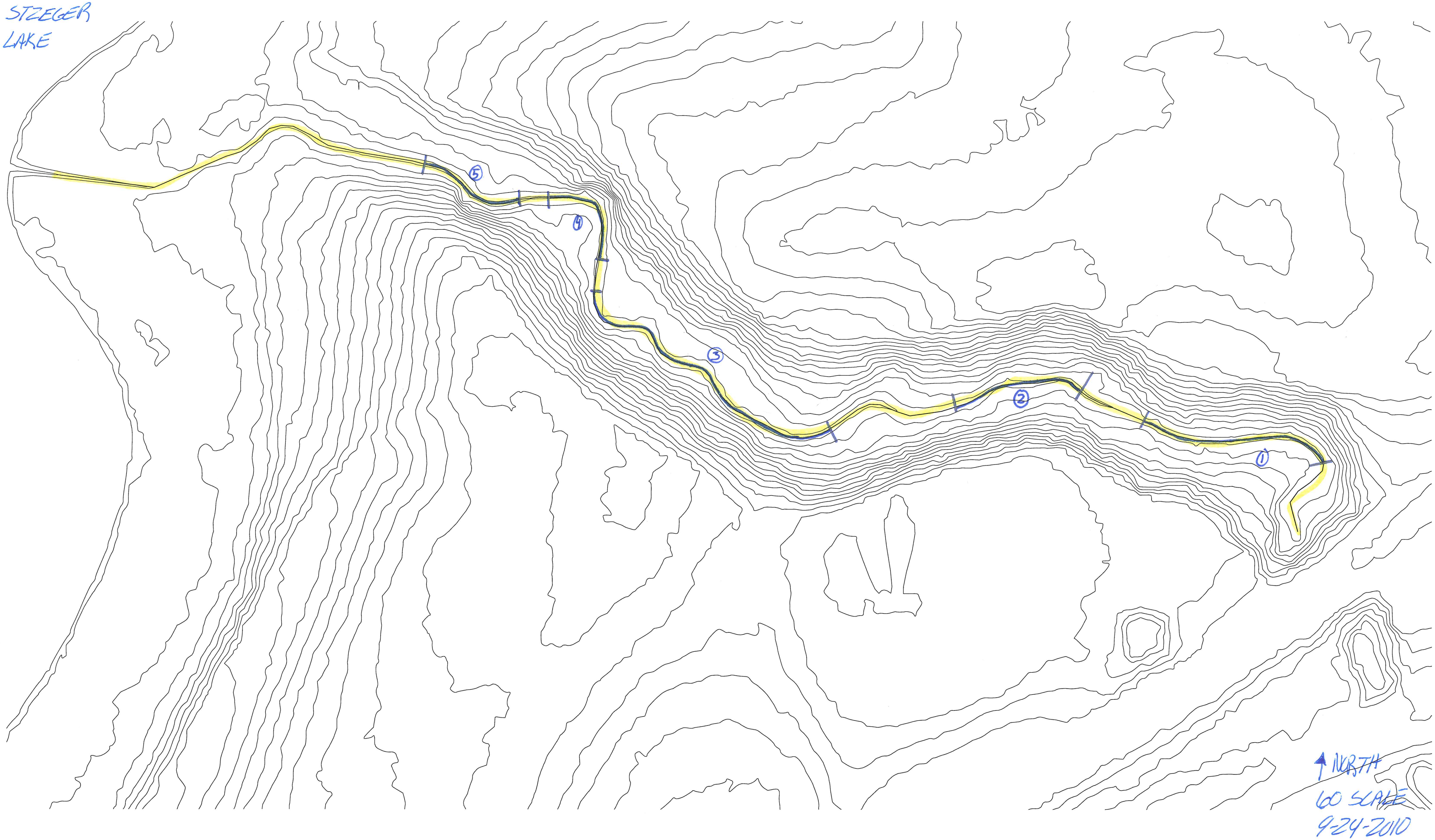
| Field Number | Eroding Streambank Reach Number | Eroding Bank Length (Feet) | Eroding Bank Height * (Feet) | Area of Eroding Streambank ($FT^2$) | Lateral Recession Rate (Estimated) (FT / Year) | Estimated Volume ($FT^3$) Eroded Annually | Soil Texture | Approximate Pounds of Soil per $FT^3$ | Estimated Soil Loss (Tons/Year) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | Total Estimated Annual Streambank Erosion Soil Loss (Tons): | | | | | |

* Eroding bank height is measured along the bank, not the vertical height of bank.

*Streambank Erosion Calculation Formula:*

$$\frac{\text{Eroding Bank Length} \times \text{Eroding Bank Height} \times \text{Lateral Recession Rate (FT/YR)} \times \text{Soil Weight (lbs/ft}^3\text{)}}{2000} = \text{Estimated Soil Loss Per Year (Tons)}$$

VT NRCS Streambank Erosion Estimator (June 2006)


STZEGER
LAKE
5
4
3
2
1
NORTH
60 SCALE
9-24-2010