SUMMARY DRAFT FINDINGS
DITCH 20 WETLAND RESTORATION FEASIBILITY STUDY TO BENEFIT DOWNSTREAM WATER QUALITY

Prepared by:

October 11, 2017
Report Summary

Purpose
The purpose of this feasibility study is to identify and evaluate projects that will reduce phosphorus export from lands adjacent to Ditch 20, thereby benefitting water quality in downstream impaired waterbodies including Typo Lake and Martin Lake. A suite of 6 projects were explored in-depth, and ultimately revised to a list of four projects which were feasible and had landowner support. Concept designs and cost estimates were developed. Projects were ranked by cost effectiveness at reducing phosphorus. This report discusses the overall feasibility of these projects such that local water planners can consider whether to pursue them.

Background
Ditch 20 lies in southeastern Isanti County, Minnesota (Figure 1). County Ditch 20 and 13 join and become Data Creek. Data Creek flows into Typo Lake, which in turn flows to Martin Lake. Ultimately, these waters flow to the Sunrise River and St. Croix River.

**FIGURE 1. FEASIBILITY STUDY LOCATION**

Many of the waterways in this system are “impaired” – not meeting state water quality standards for nutrients and/or turbidity and related factors. During Total Maximum Daily Load (TMDL) studies for Martin and Typo Lakes, Ditch 20 was identified as a significant contributor of phosphorus to these impaired waters.
Water Monitoring

Between 2001 and 2017 a variety of water monitoring was conducted throughout the Ditch 20 system to understand water quality and inform the models used in this feasibility study. This monitoring included grab samples for water quality analyses, continuous tracking of water levels in the stream and nearby surficial groundwater, and soil nutrient testing.

The earliest water quality monitoring found phosphorus levels in Ditch 20 were as much as 7 times higher than today’s phosphorus standard for streams (Figure 2). This is unusual, given that the landscape contains few typical pollutant sources such as urbanization or agriculture. Instead, Ditch 20 is in the middle of wide lowlands with peat soils and natural habitats.

Through additional testing and research, we came to understand that ditched wetland (peat) soils, driven by alternating periods of drying and re-wetting, were the phosphorus source. During dry periods, aerobic decomposition breaks down organic material in the peat. During wet periods now-soluble nutrients are moved toward the ditch as it drains the surrounding lands. Other biological and chemical processes also contribute, but ultimately restoring a more natural hydrology to the ditched wetlands would reduce nutrient exports.

More recent water quality monitoring has found much lower phosphorus levels in Ditch 20 (Fig. 2). It is unknown why the water quality has improved. Recently, phosphorus levels are near the state water quality standard for stream of 100 µg/L. This may mean that Ditch 20 is now a lower priority for watershed managers than other projects.

**Figure 2. Time series of total phosphorus (P) measurements in Ditch 20.**

High P was observed in the earlier readings, and moderate readings more recently. The state water quality standard for streams is 100 µg/L.
Modeling
We created a XPSWMM hydrologic model of the Ditch 20 drainage area to evaluate the impact of a variety of possible projects. The model includes a network of flow paths, structures like culverts, and land uses. We calibrated this model to field-collected flow and water quality measurements. Possible projects were added to the model and manipulated to determine appropriate sizing and placement. We paired this hydrologic model with a water quality model software called P8 and literature research to estimate pollutant reductions from each possible project.

Potential Water Quality Projects
Three primary project types were explored: lateral ditch blocks, ditch channel weirs and settling ponds. The first two would restore wetland hydrology to portions of the drained area. The third, settling ponds, would be aimed at capturing of phosphorus that is attached to particles (monitoring found ~50% of P is particulate). Specific project sites have been identified (Figure 3) where landowners are receptive. Concept designs for each project are provided as Appendix 1.
FIGURE 3. PROPOSED WATER QUALITY IMPROVEMENT PROJECT LOCATIONS.
LATERAL DITCH BLOCKS

Lateral ditch plugs involve using an earthen structure to block drainage of small private lateral ditches. We modeled lateral ditch plugs at 2 locations (Figure 3) that would raise water levels 2 feet during base flow conditions impacting 11 and 8 acres respectively. Water would be raised to approximately ground level. During storm conditions, a somewhat larger footprint of impounded water would occur (see Appendix).

While we have positioned proposed lateral ditch plugs where they will entirely or mostly impact a single landowner who has already expressed support, the final design would further analyze the extent of impacts. If the lateral ditch plug would impact drainage for upstream properties that do not want their drainage changed, we could accommodate them by digging a new bypass ditch around the wetland that is restored by the ditch plug. Not only does this add substantial cost, but if the new bypass ditch is dug to the original/historic ditch profile, it may increase drainage impacts and have a negative water quality impact itself.

FIGURE 4. EXAMPLE OF A LATERAL DITCH BLOCK INSTALLATION.

WEIRS

A weir in Ditch 20 was evaluated at one location. Base flow water levels adjacent to the weir would be raised 2.6 in the scenario we modeled, creating wetland hydrology over a 22 acre area. A modestly larger area of hydrologic impact would occur during larger storms (see Appendix). Because it would be on the main stem of the ditch, a mechanical weir with adjustable stoplogs may be preferred over an earthen plug and was modelled. Also, because of its status as a county ditch, there are additional legal proceedings and approvals needed.

FIGURE 5. EXAMPLE WEIR WITH STOP LOGS TO ADJUST WATER LEVEL.
An alternate weir placement is possible that would accomplish projects 2A and 1B simultaneously (Figure 6). The weir placement we explored on Ditch 20 is just upstream of the confluence with a lateral ditch where a plug was explored. If instead the weir were placed just downstream of the lateral ditch, wetland would be restored along both the lateral Ditch 20. Such an arrangement would require willing landowners throughout both areas, and perhaps bypass ditches around restored wetland.

**FIGURE 6. OPTION FOR A DITCH 20 WEIR PLACEMENT THAT COMBINES PROJECTS 2A AND 1B.**
See Figure 3 for general location of projects 2A and 1B. Placing a weir downstream of Ditch 20’s confluence with a lateral ditch would restore wetland areas of both project 2A and 1B with a single structure. Bypass ditches to maintain upstream drainage may be needed for each waterway.
SETTLING POND

A settling pond at one location was evaluated. The ditch would be routed through the pond (i.e. an in-line pond). Depths of at least 6 feet are preferred to maximize particle capture and maximize the time interval between pond cleanouts. A 1.3 acre pond area was modeled.

**Figure 6. Example excavated settling pond.**

Feasibility Analysis

Only feasible projects are presented in this report. To be considered feasible, a project:

- Had landowner support.
- Engineering concepts that could reasonably be constructed.
- Reasonable assurance the project would achieve pollutant reductions.

While other projects were explored, only four met these criteria. Cost-benefit ranking was done for these four projects.

Factors that generally increase the feasibility of all these projects include:

- Small drainage area of the ditch.
- Large parcels sizes, and the ability to scale project sizes such that impacts are only on parcels that allow it.
- Impacted lands are idle and close to wetland hydrology already.
- The possibility of wetland restoration credit banking as a funding mechanism.

All four projects would face large hurdles, including:

- Drainage needs to be maintained for upstream landowners who want it. While bypass ditches can accomplish this, they add substantial expense.
- Any new bypass ditches dug around restored wetland to maintain drainage would likely be dug to the original profile of Ditch 20, and therefore have a greater drainage and negative water quality impact than Ditch 20 currently has.
- Remote construction sites, often on unstable soils.
- Phosphorus reduction estimates for lateral ditch plugs or a weir assume all upstream drainage is treated by the practice. If a bypass ditch is dug around the practice, much of the upstream water is not treated and actual phosphorus reductions will be much lesser.
- Lack of an identified entity to own and maintain the structures.
Permitting will be time consuming and require additional research, monitoring or modeling to assure favorable results. Permitting will likely include the Minnesota Wetland Conservation Act and local mining ordinances (for pond excavations) administered by Isanti County, and Section 404(d) of the Clean Water Act administered by the US Army Corps of Engineers.

Cost-Benefit Analysis
Costs of each project are divided by the estimated pollutant reduction it will achieve to yield a cost-benefit comparison among projects. Costs for construction and engineering were provided by the engineer for this feasibility study. Costs for legal expenses associated with permitting and maintenance access were estimated by the Anoka Conservation District (ACD). ACD also estimated maintenance costs over a 30-year practice lifespan. All of these costs were added.

Benefits were calculated in pounds of pollutant (phosphorus) reduction annually. These estimations were made through an XP-SWMM hydrologic model paired with a P8 water quality model. For wetland restoration projects (ditch plugs and weirs), which are not a strength of the models, primary literature was referenced to determine appropriate phosphorus removal rates. In these cases we used 46% removal of particulate phosphorus and 12% removal of dissolved phosphorus.

There is a reasonable amount of uncertainty in these pollutant reduction estimates for wetland restoration projects. Researchers studying similar projects have found widely varying pollutant reductions. In some cases, phosphorus export increases after restoration of similar wetlands for a period.

Cost per pound of phosphorus removed for each of the four feasible projects is in Table 1. In urban settings, ACD has found that any projects costing less than $500 per pound of phosphorus removed are highly favorable. Projects between $500 and $1,000 are moderate. Three of the Ditch 20 projects fall in these categories. This cost-benefit analysis does not consider wildlife benefits.
TABLE 1 – COST-BENEFIT ANALYSIS OF DITCH 20 POTENTIAL WATER QUALITY PROJECTS.
The right, blue shaded columns indicate cost per pound of phosphorus reduction without and with a bypass ditch. A bypass ditch would ensure current drainage to be maintained for upstream landowners, and may or may not be needed. Costs below $500/lb of P are most favored. Costs above $1,000/lb P are not favored. When selecting projects to construct, political, social, legal and scientific uncertainties discussed elsewhere in this report should be considered.

<table>
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<tr>
<th>Project ID</th>
<th>Project</th>
<th>TP reduction (lbs/yr)</th>
<th>Construction</th>
<th>Design/Engineering</th>
<th>Legal fees (permitting etc.)</th>
<th>Maintenance (over 30 yrs)</th>
<th>Total WITHOUT Bypass ditch option</th>
<th>Total WITH Bypass ditch option</th>
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<td>$1,894</td>
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</tbody>
</table>

Conclusions

- **Three favored projects.** Of the four possible projects that were deemed feasible, the two lateral ditch plugs and the weir on the main stem of Ditch 20 offer moderate benefits per dollar spent, and should be considered. Total costs for each project are found in Table 1. If any projects are pursued, each will require substantial work to reach completion. While our analysis includes reasonable cost and benefit estimates, the complexity of these projects means there is a moderately wide range of possible costs and benefits.

- **Moderate priority compared to other projects in the watershed.** A variety of projects will be needed to improve water quality in this system of interconnected streams and lakes. In-lake projects are some of the highest priority based on TMDL analyses. Ditch 20 was thought to also be a high priority. However, based upon the newest monitoring data, Ditch 20 does not export as much phosphorus as previously calculated. This may mean that other projects are a higher priority. Other projects include in-lake phosphorus treatment, rough fish management fixing failing septic systems, and others.

- **Avoid cleaning the ditch.** Cleaning or re-excavating Ditch 20 and its tributaries should be discouraged. These ditches are probably not at their original depth/profile and have filled in to some unknown extent over time. This has lessened the drainage capacity, presumably with water quality benefits. If the ditch were cleaned to a deeper profile, cycles of drying and wetting that drive phosphorus release, as well as the acreage drained by the ditch, would likely increase and negatively impact downstream waterways.

Local water planners should consider this report’s findings when doing comprehensive planning. The water planners include Isanti County, the Sunrise River Watershed Management Organization, the Anoka Conservation District and Isanti Soil and Water Conservation District. Each organization has multi-year management plans that prioritize projects to be built. The Ditch 20 projects should be
considered, and balanced with other priorities. If included in local water plans and 10-25% locally funded, these projects could compete for state grants that could provide the remainder of needed funding.

Acknowledgements
This feasibility study was completed with an Accelerated Implementation Clean Water Fund grant from the MN Board of Water and Soil Resources. Funds are from the Clean Water Land and Legacy Amendment.

Other funding was from the Sunrise River Watershed Management Organization and the Martin Lakers Association.

Landowners informed this feasibility study with their intimate knowledge of the lands and waters. They also thoughtfully considered project concepts that might apply to their own property.

Collaborative input was provided to the Anoka Conservation District by:
Dr. Chris Lenhart, University of Minnesota
Isanti County
Isanti Soil and Water Conservation District
Landowners
MN Department of Natural Resources
MN Board of Water and Soil Resources, particularly engineer Tom Wenzel

This project’s consulting engineer was Civil Methods, Inc.
Concept Designs for Modeled Water Quality Projects
Note - Optional Control Structure:
As indicated on the plan view, it may be desired to install a water control structure at the time of installation of the ditch plug, in order to provide a means of releasing water from the restored area (the area upstream of the ditch block). Although this measure is to relieve the water quality benefits for the overall watershed, it may create unforeseen upstream consequences by allowing drainage of the area if necessary. The ability to design/deliver the area upstream of the ditch block can also be used for additional water quality benefits, by seasonally dropping down the water level and storing more stormwater available to capture spring flow events. It should be noted that there are feasibility concerns with these structures. They can become easily clogged in this type of landscape and they are difficult to get out of the right elevation when there is so little topographic relief.

POLLUTANT REMOVAL SUMMARY:

**S.D. DITCH 20 WETLAND RESTORATION FEASIBILITY STUDY**

**GENERAL NOTES:**
1. Calculation of preliminary costs assume that adequate amounts of suitable material can be located on site for construction of the ditch plug. This must include material with an adequate amount of clay/fine material in order to effectively block flow where desired.
3. Calculation of phosphorus loading based on monitoring data, with average of 0.75 lb/acre/year of phosphorus loading for the overall drainage area. Estimated proportions of dissolved vs. particulate phosphorus are based on monitoring data.
4. Numerous literature references were consulted in order to determine the most appropriate estimate of P removal/preservation by restored wetlands. Based on the literature review, and considering specific elements of this watershed including location, ratio of wetland area to watershed area, and other factors, removal percentages of 18% (DP) and 12% (PP) were selected for planning purposes.
5. Estimated proportions of dissolved vs. particulate phosphorus for the overall watershed for sequestration of P. Short-term increases in P discharge following hydrologic restoration have been reported and attributed to release of P under anoxic conditions.
6. Constructing multiple ditch plugs or other controls as part of a single project would eliminate the need for multiple mobilization fees.
7. P removal estimates are based on a nutrient cycling model that considers the long-term viability of the wetland for sequestration of P. Initial construction will result in only slight increases in P discharge, although it presents several concerns. Bypass configuration to be determined in final design. To the extent practicable low flows from upstream areas would continue to be directed to the restoration areas, with sufficient bypass capacity to maintain drainage benefits.
8. Per discussion with BWSR, in final design it will be necessary to ensure that the ditch block does not negatively impact upstream property. An open bypass ditch alignment is depicted, as that is likely the most feasible option. Installation of a solid wall tile to convey upstream low flows may be considered, although it presents several concerns. Bypass configuration to be determined in final design. To the extent practicable low flows from upstream areas would continue to be directed to the restoration areas, with sufficient bypass capacity to maintain drainage benefits.

**ESTIMATE OF QUANTITIES AND COSTS:**

**S.D. DITCH 20 WETLAND RESTORATION FEASIBILITY STUDY**

**PROPOSED DITCH BLOCK**

1318 MCKAY DR NE
HAM LAKE, MN 55304

ANOKA CONSERVATION DISTRICT

18B: LIDDLER LATERAL DITCH PLUG

DITCH 20 WETLAND RESTORATION FEASIBILITY STUDY

ISANTI COUNTY, MN

CIVIL METHODS, INC.
1551 Livingston Avenue, Suite 104
West St. Paul, MN 55118

DATE / REVISION:

OWNER: TITLE:

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DITCH 20 WETLAND RESTORATION FEASIBILITY STUDY

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site for construction of the ditch plug. This must include material with an adequate amount of clay/organic
material in order to effectively block flow where desired.
2. Ditch plug construction shall follow guidelines laid out in the Minnesota Wetland Restoration Guide,
3. Calculation of phosphorus loading based on monitoring data, with average of 0.302 lb/acre-ft of
phosphorus loading for the overall drainage area. Estimated proportions of dissolved vs. particulate
phosphorus and based on monitoring data.
4. Numerous literature references were consulted in order to determine the most appropriate estimate of P
removal/sequestration by restored wetlands. Based on the literature review, and considering specific
parameters of this wetland including location, ratio of wetland area to watershed area, and other
factors, removal percentages of 40% (PP) and 12% (DP) were selected for planning purposes.
5. P removal estimates are based on a nutrient cycling model that considers the long-term viability of the
wetland for sequestration of P. Short term increases in P discharge following hydrologic restoration
have been reported and it is not clear if this is likely the most feasible option. Installation of a solid wall to convey upstream low flows may be considered,
although it presents several concerns. Bypass configuration to be determined in final design. To the
extent practicable low flows from upstream would continue to be directed to the restoration area, with
sufficient bypass capacity to maintain drainage benefits.

ESTIMATE OF QUANTITIES AND COSTS:

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<thead>
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<th>Item</th>
<th>No.</th>
<th>Base</th>
<th>Estimated Quantity</th>
<th>Units</th>
<th>Unit Cost</th>
<th>Total Amount</th>
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SUBTOTAL ESTIMATED CONSTRUCTION: $522,550.00

ESTIMATED COST OF ALL ITEMS: $522,550.00

POLLUTANT REMOVAL SUMMARY:

| Item | No. | Base | Estimated Annual Flushing | Hydrologically Restored Wetland Area | | |
|------|-----|------|---------------------------|-------------------------------------| | |
| 1. | DITCH PLUG | | | | | |

ESTIMATED ANNUAL REMOVAL OF DREDGED AND PARTICULATE P: 27.80 lb/yr

ESTIMATED ANNUAL REMOVAL OF SOLID WASTE (OSW): 134.5 lb/yr

ANNEX 5

ECONOMICS

CEMPERSON

CIVIL METHODS, INC.
1551 Livengton Avenue, Suite 104
West St. Paul, MN 55118

ADDENDUM

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED
BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED
PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

ESTIMATED HYDROLOGIC RESTORATION AREA

GENERAL NOTES:

CIVIL METHODS, INC.
1551 Livengton Avenue, Suite 104
West St. Paul, MN 55118

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ESTIMATED HYDROLOGIC RESTORATION AREA

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ADDENDUM

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED
BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED
PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

ESTIMATED HYDROLOGIC RESTORATION AREA

GENERAL NOTES:

CIVIL METHODS, INC.
1551 Livengton Avenue, Suite 104
West St. Paul, MN 55118

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ESTIMATED HYDROLOGIC RESTORATION AREA

GENERAL NOTES:
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1. Calculation of preliminary costs accounts for the requirement to transport excavated material for disposal off the marshland available on site. The pond location to be determined through consultation with the landowner and consideration of existing topography and soil conditions.
3. P removal estimates based on rate of P removal in pond water quality models.
4. Planting plans estimate P concentrations in runoff, which are determined based on water quality samples taken from several different years. The average concentration of samples from each year was calculated, and the median annual average concentration was used for estimating loads.
5. Pond location shown is for illustrative purposes only. Final pond location will impact access, ownership, and maintenance configuration.
6. Appropriate construction arrangement will be required in order to ensure long-term pond operation, access, maintenance, etc.

ESTIMATE OF QUANTITIES AND COSTS:

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Estimated Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Installation of Pump and Diversion Structure in Ditch to Direct Water to New Ponds</td>
<td>3</td>
<td>CF</td>
<td>$300.00 CF</td>
<td>$900.00</td>
</tr>
<tr>
<td>2. Erosion Control &amp; Restoration</td>
<td>3</td>
<td>CF</td>
<td>$400.00 CF</td>
<td>$1,200.00</td>
</tr>
<tr>
<td>3. Location and Transport of Material</td>
<td>500</td>
<td>CF</td>
<td>$4.00 CF</td>
<td>$2,000.00</td>
</tr>
<tr>
<td>4. Inlet/Outlet Configuration</td>
<td>3</td>
<td>CF</td>
<td>$1,500.00 CF</td>
<td>$4,500.00</td>
</tr>
</tbody>
</table>

POND REMOVAL IN POND QUALITY BENCHMARKS:

| PONDS REMOVED (FOR POND REMOVAL) | 10 | ACRE |

ESTIMATED ANNUAL FLOWS FROM DRAINAGE AREA (EPA) POND AREA (NORMAL WATER LEVELS) (ACRE) 1.31 (ACRE) POND AREA (NORMAL WATER LEVELS) 1,310 (ACRE) PERCENT REMOVAL OF TOTAL-PHOSPHORUS 54.91 (PERCENT) ESTIMATED ANNUAL REMOVAL OF TOTAL-PHOSPHORUS 54,915 (LBS)