MINNEHAHA CREEK
WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

Meeting: Board of Managers
Meeting date: 10/20/2022
Agenda Item #: 11.2
Action type: Action

Title:	Authorization to Release Request for Proposals for East Auburn Wetlands Feasibility Study
Resolution number:	22-063
Prepared by:	Name: Daniel Mock Phone: 952-247-1368 dmock@minnehahacreek.org
Reviewed by:	Name/Title: Michael Hayman, Project Planning Manager
Recommended action:	The Board of Managers authorizes the release of a request for proposals (RFP) for a feasibility study to address phosphorus loading to East Auburn Lake from a degraded wetland complex in Victoria, Minnesota
Schedule	December 2022 – Authorize feasibility contract Winter 2022/2023 – Conduct feasibility Summer/Fall 2023 – Design development Winter 2023/2024 – Construction commences
Budget considerations:	Fund name and code: Project Planning, Engineering 2002-4340 Fund budget: $222,500 Expenditures to date: $51,011 Requested amount of funding: N/A
Past Board action:	Res # 14-047 Identifying Six Mile Creek Sub-watershed as a Priority Focus Area Res # 15-030 Authorization to Execute a Memorandum of Understanding with the City of Victoria Res # 21-052 Authorization to Execute Contract for Assessment for the East Auburn Wetland Monitoring and Feasibility Support

Summary:
The 2017 Minnehaha Creek Watershed District (MCWD) Watershed Management Plan (WMP) identifies that impairments in East Auburn Lake are driven primarily by external wetland phosphorus export making its way into the lake. The WMP also identifies the wetland systems between Wassermann Lake and East Auburn Lake as a potential restoration opportunity to address nutrient export to East Auburn Lake.

Beginning in 2019, MCWD staff analyzed historical water quality data to determine the extent to which the wetland system between Wassermann Lake and East Auburn Lake exports phosphorus. That analysis revealed that the wetland exports approximately 135 pounds of phosphorus per year to East Auburn Lake. In comparison, the total watershed load reduction needed for East Auburn Lake to meet water quality standards is 341 pounds of phosphorus per year, as identified in the Six Mile Creek – Halsted Bay Diagnostic Study. Therefore, a wetland restoration focused on phosphorus reduction could achieve nearly half of the total watershed load reduction needed for East Auburn Lake.

In 2021, MCWD staff commenced a refined water quality sampling, hydrology, and vegetation analysis, in cooperation with Stantec, in the wetland system between Wassermann Lake and East Auburn Lake to identify if there is a specific area within the wetland responsible for the majority of the phosphorus export. This analysis indicated that a relatively small portion of the wetland is the primary driver of phosphorus export. With a characterization of the location and magnitude of the phosphorus export pinned down, identifying an engineering solution to reduce export from this wetland was identified as the next step.

MCWD staff worked with Stantec to develop a scope of work to support monitoring in 2021 and 2022 that would inform preliminary engineering design. The two key questions that the monitoring plan for the East Auburn wetland assessed are:

1. Is there high phosphorus throughout the soils of the wetland?
2. Are there areas of high phosphorus that can mobilize and move downstream into East Auburn Lake?

As part of its refined monitoring effort, District Staff installed 40 monitoring wells to assess groundwater phosphorus concentrations and water levels at varying depths and locations throughout the wetland. These wells were designed to inform staff as to whether the elevated soil phosphorus could be mobilized and transported downstream to East Auburn Lake. The groundwater phosphorus concentrations and water level data collected in these wells clearly show that phosphorus-rich groundwater was being transported to the channel.

The wetland monitoring assessment was completed in late September 2022. The key findings of the assessment, included in the Stantec technical memorandum (exhibit D in the Request for Proposals) are:

- Water quality sampling in the groundwater wells and stream samples indicated that median total phosphorus concentrations in groundwater were approximately 4.5-times higher than the median total phosphorus concentrations in the stream channel.

- Solid-phase mobile phosphorus from soils is likely driving elevated groundwater concentrations.

- Phosphorus-rich groundwater is then transported downstream, via Six Mile Creek, to East Auburn Lake.

The next step in project development is to issue a Request for Proposals (RFP) for feasibility to identify opportunities to address phosphorus export from the wetland. This feasibility effort will likely reveal a range of design options falling under three general wetland restoration categories:

1. Trap and contain legacy phosphorus within the wetland
2. Remove legacy phosphorus from within the wetland
3. Treat legacy phosphorus within the wetland

Request for Proposal process:
At the October 20, 2022, MCWD Board Meeting, staff will present the draft RFP for Board consideration. If authorized for release, the RFP process will solicit proposals from October 20, 2022, through November 17, 2022. There will be an informational meeting for bidders to attend at the MCWD office on October 31, 2022 to answer any questions and provide guidance on the submittal process. Project Planning will return to the Board on the December 15, 2022 to request authorization to award the feasibility contract.

Staff Recommendation:
Staff recommends that the Board authorize the release of the RFP for the East Auburn Wetland feasibility study to continue its efforts in addressing nutrient export from the wetland complex to downstream East Auburn Lake.

Supporting documents (list attachments):
A. Request for Proposals – Engineering and Consultant Services: East Auburn Wetland

MINNEHAHA CREEK
WATERSHED DISTRICT
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RESOLUTION

Resolution number: 22-063

Title: Authorization to Release Request for Proposals for East Auburn Wetlands Feasibility Study

WHEREAS the Minnehaha Creek Watershed District (MCWD) has developed a plan for the Six Mile Creek-Halsted Bay Subwatershed (SMCHB) that identifies implementation strategies to achieve the District's goals of protecting and improving water quality, water quantity, ecological integrity, and thriving communities through land use and water integration;

WHEREAS the MCWD Watershed Management Plan (WMP) identifies the wetlands between Wassermann Lake and East Auburn Lake as a planned capital investment to reduce watershed nutrient loading to improve water clarity and create a more abundant and diverse aquatic vegetation community in East Auburn Lake;

WHEREAS in 2019, MCWD staff analyzed historical water quality data to determine the extent to which the wetland system between Wassermann Lake and East Auburn Lake exports phosphorus, and concluded that the wetland exports approximately 135 pounds of phosphorus per year to East Auburn Lake, nearly one-half of the necessary reduction for East Auburn Lake to meet water quality standards;

WHEREAS in 2021 and 2022, MCWD staff conducted a refined water quality sampling, hydrology, and vegetation analysis in the wetland system between Wassermann Lake and East Auburn Lake to identify specific areas within the wetland responsible for the majority of the phosphorus export;

WHEREAS analysis indicates that a relatively small portion of the wetland complex is the primary driver of phosphorus export to East Auburn Lake, identifying total phosphorus concentrations in groundwater are much greater than that in the stream channel, and that the phosphorus in groundwater and wetland soil is mobilizing and exporting to downstream East Auburn Lake;

WHEREAS the next step in project development is the issuance of a Request for Proposals (RFP) for feasibility to identify opportunities to address phosphorus export from the wetland complex and identify a range of design options for wetland restoration that will target nutrient issues.

NOW, THEREFORE, BE IT RESOLVED that the Minnehaha Creek Watershed District Board of Managers authorizes staff to release a Request for Proposals for the East Auburn Wetlands feasibility study.

Resolution Number 22- 063 was moved by Manager _____________, seconded by Manager ____________. Motion to adopt the resolution ___ ayes, ___ nays, ___abstentions. Date: October 20, 2022

____ Date: ___________________________
Secretary

MINNEHAHA CREEK WATERSHED DISTRICT
QUALITY OF WATER QUALITY OF LIFE

REQUEST FOR PROPOSALS - ENGINEERING AND CONSULTING SERVICES
Minnehaha Creek Watershed District

Minnehaha Creek Watershed District (MCWD) is accepting proposals for engineering and consulting services to complete a Feasibility Study for the East Auburn Wetlands Restoration (EAWR) project. The wetlands corridor includes sections of Six-Mile Creek (SMC) and contains several types of wetlands, including emergent, aquatic bed, scrub-shrub, and unconsolidated bottom (map-appendix A). MCWD's internal Research and Monitoring team (R&M) conducted a wetland monitoring assessment (appendix B) completed in September 2022. The assessment indicated a phosphorus loading issue and determined that cell A1, located at the outlet of Wassermann Lake, had the highest phosphorus loading in the corridor. EAWR represents a unique opportunity for MCWD as it explores wetland systems as potential sources of nutrient loading, and as such, it seeks innovative solutions that may be repeatable in other wetland systems.

The issue to Solve:

- The wetland complex between Wassermann Lake and East Auburn Lake is an identified source of phosphorus export. The first cell at the outlet of Wassermann Lake is identified as the potential primary source of phosphorus.
- Solid phase mobile hosphorus concentrations in the soil are high in wetland soils
- Solid phase mobile phosphorus adsorbed tosoils are are likely driving elevated phosphorus concentrations in groundwater
- Phosphorus-rich groundwater is being transported via advective flux to the stream channel, which is impacting the downstream waterbody East Auburn Lake

MCWD is asking for the following:

- Feasible, cost effective, and innovative solutions to address phosphorus export from the identified wetland complex to downstream East Auburn Lake for a reduction of phosphorus levels presently exporting from the wetland complex to downstream East Auburn Lake.

Goals:

- The MCWD Water Resources Management Plan identifies a reduction of phosphorus export from five degraded wetland systems that drain into East Auburn
- MCWD Research and Monitoring identified that the wetland is on average exporting 135 lbs./yr
- Secondary benefits include:
    - Potential habitat restoration within the wetland complex
    - Improve/increase water storage capacity within the wetland complex

- Create internal processes and methods for addressing nutrient loading in other wetland systems

Appendix Items:

A. East Auburn Wetlands Corridor Map

B. 2019 Wenck Associates Wetland Vegetation Assessment

C. 2020 MCWD Wetland Water Quality Assessment

D. 2022 Auburn Wetland Monitoring Project – Technical Memo

PROJECT PROPOSAL CONTENTS

1. Cover Letter
2. Statement of Methodology and Experience (SME) (see criteria below)
    a. Background information about the consulting firm
    b. Identification of team members, their qualifications and experience as it relates to the project, and expected percent time contributed toward the project by individual team members
    c. If applicable, a description of any similar projects completed by a consulting firm with contact information for two references
    d. Three-page maximum (approach and methodology):
    Description of the proposed approach, including specific methodology and any assumptions. Please include specifics for: time in the field, geotechnical work, and survey work
3. Separate sealed Project Budget Worksheet
4. Contact information
5. Conflicts of interest (see below)

PROJECT PROPOSAL DUE DATE: Thursday, November 17, 2022 at 4:30 pm

Please submit electronic copies of proposals to Daniel Mock at: dmock@minnehahacreek.org
Hard copies are not required but can be mailed to 15320 Minnetonka Blvd, Minnetonka, MN 55345

INFORMATIONAL MEETING:

An informational meeting will be held on **Monday, October 31, 2022, at 10:00 AM** (15320 Minnetonka Blvd, Minnetonka, MN 55345) to answer any questions about the project or process. At this time, MCWD staff will present a summary of the project and will provide a description of the desired products to any CONSULTANT interested. **Please RSVP** and submit any questions via email in advance of the meeting to dmock@minnehahacreek.org

PROPOSAL EVALUATION PROCEDURE:

All feasibility studies will be subject to competitive evaluation in this order:

1. SME will be evaluated according to the criteria (below) by a committee of MCWD staff.
2. Cost estimates will be opened and evaluated.

    a. The total project cost will be considered
    b. Cost per hour will be considered
3. Committee will weigh methodology and experience at 70 to 80% and cost at 20 to 30%.
4. The proposal with the best-combined evaluation will be recommended for approval by the Board of Managers.

CRITERIA:

Methodology

- *Project Understanding*: Does the proposal make it clear that the consultant fully understands the project's scope, goals, and technical requirements?
- *Completeness and Specificity*: How fully does the proposal explain what the consultant will do to develop the required deliverables?
- *Identification of Needs*: Does the proposal carefully consider what resources will be required to complete the tasks, including staff time, additional technical information, etc.?
- *Innovation*: Does the approach incorporate modern or cutting-edge techniques and analysis consistent with a technically sound product, where appropriate and requested in the RFP?

Experience

- *Company Experience*: What other similar projects has the consultant performed that are directly related to the proposed work (evaluated via the proposer's submittal materials)?
- *Staff Experience*: What qualifications and work experience do the proposed staff members or subcontractors bring to the project?
- *Area Knowledge*: Does the company or any of the project team have specific knowledge about the project area that would aid in the study?

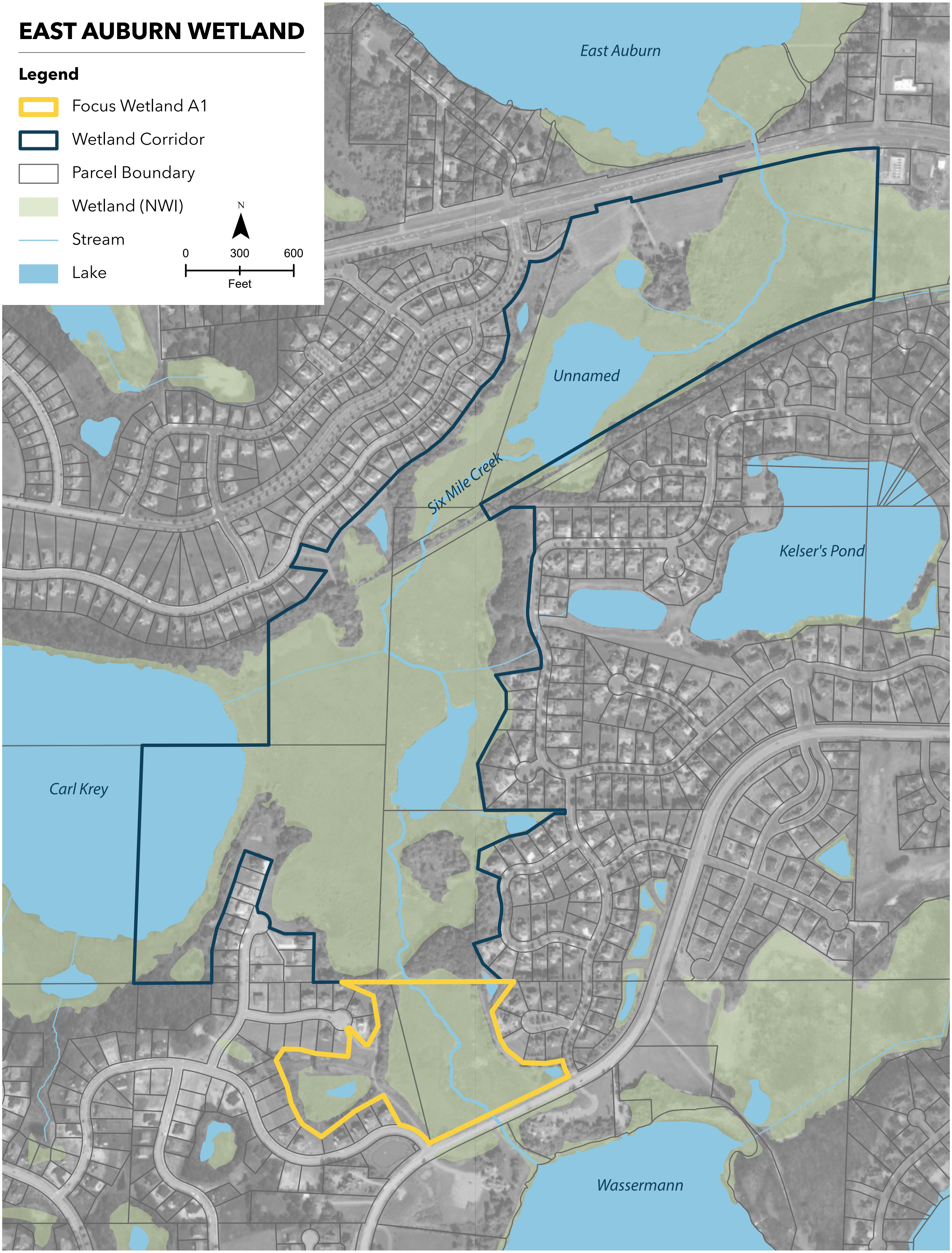
CONTRACTUAL AGREEMENT:

MCWD will execute a contract referencing the Scope of Work and Project Budget Worksheet submitted by the CONSULTANT. Payments will be issued in hourly payments upon certification of completion of identified tasks. The payment schedule can be negotiated and finalized through the contract after the selection of a CONSULTANT by MCWD.

CONFLICT OF INTEREST:

It is the Policy of the MCWD that the CONSULTANT may not simultaneously represent governmental jurisdictions fully or partially located within the DISTRICT without prior written approval from the District Administrator. Any existing or anticipated future conflicts of interest must be identified in the proposal submitted by the CONSULTANT.

Please direct any questions to Daniel Mock at 952-471-0590 or dmock@minnehahacreek.org. Answers to all questions (emailed and meeting questions) will be distributed to each of the firms receiving this RFP.


EAST AUBURN WETLAND
Legend
Focus Wetland A1
Wetland Corridor
Parcel Boundary
Wetland (NWI)
Stream
Lake
N
0
300
600
Feet
East Auburn
Unnamed
Six Mile Creek
Kelser's Pond
Carl Krey
Wassermann

Technical Memo

WENCK

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To: Brian Beck, MCWD

From: Wes Boll, Wenck Associates, Inc.

Date: December 4, 2019

Subject: East Auburn Wetland Assessment

Introduction

Wenck was contracted by MCWD to assess the wetland basin identified as "East Auburn Wetland" by MCWD (See Figure 1). The East Auburn Wetland, which is located along Six Mile Creek between Wasserman Lake and Lake Auburn, was identified as a potential location for a restoration or water quality improvement project by MCWD. Wenck's specific tasks in this assessment are to summarize the previously completed off-site assessment of existing and historical wetland conditions, assess the hydrology and vegetation of the wetland to supplement MCWD's assessment of the nutrient cycling and feasibility of a project in this location.

This memo provides a summary of the assessment of the existing hydrology of the site and the characterization of existing vegetation communities on the site.

Methodology

The scope of work for this assessment included the desktop review of available information that was completed in an earlier project (aerial photographs, LIDAR, NWI, soil survey, MCWD Functional Assessment of Wetlands (FAW)/McRAM). The scope of work also included the installation of monitoring wells, the assessment of data collected in the wells, and a field vegetation assessment.

Results

<u>Off-Site Information Review</u>
Review of aerial photographs, soil survey, and NWI that was conducted as part of a previous investigation indicates that the wetland complex contains a shallow open water basin fringed by shallow/deep marsh with shallow marsh and shrub swamp communities present in the eastern portion of the wetland. Six Mile Creek flows through the wetland and a constructed ditch draining to the creek channel from the east was also observed in aerial photographs dating back to 1963. It also appears that the natural Six Mile Creek channel was historically straightened or altered through this reach. Other disturbances observed on aerial photographs include what appears to be constructed crossings and fill along the northeast edge of the wetland. Aerial photographs from the previous investigation on the site are in Appendix A.

The wetland appears to have been a drier hydrologic regime (wet meadow) in 1940. It appears that the wetland shifted to a wetter hydrologic regime (shallow marsh) during the time period from 1940 to 1963, which corresponds to water levels also apparently increasing in Lake Auburn to the north. It is possible that this apparent change was due to climactic conditions or a change to water level controls in Lake Auburn downstream that may have occurred during this time period. The hydrology conditions do not appear to have changed significantly from 1963 to the existing conditions, as surface water is observed in ditches to a similar extent in aerial photographs from 1963 to 2016. It does not appear that Six Mile Creek or the constructed ditch significantly altered the hydrology of the wetland or converted it to non-wetland historically, based on review of aerial photographs.

The MCWD FAW identified the vegetation communities in the wetland as low quality.

Based on the observations of wetland signatures and vegetation communities in aerial photographs, it does not appear that the existing wetland extent or hydrologic regime is significantly different from what was present dating back to 1963. However, it is likely that the ditching present in the wetland has resulted in some minor alterations to hydrology and how water flows through the wetland, which could have potentially contributed to the degradation of some wetland functions and the quality of the vegetation community.

Hydrology

Wenck and MCWD staff installed two monitoring wells on August 7, 2019 (see locations in Figure 2). MCWD staff installed pressure transducers to collect continuous water level data at these two locations from mid-August to early October 2019. While this is typically the driest portion of the growing season, when water levels would be expected to be lower, precipitation was above average during nearly the entire monitoring period in 2019.

Water surface elevations at the two monitored locations and elevations of other site features are shown in Exhibit 1. For the purposes of this assessment, the water surface elevation data is used to assess the hydrologic regime of the wetland in order to determine the extent and duration of wetland hydrology in the wetland and whether the hydrology appears to have been altered. Water surface elevations were observed to be approximately 0.7 ft higher at the upstream end of the wetland (CSI19).

The elevation of the culverts upstream and downstream of the wetland were also surveyed and the elevation of the downstream culvert is shown in Exhibit 1. The elevation of the downstream culvert (940.2 ft) is approximately 1.5 feet to 2 feet lower than the water levels observed at the downstream end of the wetland. Based on the observations of hydrology in 2019, this indicates that hydrology in the wetland is not significantly affected by the ditch through the wetland, as the ditch is not capable of removing hydrology if water levels in the ditch are similar to the adjacent wetland and higher than the ditch bottom. The observation of water levels that are consistently higher than the outlet also may be an indication that water levels in Lake Auburn downstream influence water levels in the wetland under most conditions.

Data from the monitoring location at the upstream end of the wetland (CSI19) demonstrates that water levels were near or above the observed ground surface of the adjacent wetland for the entire time the wetland was monitored.

Data from the downstream end of the wetland (CSI05) demonstrates that a slightly wetter hydrologic regime is present as water levels were above the ground surface (to a depth of approximately 0.75 feet) for the entire monitored period.

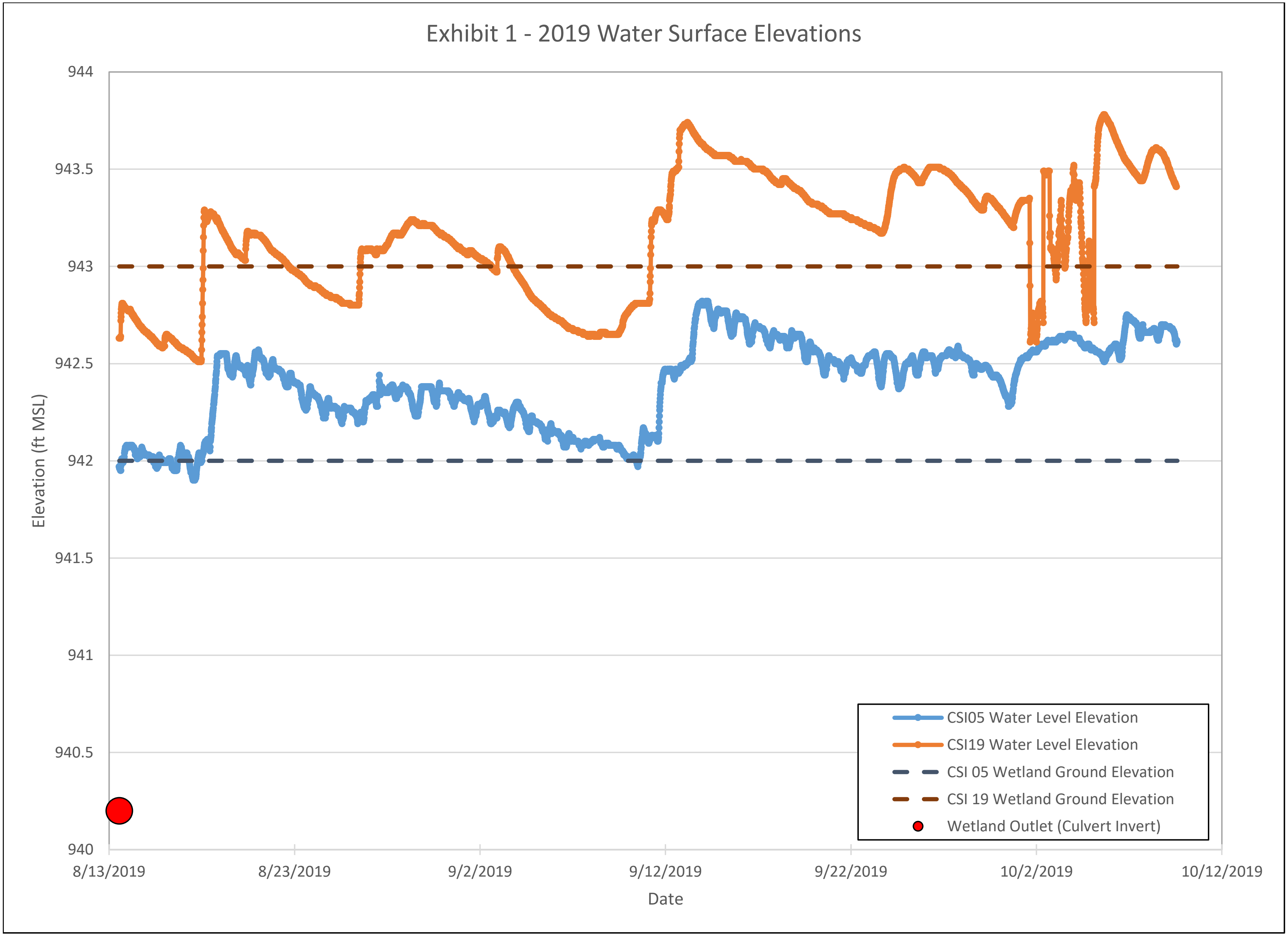


Exhibit 1 - 2019 Water Surface Elevations
Elevation (ft MSL)
944
943.5
943
942.5
942
941.5
941
940.5
940
8/13/2019
8/23/2019
9/2/2019
9/12/2019
9/22/2019
10/2/2019
10/12/2019
Date
CSI05 Water Level Elevation
CSI19 Water Level Elevation
CSI 05 Wetland Ground Elevation
CSI 19 Wetland Ground Elevation
Wetland Outlet (Culvert Invert)

The hydrologic regime demonstrated by the monitoring data is typical for the shallow marsh vegetation community that comprises the majority of the wetland. The observation that water levels remain relatively stable and do not fluctuate significantly in a short period of time also demonstrates that wetland hydrology is not removed or significantly altered by the ditch. Options to raise water level elevations higher than they are under the existing condition in the wetland would be limited by the adjacent properties to the northeast that have buildings near the existing wetland and water level elevations.

Vegetation

Wenck and MCWD staff completed an assessment of the vegetation communities in the wetland on August 28, 2019. Since access to the entire wetland was not possible, observations were made from trails and other access points on the perimeter of the wetland. Figure 3 shows the estimated boundaries of the different vegetation communities observed in the wetland. Overall, the wetland communities were determined to be dominated by invasive narrow leaf cattail, phragmites, and reed canary grass. The list of species observed in the wetland communities is shown in Table 1. As demonstrated by this table, several native species were observed at low densities in each wetland vegetation community.

As demonstrated by Figure 3, the majority of the wetland is a shallow marsh that is dominated by invasive cattail, with several other species present at low densities. Pockets of shrub swamp/floodplain forest with more diversity of native species were observed along the northern and southern edge of the wetland. Invasive buckthorn was also observed to be prevalent in this community. A wet meadow community was observed along the northern edge of the wetland. The wet meadow was dominated by reed canary grass, with several native species present in low densities. The western portion of wetland complex contains a shallow open water basin fringed with invasive cattail and phragmites. The monitoring well data demonstrates that the hydrology of the wetland is similar to what would be expected in the vegetation communities observed on the site.

Since it was determined that the wetland was dominated by invasive cover (>90% cover) and a meandering survey was not conducted, a complete RFQA survey was not completed. Based on the observation and assessment of vegetation communities from available access points, the vegetation communities currently present in the wetland would score in the lowest category of the RFQA and are low in quality, as previously characterized by the MCWD FAW.

Table 1 – Observed Species in Wetland Vegetation Communities

Wet Meadow	Shallow Marsh	Shrub Swamp/ Floodplain Forest	Shallow Open Water
Reed canary grass	Reed canary grass	Basswood	Duckweed
Lake sedge	Phragmites	Green ash	Water lily
Blue joint	Cattail	American elm	Arrowhead
Bugleweed	Softstem bulrush	Boxelder	Cattail
Boneset	Hemlock	Buckthorn	Phragmites
Verbena	Woolgrass	Dogwood	
Phragmites		Silver maple	
Jewelweed		Sensitive fern	
Joe pye		Hog peanut	
Smartweed		Grapevine	
Equisetum			
Rice cut grass			

Conclusion

Assessment of the East Auburn Wetland was conducted to document existing hydrologic conditions and vegetation community composition and condition to guide the feasibility evaluation of potential improvement projects by MCWD.

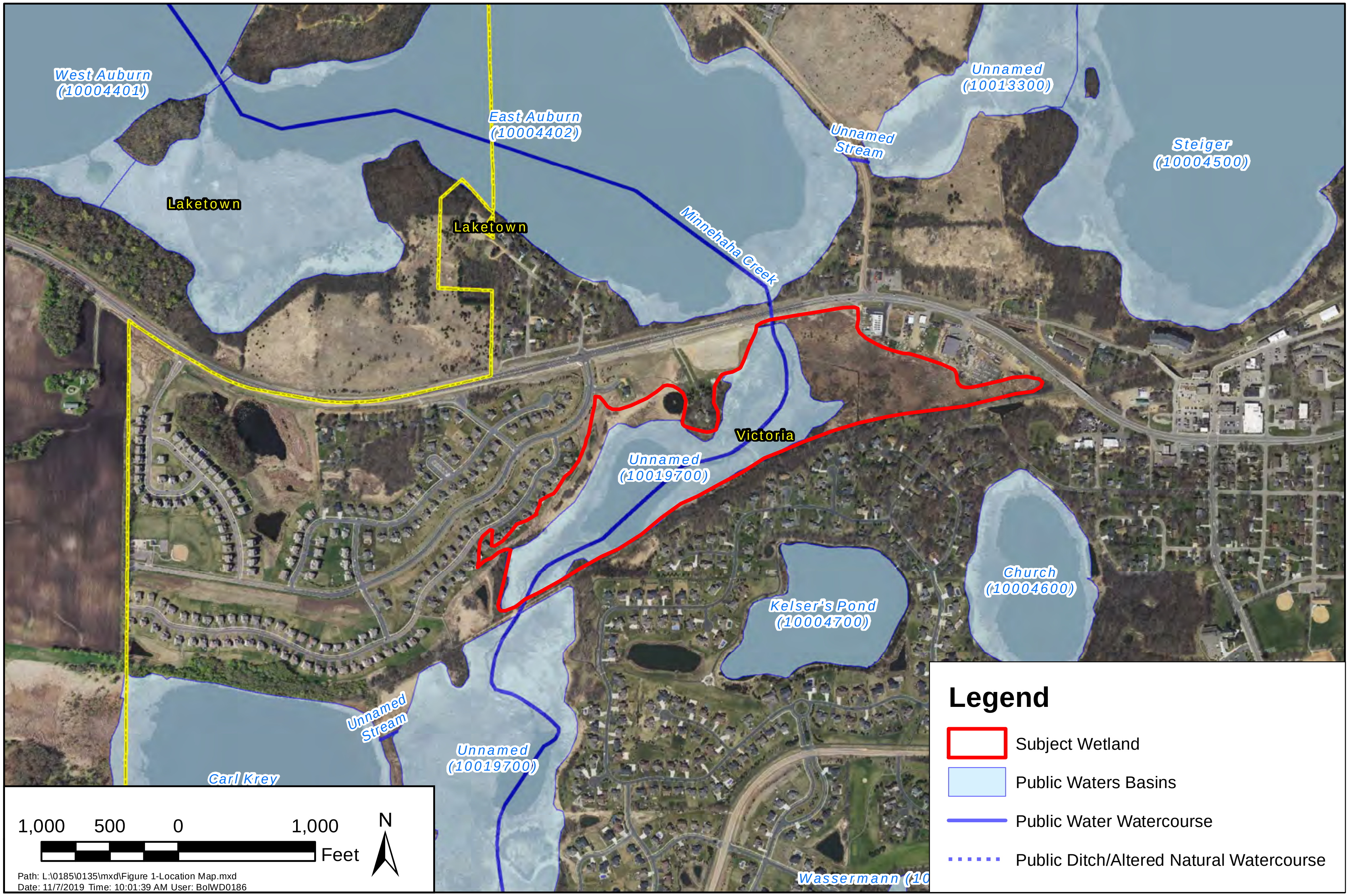
Hydrology monitoring data demonstrates that the hydrologic regime in the wetland meets wetland hydrology criteria and also matches what would be expected for the vegetation communities observed in the wetland. The monitoring data and survey information also indicates that water levels in the wetland are likely influenced by downstream water bodies. Assessment of this data indicates that wetland hydrology is not significantly altered by the ditches in the wetland. Options to manipulate water levels in the wetland by altering the outlet control of the wetland would likely be limited by the elevations of adjacent properties that are near the existing water levels in the wetland. Other potential methods of restoring wetland functions without manipulating water levels may be possible on the site, but additional investigation would be needed to ensure that the proposed methods would meet regulatory requirements and not cause issues on adjacent properties.

The assessment of vegetation communities in the wetland identified several types of wetland communities. The assessment also confirms earlier observations that the communities are dominated by invasive species with low densities of favorable native species. Management and improvement of the vegetation communities would be difficult and costly due to the high density of invasives and lack of ability to manipulate water levels in the wetland.

Attachments:

1. Figure 1 – Site Location Map
2. Figure 2 – National Wetland Inventory
3. Figure 3 – MCWD McRAM
4. Exhibit 1 – 2019 Continuous Water Level Elevation Data
5. Appendix A – Historical Aerial Photographs

Figures



MCWD

East Auburn Wetland Location

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OCT 2019

Figure 1

MCWD

Monitoring Well Locations

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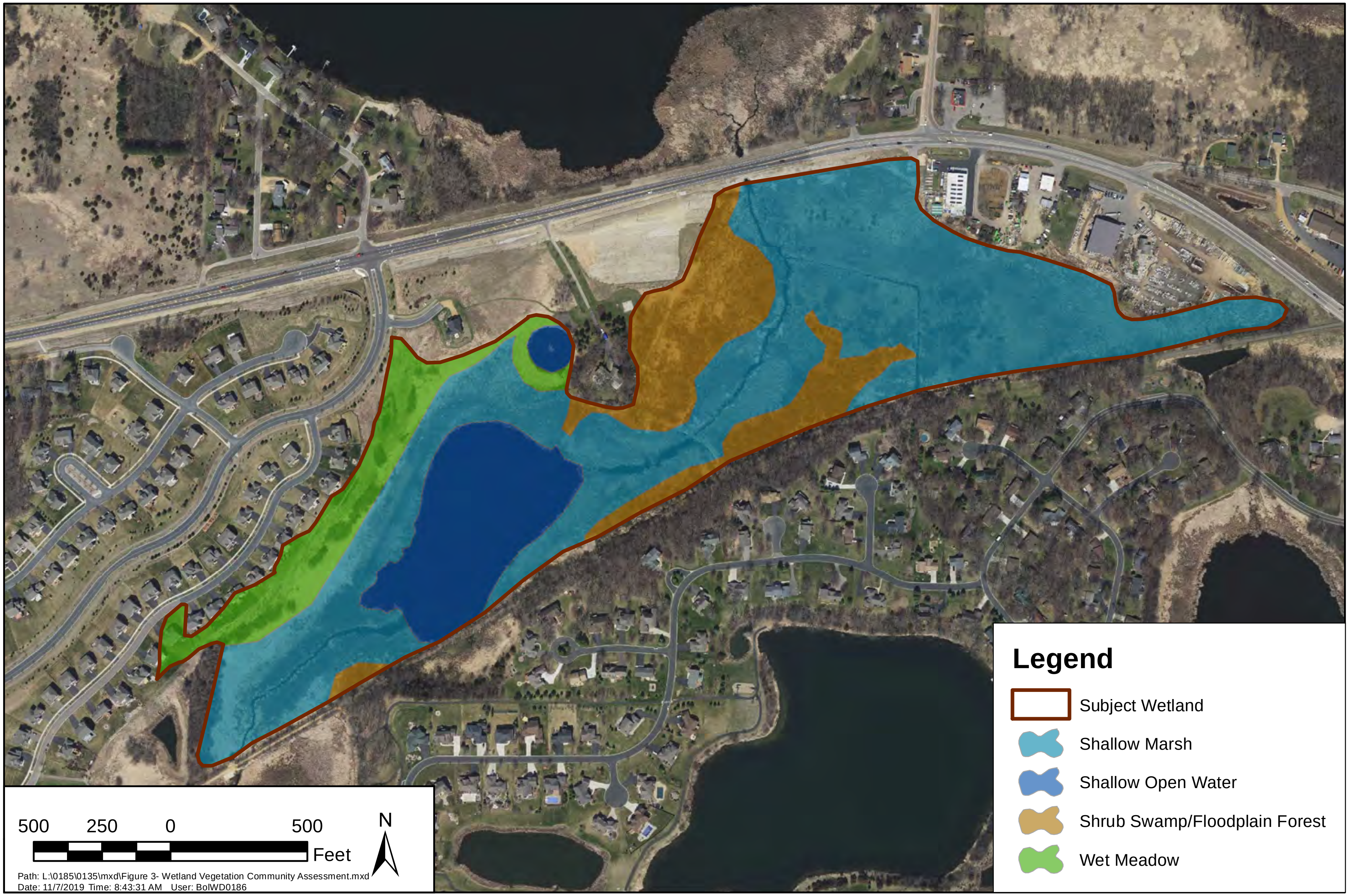
Figure 2



MCWD	WENCK Responsive partner. Exceptional outcomes.	OCT 2019
East Auburn Wetland Vegetation Communities		Figure 3

Appendix A

Historical Aerial Photographs

1937 Aerial Photograph (Source: MHAPO)

N

650 325 0 650 Feet

Legend

East Auburn Wetland Sites

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MINNEHAHA CREEK WATERSHED DISTRICT

Wetland 2 Historical Aerials - 1937

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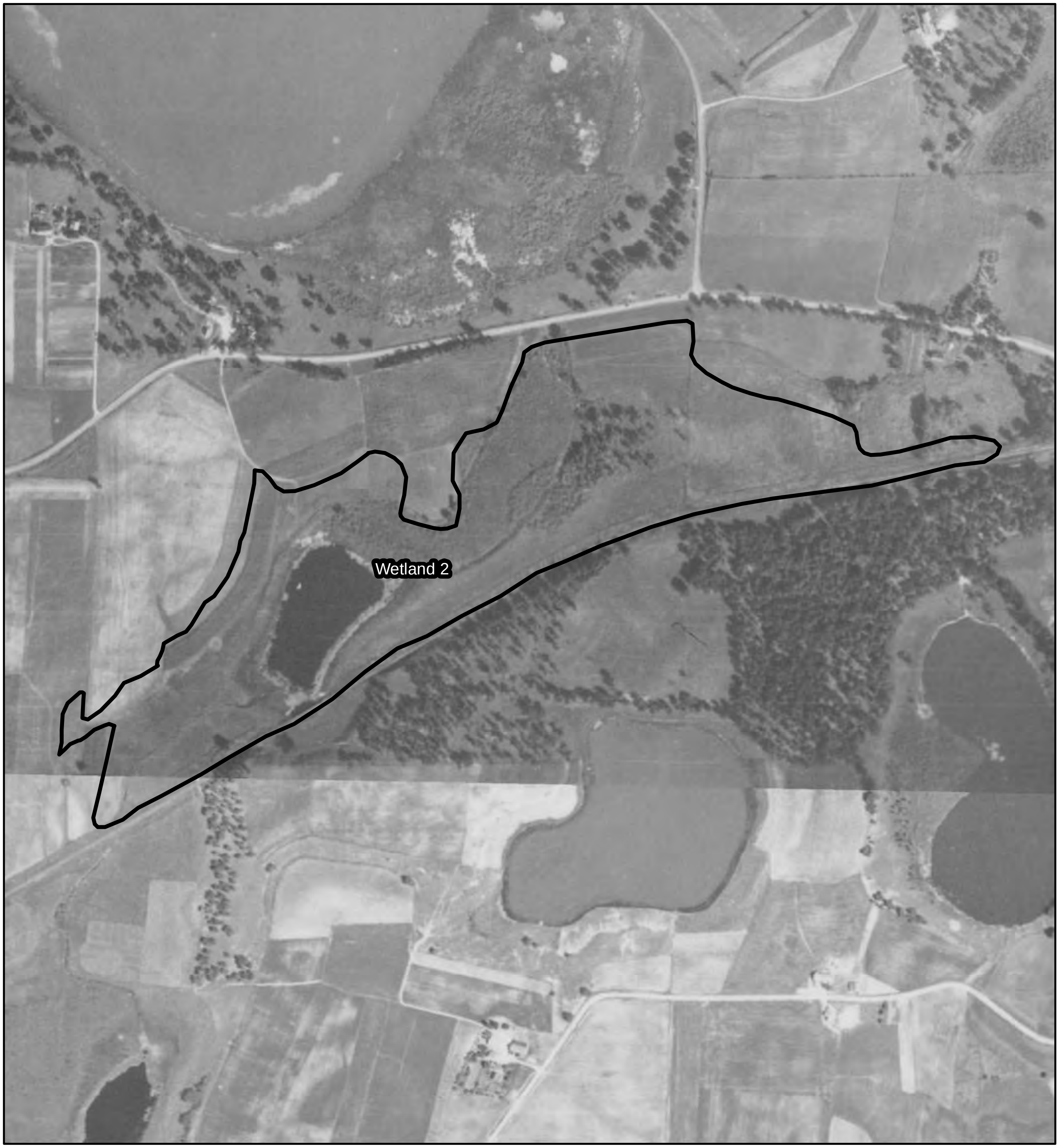
APP A



1940 Aerial Photograph (Source: MHAPO)

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East Auburn Wetland Sites

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MINNEHAHA CREEK WATERSHED DISTRICT	WENCK Responsive partner. Exceptional outcomes.	FEB 2019
Wetland 2 Historical Aerials - 1940		APP A

1963 Aerial Photograph (Source: MHAPO)

N

650 325 0 650

Feet

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Legend

East Auburn Wetland Sites

MINNEHAHA CREEK WATERSHED DISTRICT

Wetland 2 Historical Aerials - 1963

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FEB 2019

APP A

1979 Aerial Photograph (Source: FSA)

N

650 325 0 650
Feet

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Legend

East Auburn Wetland Sites

MINNEHAHA CREEK WATERSHED DISTRICT

Wetland 2 Historical Aerials - 1979

WENCK
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FEB 2019

APP A

1985 Aerial Photograph (Source: FSA)

N

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Feet

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Legend

East Auburn Wetland Sites

MINNEHAHA CREEK WATERSHED DISTRICT	WENCK Responsive partner. Exceptional outcomes.	FEB 2019
Wetland 2 Historical Aerials - 1985		APP A

1991 Aerial Photograph (Source: MN GEO)

N

650 325 0 650 Feet

Legend

East Auburn Wetland Sites

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Date: 2/19/2019 Time: 9:11:18 AM User: WatME0697

MINNEHAHA CREEK WATERSHED DISTRICT

Wetland 2 Historical Aerials - 1991

WENCK
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FEB 2019

APP A

2000 Aerial Photograph (Source: MN GEO)

N

650 325 0 650 Feet

Legend

East Auburn Wetland Sites

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Date: 2/19/2019 Time: 9:11:55 AM User: WatME0697

MINNEHAHA CREEK WATERSHED DISTRICT

Wetland 2 Historical Aerials - 2000

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FEB 2019

APP A

2010 Aerial Photograph (Source: MN GEO)

N

650 325 0 650 Feet

Legend

East Auburn Wetland Sites

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Date: 2/19/2019 Time: 9:12:22 AM User: WatME0697

MINNEHAHA CREEK WATERSHED DISTRICT

Wetland 2 Historical Aerials - 2010

WENCK
Responsive partner. Exceptional outcomes.

FEB 2019

APP A

2016 Aerial Photograph (Source: MN GEO)

N

650 325 0 650

Feet

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Date: 2/19/2019 Time: 9:13:01 AM User: WatME0697

Legend

East Auburn Wetland Sites

MINNEHAHA CREEK WATERSHED DISTRICT

Wetland 2 Historical Aerials - 2016

WENCK

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FEB 2019

APP A

TECHNICAL MEMORANDUM

To: Anna Brown

From: Brian Beck

Date: November 18, 2019

Re: East Auburn Wetland Phosphorus Analysis

Purpose:

The purpose of this evaluation is to determine if the wetlands located between Wasserman Lake and East Auburn Lake (Auburn Wetland) are acting as a source of phosphorus. Furthermore, we want to develop a better understanding phosphorus release from specific areas within the wetland. Ultimately, phosphorus export information will inform potential management actions and land acquisitions.

Water Quality Analysis:

Minnehaha Creek Watershed District (MCWD) has historic water quality and flow data from upstream and downstream of the Auburn Wetland, which provides information about phosphorus cycling and hydrology (Figure 1). We primarily focus on dissolved phosphorus since it is typically the best metric for characterizing phosphorus export in wetlands. Particulate phosphorus concentrations can also be used to determine if more phosphorus is being captured or released by a wetland.

Typically, the first cut analysis is to determine if total phosphorus concentrations increase between the inlet and outlet of the Auburn wetland due to phosphorus release from wetland sediments. Total phosphorus concentrations at the outlet of the wetland are higher than the inlet, which indicate that the East Auburn Wetland is exporting phosphorus (Figure 2). Separating dissolved and particulate phosphorus show that the Auburn Wetland is exporting dissolved phosphorus, but has little impact on particulate phosphorus (Figure 2).

Figure 1. Overview of wetland complex located between Wasserman Lake and Auburn Lake. Yellow points represent historic monitoring locations and the brown monitoring point represents a monitoring location added in 2019.

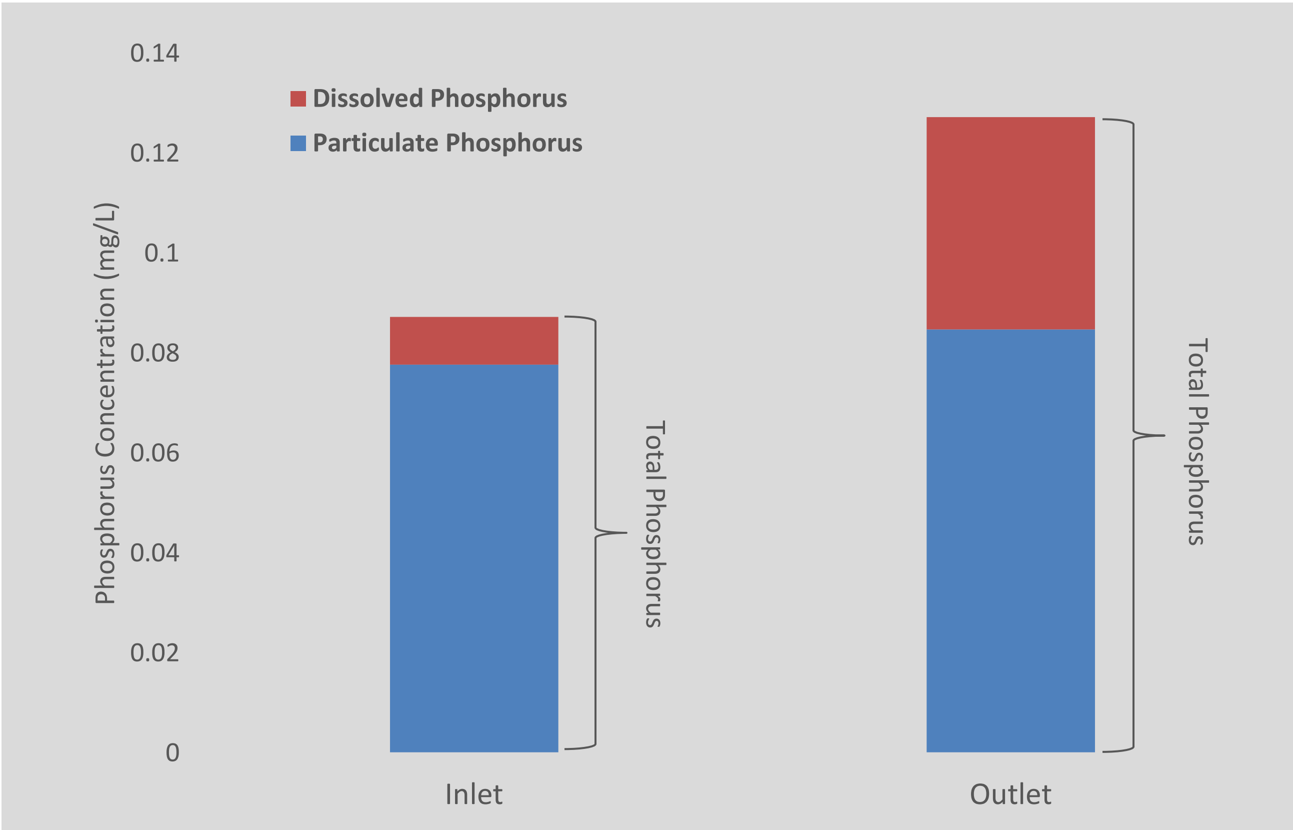


Figure 2. Total (blue) and dissolved (red) phosphorus concentrations at the inlet (left) and outlet (right) of the Auburn Wetland.

An initial assessment of the data clearly shows that the Auburn Wetland is exporting dissolved phosphorus. A secondary method to confirm wetland phosphorus export is characterizing seasonal dissolved phosphorus concentrations at the inlet and outlet of the wetland. Generally, microbial activity within wetland soils is the primary driver of legacy phosphorus export in wetlands. Microbial activity is typically regulated by temperature assuming all other factors are equal. Therefore, we would expect that phosphorus export in a wetland would be elevated during warm summer months and suppressed during cooler spring and winter months. The seasonal dissolved phosphorus concentrations further support the concept that the East Auburn Wetland is exporting phosphorus since the months with the greatest increase in dissolved phosphorus coincide with warmer summer months (June, July, August, and September; Figure 3).

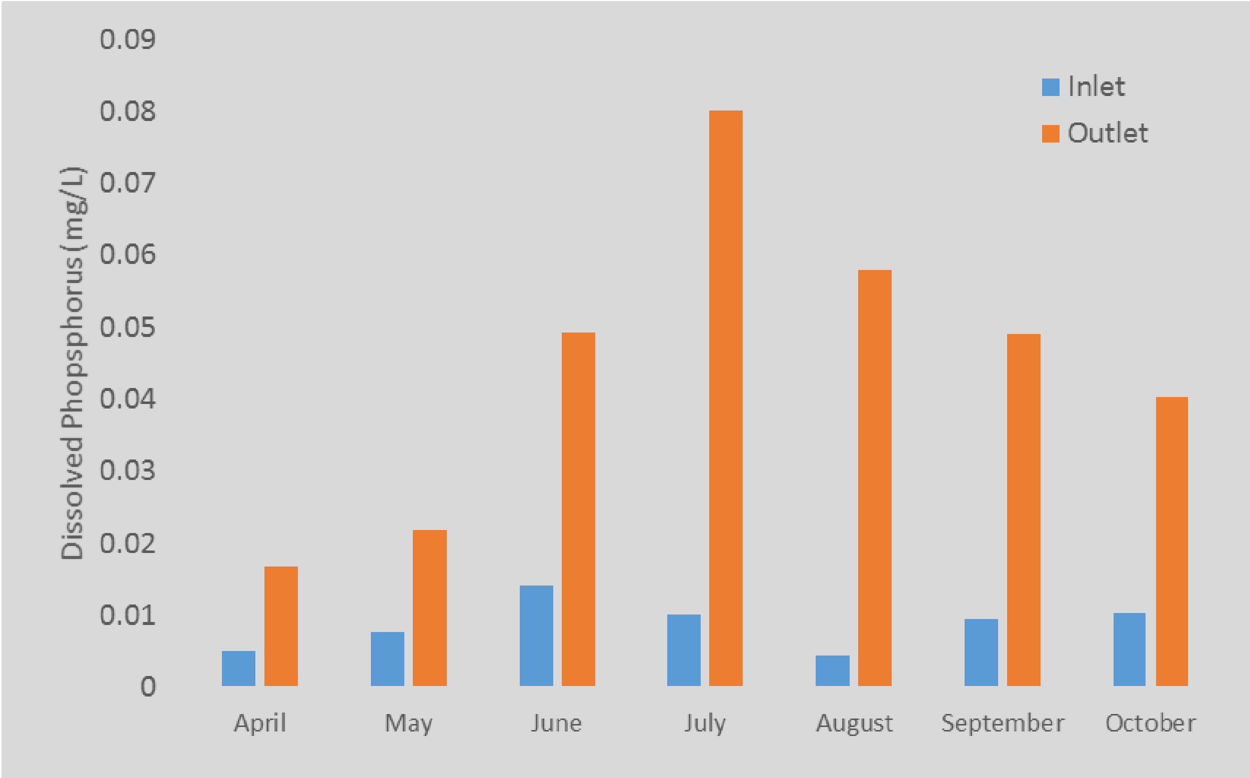


Figure 3. Monthly inlet and outlet phosphorus concentrations measured in the Auburn Wetland.

Quantifying the phosphorus load is a critical next step because concentration does not tell the entire story. We also need to characterize dissolved phosphorus load from the Auburn Wetland, which represents the mass of phosphorus that is impacting downstream water bodies (Figure 4). Based on this analysis the Auburn Wetland exports 135 pounds of dissolved phosphorus per year to East Auburn Lake.

We can put the Auburn Wetland phosphorus export in context of the total phosphorus load reductions necessary to meet water quality standards. The phosphorus watershed load reductions necessary to meet water quality standards are 341 pounds of phosphorus per year (Wenck, 2013). Therefore, we have the potential to meet nearly half of the total watershed phosphorus load reduction for East Auburn Lake by reducing the phosphorus export from the Auburn Wetland.

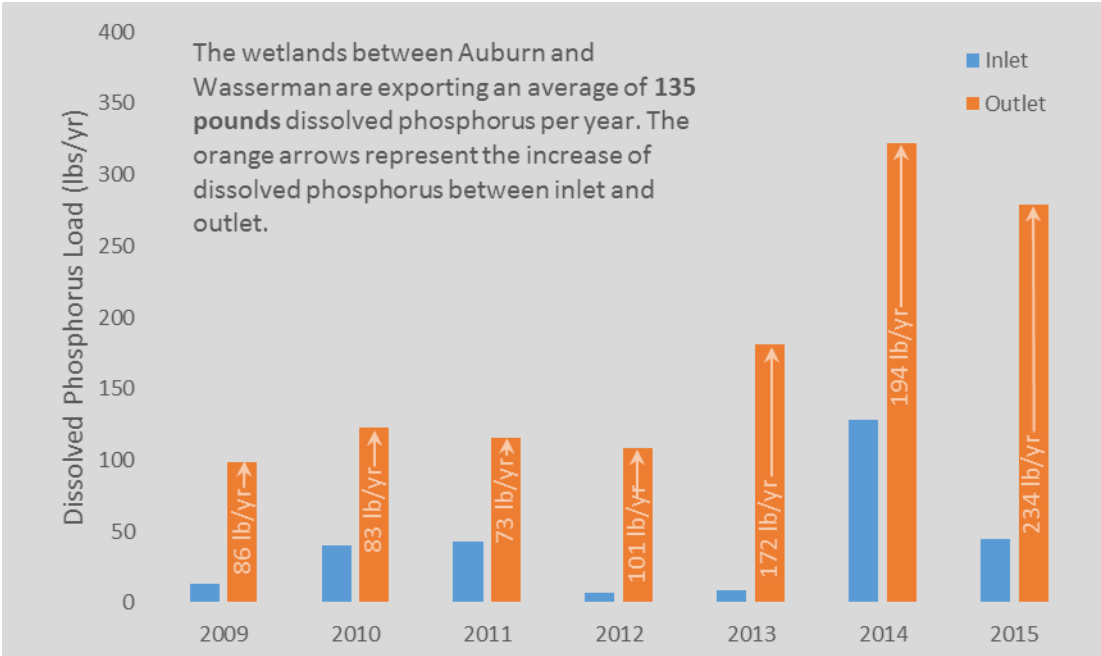


Figure 4. Dissolved phosphorus loading at the inlet (blue) and the outlet (orange) of the Auburn Wetland. The light orange arrows and loading numbers represent the net dissolved phosphorus release from the Auburn Wetland, which can be attributed to phosphorus release from sediments.

In 2019, water quality samples were collected at the inlet, midpoint, and outlet of the East Auburn Wetland to identify if the upstream or downstream wetland locations have a disproportionately large impact phosphorus export in the East Auburn Wetland (Figure 1).

Water quality samples collected in 2019 at the inlet, midpoint, and outlet of the East Auburn Wetland indicate that dissolved phosphorus concentrations increase by an order of magnitude (+600%) between the inlet of the wetland and the midpoint (Figure 5). Conversely, the average increase of dissolved phosphorus between the midpoint and outlet is relatively small (+20% increase).

These findings make sense in context of historic phosphorus loading from Wassermann Lake. Over the last century, Wassermann Lake has had poor water quality due to elevated watershed loading, which has exceeded Wassermann Lake's ability to assimilate the phosphorus. The excess phosphorus that Wassermann Lake could not assimilate was exported to the East Auburn Wetland.

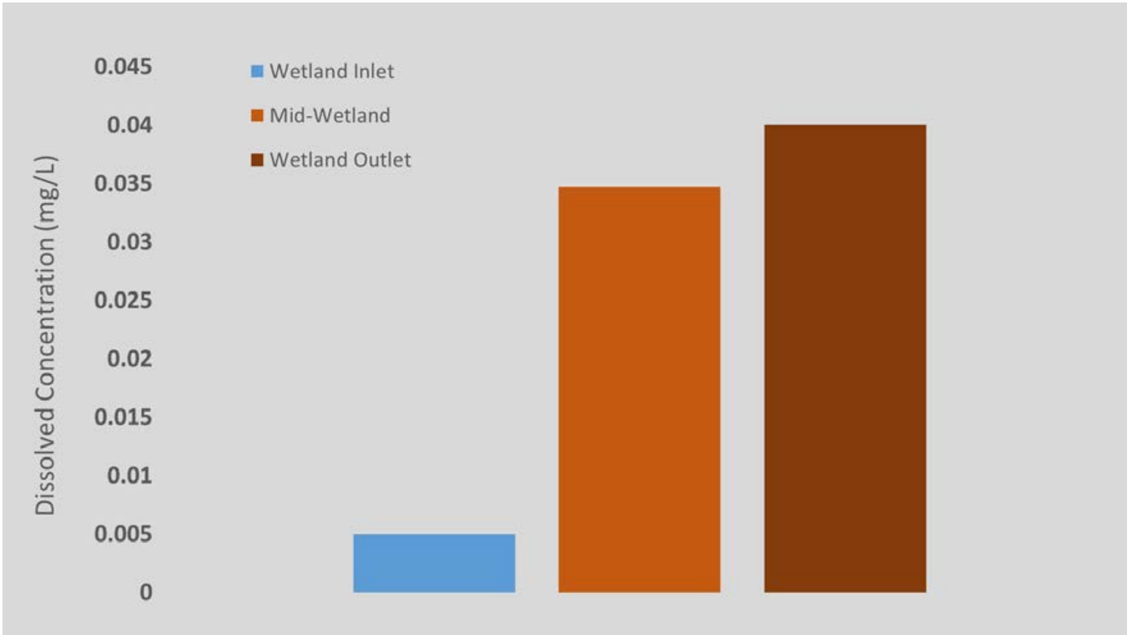


Figure 5. Dissolved phosphorus loading at the inlet (blue), midpoint (light orange), and outlet (dark orange) of the East Auburn Wetland.

Interestingly, the East Auburn Wetland is split into two cells by a trail, but is still hydrologically connected by a 36” culvert. Both wetland cells continue to remove phosphorus at a similar rate (Figure 6). However, the upstream cell has likely accumulated a greater amount of particulate phosphorus, which is driving greater phosphorus export (Figure 5).

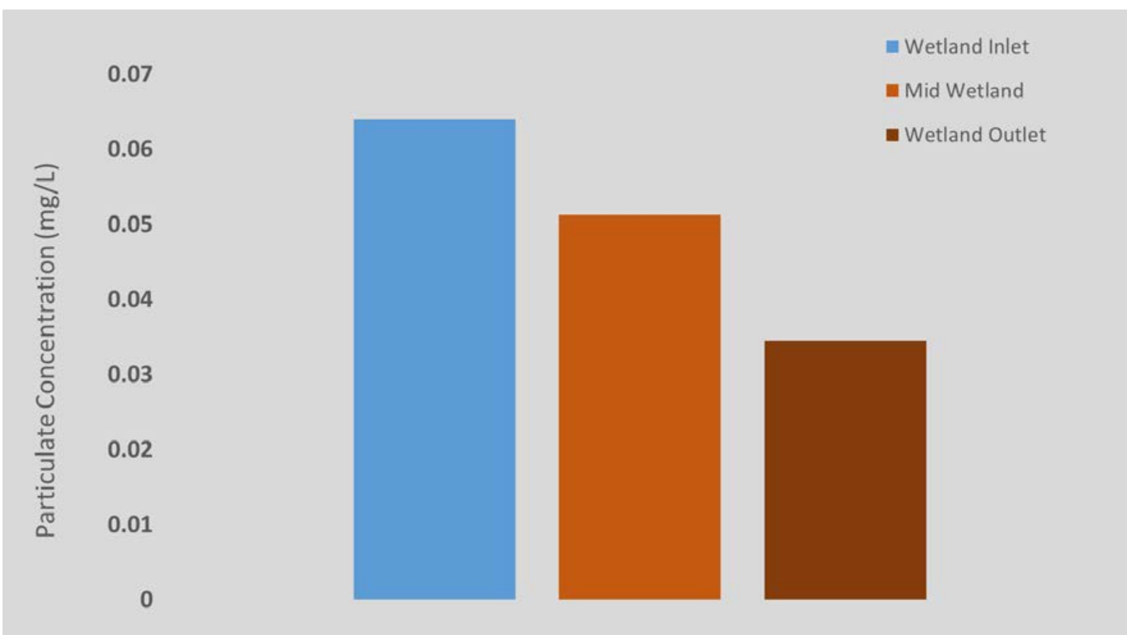


Figure 6. Particulate phosphorus loading at the inlet (blue), midpoint (light orange), and outlet (dark orange) of the East Auburn Wetland.

Conclusions

This analysis revealed several important details about the magnitude and location of phosphorus export within the East Auburn Wetland. These items include:

1. The annual load from the Auburn Wetland to East Auburn Lake is 135 pounds per year.
2. The Auburn Wetland is a source of total and dissolved phosphorus to East Auburn Lake.
    a. The upstream cell is responsible for the majority of phosphorus export in the East Auburn Wetland.
    b. Both cells remove particulate phosphorus at a similar rate, however, dissolved phosphorus release from the upstream wetland cell overwhelms the wetlands overall ability to remove phosphorus
3. The focus of water quality restoration should be on the upstream cell since it is the driver of phosphorus release from the wetland.

Stantec **Memo**

To:	Kailey Cermak, MCWD Brian Beck, MCWD Daniel Mock, MCWD Michael Hayman, MCWD	From:	Dendy Lofton, PhD, CLM Tom Beneke Joel Thompson, PG Erik Megow, PE Mike Holly, PhD, PE
Project/File:	227704313	Date:	October 13, 2022

Reference: Auburn Wetland Monitoring Project - Technical Memo

BACKGROUND

The Auburn wetland is located along Six Mile Creek between Wasserman Lake and Lake Auburn in Victoria, MN. The Minnehaha Creek Watershed District (MCWD) monitored water quality and flow in Six Mile Creek from upstream and downstream of the Auburn wetland system from 2009 through 2015. Data analysis indicated that the stream channel gained phosphorus from inlet to outlet serving as a potential phosphorus load to downstream Auburn Lake, which is impaired due to excess phosphorus. Through more refined monitoring, MCWD identified that the most upstream cell from the Wasserman Lake outlet to the boardwalk across from the Butternut Court is responsible for the majority of the phosphorus export from the wetland system. Stantec was contracted by MCWD to assist with development and execution of a targeted monitoring plan that would support future feasibility work. The scope of work included three primary tasks:

- Task 1 – Develop targeted monitoring plan
- Task 2 – Execute monitoring plan
- Task 3 – Evaluate engineering options

This technical memo describes the monitoring approach and results of the hydrology and water quality monitoring effort (Tasks 1 and 2). Stantec has provided conceptual engineering options (Task 3) that could mitigate phosphorus loads from the wetland to East Auburn Lake, which are shown in Appendix A.

WETLAND MONITORING APPROACH

To further understand the mechanism behind nutrient export from this portion of the wetland, additional monitoring needed to be conducted with the goal of addressing two primary questions:

1) Is phosphorus high in the wetland complex (soils, sediments, groundwater, channel water)?
2) If phosphorus is high in the wetland complex, then is it able to mobilize to the stream channel?

To answer the questions above, Stantec developed a targeted monitoring plan, which was reviewed and approved by MCWD in January 2022 (Stantec 2022). Details of the monitoring approach can be found in Stantec (2022) and are briefly described below.

The main elements of the monitoring approach included the following components:

- Installation of multilevel piezometers and collection of groundwater level measurements and water quality samples;
- Installation of stilling wells within Six Mile Creek and collections of surface water level measurements, and water quality samples; and
- In-channel sediment and wetland soil chemistry sampling.

WETLAND MONITORING METHODS

Fifteen multi-level nested piezometers were installed at the locations shown in Figure 1 to facilitate measurement of groundwater elevation and collection of water quality samples. Each nested location within the wetland complex consisted of 3 piezometers (surface, shallow and deep) installed at progressively deeper intervals. The surface, shallow and deep depths corresponded to 0-1 feet, 1-2 feet, and 4-5 feet below the surface. The piezometers were oriented in four east-west oriented transects across the wetland (perpendicular to the channel) to provide sufficient areal coverage to support characterization of site hydrology and characterize the horizontal and vertical distribution of phosphorus in groundwater and surface water. One piezometer location was located east of the wetland complex in the upland soils. The purpose of this piezometer was to monitor local groundwater elevations outside of the wetland complex and facilitate evaluation of the interaction between groundwater within upland soils groundwater within the wetland soils.

The deep piezometers were installed in December 2021 before the ground froze and the remaining infrastructure was installed in April/May 2022 once thawed conditions returned. Bog-like conditions at PZ-8 prevented installation of piezometer in that location so no data was collected from that location.

Four stilling wells were installed within the wetland channel of Six Mile Creek that bisects the Auburn Wetland. Stilling wells provided a stable location for measurement of surface water elevations to provide data to evaluate surface water/ groundwater interaction.

The piezometers and stilling wells were surveyed to document horizontal coordinates, elevations of ground surface and top of riser casing. Manual water level measurements were collected periodically from each of the piezometers and stilling wells following installation. In addition, pressure and temperature logging transducers were installed in PZ-7, PZ-9, PZ-10, PZ-11 (upland site) and S3 which is the stream channel site that lies within that transect perpendicular to the stream channel (Figure 1). The pressure transducers provided information on short-term variations in water levels and wetland hydraulics in response to precipitation events.

Data from the piezometers provided depth-specific measurements to support characterization of the vertical variability in phosphorus, geochemical environment, and vertical and horizontal components of groundwater flow while the stilling wells provided information regarding groundwater and surface water interactions.

Water samples were collected from the piezometers and surface water stilling wells to characterize phosphorus dynamics throughout the site. Total nitrogen, temperature, dissolved oxygen, and conductivity were also measured in each well and stream sample during each sampling event where possible. Stream and groundwater well samples were collected by MCWD and sent to RMB laboratory for analyses.

Groundwater elevations were monitored at the fifteen multi-level nested piezometers and surface water elevations were monitored at the four stilling wells within the wetland channel (Figure 1) to assess the areal and temporal variability of groundwater flow within the wetland. The primary hydrogeologic observation data collected consisted of continuously running pressure transducers installed in locations PZ-7, PZ-9, PZ-10, PZ-11 (upland site) and surface water channel location S3. The piezometer and surface water transducer data were used to monitor inundation and groundwater elevation dynamics throughout the monitoring period (approximately May 25, 2022 through September 6, 2022), which is discussed in the Results section.

Reference: Auburn Wetland Monitoring Project - Technical Memo

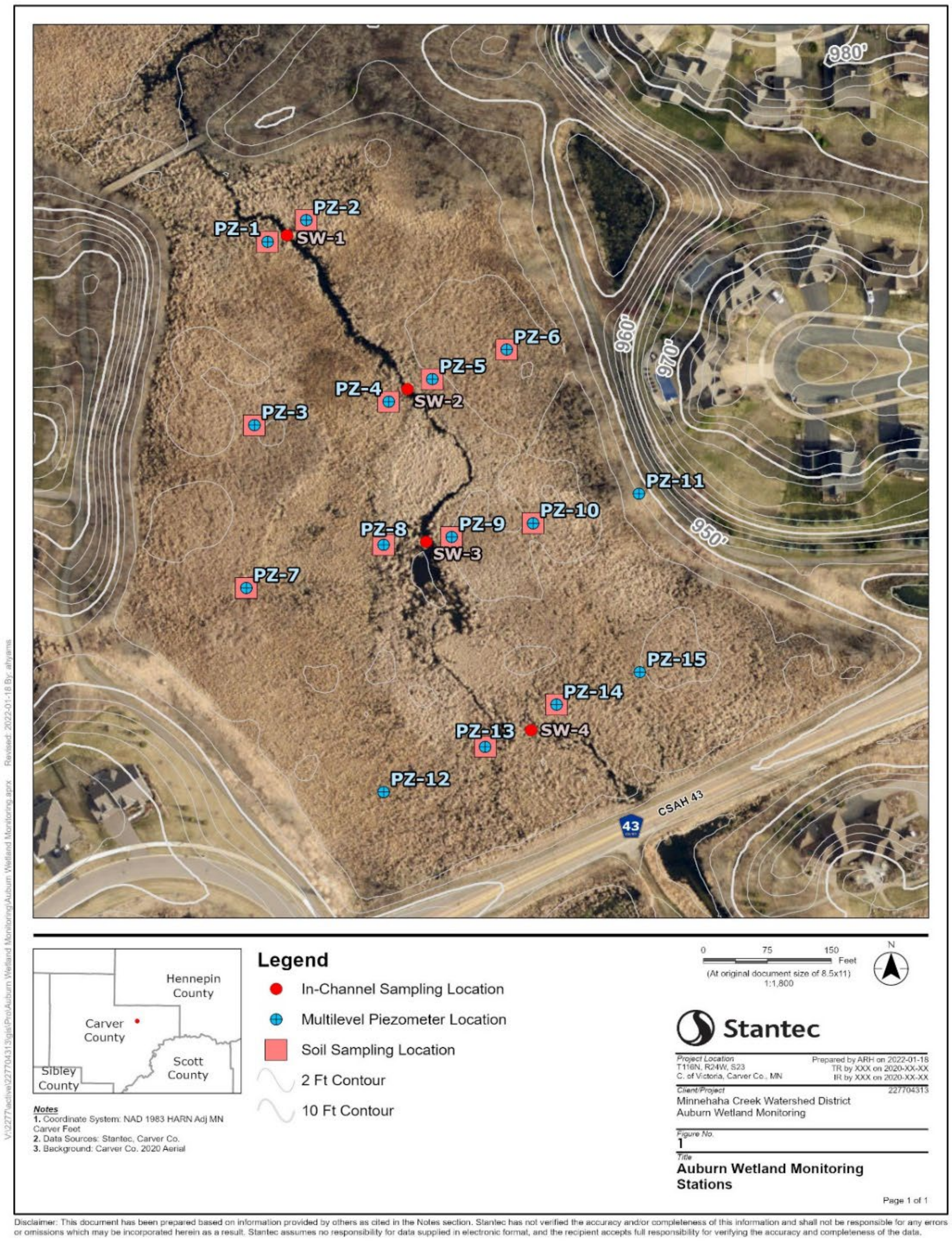


Figure 1. Monitoring locations within the Auburn wetland.

Soil and sediment samples were collected on August 1, 2022 for quantification of the phosphorus in the native soils and sediments. Sediments were collected from each of the four stream channel sites and near PZ-1, 2, 7, 9, 10. 12, 14, 14, and 15 according to the depths shown in Table 1.

Table 1. Sediment core depths by sample location.

Location	Sample Depth (below substrate surface)
Stream Channel	0-3 inches
Monitoring Wells (Surface)	0-1 feet
Monitoring Wells (Shallow)	1-2 feet
Monitoring Wells (Deep)	4-5 feet

Soil and sediment samples were delivered to the University of Wisconsin-Stout for phosphorus chemistry analyses. These analyses quantified the phosphorus into pools that are operationally defined as mobile and non-mobile phosphorus fractions (Table 2). The mobile phosphorus pool is more readily available for biological uptake and processing and has a higher likelihood of diffusion and transport due to its chemical composition. In contrast, the non-mobile pool is not readily available for biological uptake and processing because the chemical structure is more complex than the mobile pool of phosphorus. These chemistry data were evaluated with the hydrology data to assess the potential for phosphorus mobilization with groundwater across the wetland complex to the stream channel.

Table 2. Operational grouping and recycling potential of phosphorus fractions

Operational Grouping	P Fraction	Recycling Potential
Mobile P pool	Iron-bound P Loosely-bound P Labile organic P	Biologically-labile and may be recycling through biogeochemical and geochemical reactions
Permanent P pool	Aluminum-bound P Calcium-bound P Refractory organic P	Biologically-refractory and subject to burial

It is important to note that summer 2022 was a period of extreme drought in central Minnesota. In fact, flows ceased in the stream channel after early July which was accompanied by instances where some of the surface and shallow wells also dried up. However, the hydrological patterns and chemistry data that were collected provided useful information on the potential sources and pathways of phosphorus to the channel, which are discussed in the following section.

RESULTS

The following sections describe Stantec's observations in the hydrogeology and water quality data collected in the Auburn wetland complex.

Hydrogeological Observations

The hydrograph data indicated four distinct groundwater flow patterns over the monitoring period as described below. Figure 2 and Figure 3 are provided to visually support the following narrative.

The early monitoring period (late May through late June) is characterized by higher groundwater levels and inundation across much of the transect as indicated by water levels observed at surface locations PZ-7, PZ-9, and PZ-10 which monitor the surface soils and overland flow (Figure 2). During this period PZ-9 surface location water levels are nearly identical to the channel water level indicating that the surface water level is likely over the banks at this location. In general, groundwater flow is observed from the east and west and converging on the central channel within the wetlands as indicated by decreasing heads from PZ-10 to channel and from PZ-7 to the channel. Vertical hydraulic gradients within the nested piezometer sets are low as indicated by similar monitored groundwater elevations at each location.

During the late June to early July period, the channel surface water elevation drops below the groundwater elevation at all areas indicating that the channel stage has receded to within the banks of the channel and surface inundation recedes at piezometer locations PZ-7 and PZ-10 as indicated by the flat line transducer data indicating water levels that are below the transducer (Figure 2). Horizontal flow direction remains from the margins of the wetland toward the channel and vertical gradients within the nested piezometers remain low.

Early July to approximately August 6 is characterized by low rainfall and a relatively rapid decrease in water levels at PZ-7, PZ-10, and PZ-11 (Figure 2). By the end of this period, PZ-10 and PZ-7 are both below the creek elevation indicating a reversal, or partial reversal of groundwater flow direction towards the margins of the wetland. Downward vertical hydraulic gradients are observed to increase at PZ-9 during this period as evidenced by the increased difference between shallow and deep groundwater elevations.

Finally, the period between Early August and early September is characterized by higher precipitation that results in shifts the groundwater flow back from the margins of the wetland toward the channel.

As indicated above the highest flux of groundwater to the channel is anticipated to have occurred during the wetter period August 6 through early September as indicated by a higher hydraulic gradient from the margins of the wetland towards the channel and the lowest period of flux of groundwater to the channel is during the period from early July to early August when there was low precipitation and presumably high evapotranspiration (Figure 3).

Detailed hydrographs by monitoring well location are provided in Appendix B.

Reference: Auburn Wetland Monitoring Project - Technical Memo

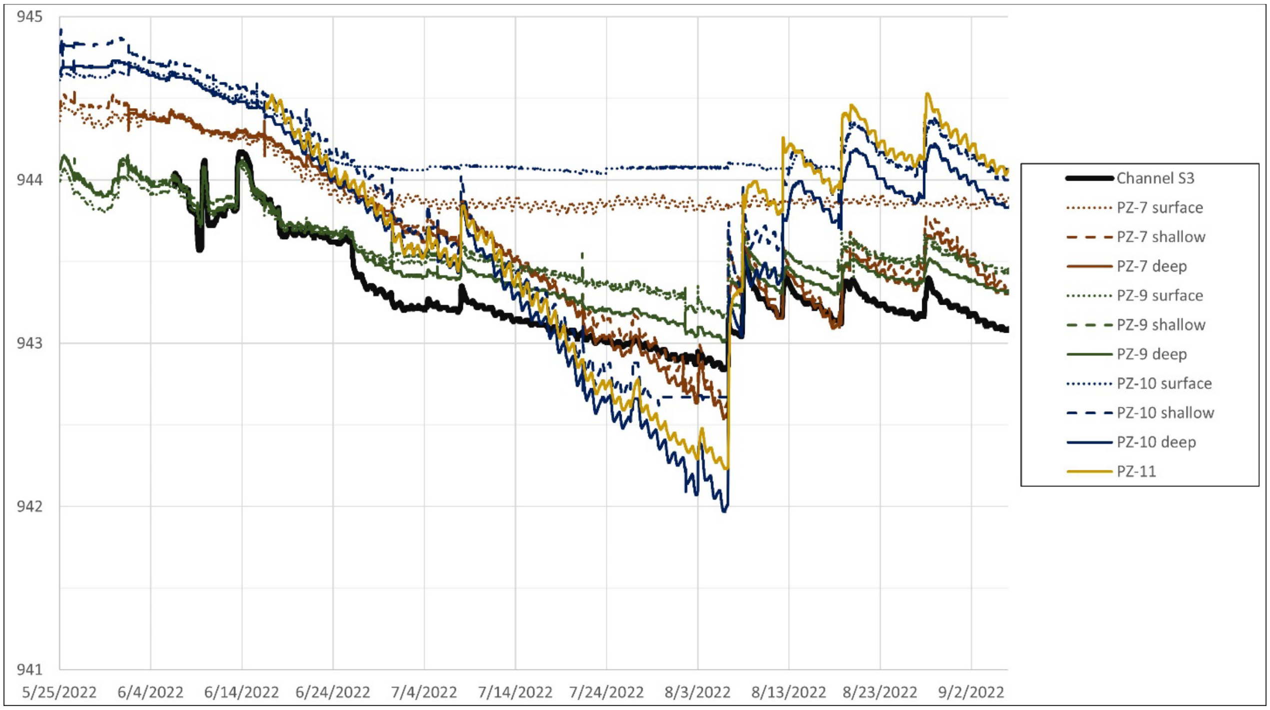


Figure 2. Hydrograph showing groundwater and surface water elevations during continuous monitoring.

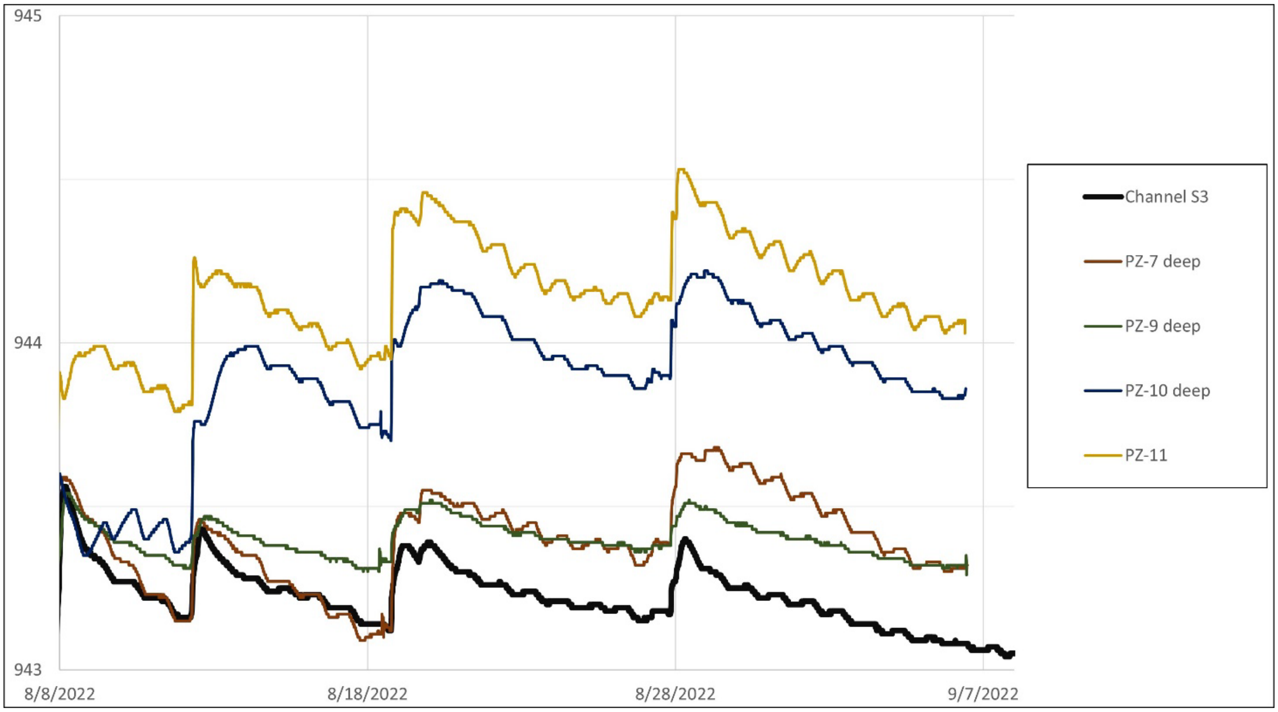


Figure 3. Hydrograph showing groundwater and surface water elevations during period from August 8, 2022 through September 8, 2022. Lateral flow within the subsurface groundwater is inferred to be from the margins of the wetland toward the channel as exhibited by water elevation decreasing from upland (PZ-11) to mid-wetland (PZ-10 and PZ-7) to near channel wetland (PZ-9) to channel (S-3).

Water Quality Results

Stream channel and groundwater monitoring well phosphorus concentrations were evaluated both temporally and spatially. Median groundwater total phosphorus concentrations (0.28 mg/L) are approximately 4.5 times higher than median surface water concentrations (0.06 mg/L) in the stream channel, presenting groundwater as a potential source of phosphorus to the stream channel (Figure 4). Substantial inflows of phosphorus to wetland streams through groundwater have been observed elsewhere (Reddy et al. 1999).

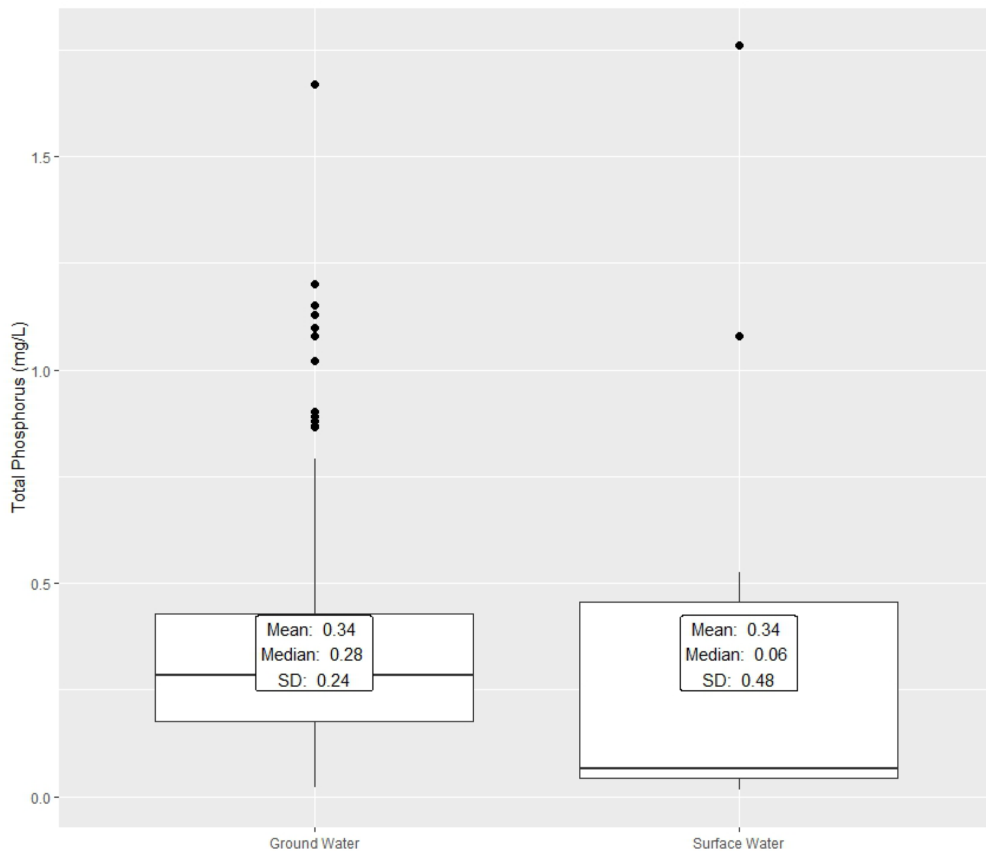


Figure 4. Box plot showing the distribution of total phosphorus concentrations in groundwater versus the stream channel. Note that the surface water samples are comprised of just four samples due to the ongoing drought conditions.

Figure 5 illustrates how these same concentrations varied over the course of the monitoring period, summarized by month. In aggregate across all well sites (vertically and laterally), groundwater TP concentrations show slight variability from month to month, but no clear temporal pattern emerged. Notably, however, stream channel concentrations increased from June to July from 0.05 mg/L to 0.76 mg/L. This trend is limited in data robustness given sampling frequency limitations due to the extreme drought that persisted for most of the summer. For example, July is only represented by a single sampling date whereas

June is represented by three sampling dates. No flow was observed in stream channel sites beyond June 13, 2022.

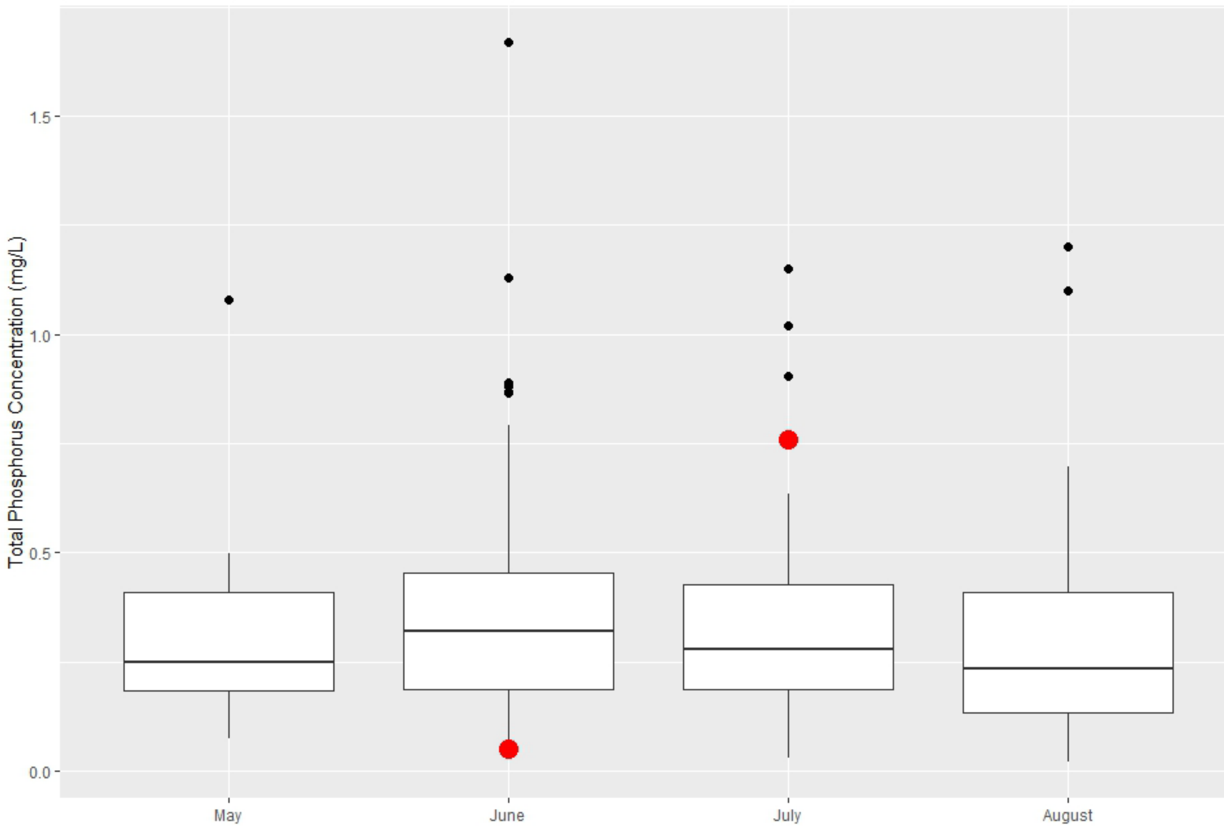


Figure 5. Monthly total phosphorus concentration boxplots for groundwater wells. Boxplots represent well data across all depths (surface, shallow, and deep). Red dots represent total phosphorus concentrations in the Auburn stream channel for months with sample data. June represents the median concentration across three sampling dates while July represents only a single sampling date.

A spatial assessment of elevated groundwater TP concentrations provides evidence that phosphorus concentrations are highly variable across the project extent, but generally high across the entire site (Figure 6). There are no established TP standards that apply to all wetlands in Minnesota to compare the Auburn wetland data to, however, groundwater TP concentrations are much higher than state eutrophication standards for TP in streams in Central Minnesota (≤ 100 µg/L; MN Statute 7050.0222).

Reference: **Auburn Wetland Monitoring Project - Technical Memo**

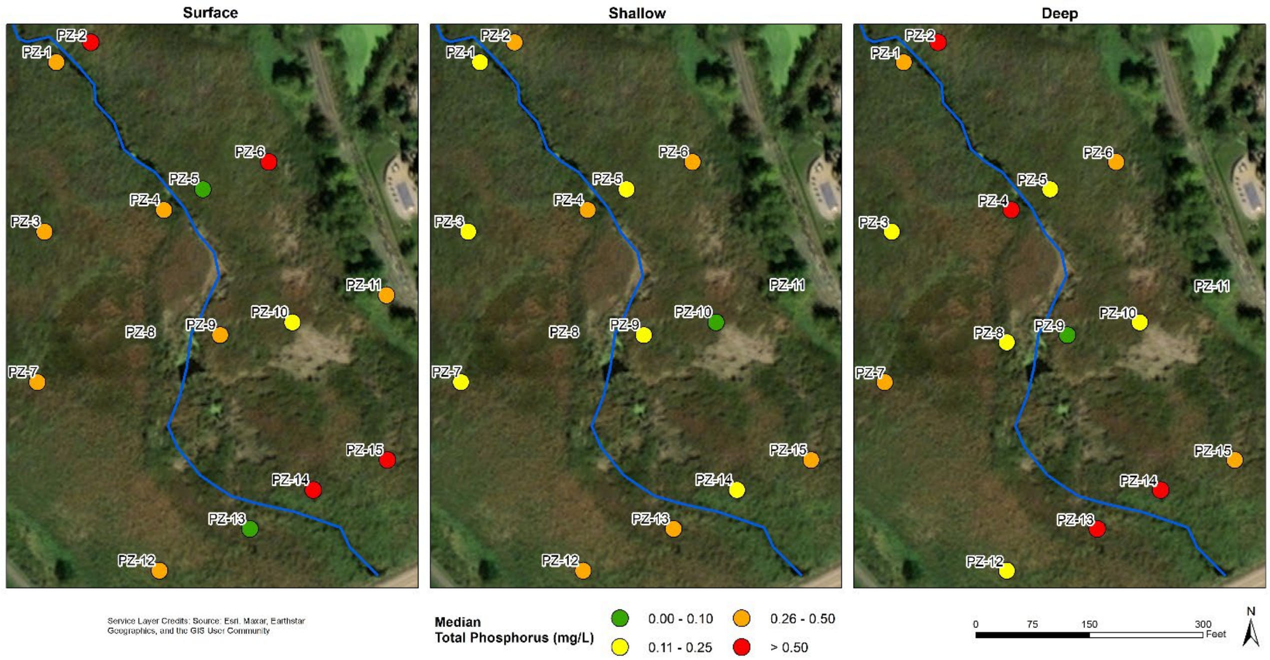


Figure 6. Spatial distribution of median total phosphorus in monitoring well samples (left to right: surface, shallow, deep wells). Green indicates median total phosphorus concentrations meeting the Minnesota eutrophication standard for TP in streams of 0.1 mg/L.

A time-series of TP concentrations in the Auburn stream channel, at each groundwater monitoring well depth, and at the upstream outlet from Wasserman Lake is shown in Figure 7. This figure demonstrates a general trend in increasing groundwater phosphorus concentrations at the deepest wells throughout the summer, whereas the surface and shallow wells demonstrate generally decreasing trends. This trend is supported by the observed downward flux of groundwater from mid-late summer. Notably, these trends are somewhat confounded by drought conditions during summer 2022, however, that caused inconsistent sampling conditions in the surface and shallow well depths (i.e., absence of water to sample).

Figure 6 also indicates that stream channel TP concentrations increased around the time that streamflow from the upstream Wasserman Lake outlet dried up (indicated by the vertical black dashed line). This provides one possible explanation for the increase in TP in the Auburn stream channel, where the absence of incoming streamflow coupled with an increase in phosphorus concentrations within the Auburn stream channel indicates groundwater phosphorus influence on stream channel phosphorus. The hydrologic exchange of groundwater and surface water is demonstrated in the prior section; the water elevation data indicates that there are periods where a groundwater and surface water interface exist thus providing evidence that groundwater phosphorus can transport to the stream channel.

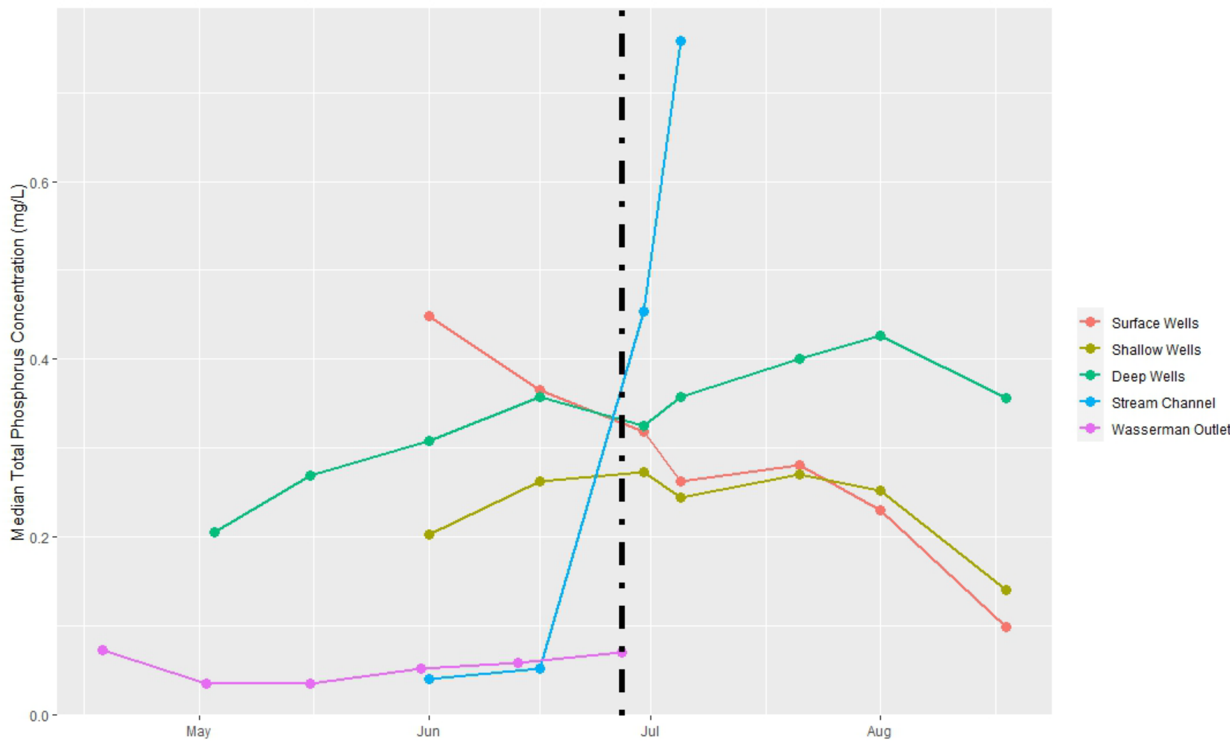


Figure 7. Median daily total phosphorus concentration for the three well depths (surface, shallow, and deep), the Auburn wetland stream channel, and the Wasserman Lake outlet. The black dashed line indicates when streamflow at the Wasserman outlet was first documented to be 0 cfs (June 27, 2022).

Soil and Sediment Results

The soil and sediment phosphorus chemistry results were also evaluated to understand the background content of phosphorus in the wetland and to quantify the pool of phosphorus that could potentially mobilize through groundwater or diffuse from the stream sediments under certain redox conditions. Sediment from the stream channel and soils from a subset of the groundwater monitoring well locations were taken at the depths listed in Table 1. The results of the soil and sediment samples are shown in Figure 8. Results from the wetland soils analyses demonstrate the highest concentrations of mobile P (see Table 2 for operational definition) at the surface depth in the monitoring wells followed closely by the stream channel. These results are consistent with other regional monitoring efforts in lakes where the largest concentrations of mobile P are closer to the substrate surface and the lowest concentrations of mobile P are furthest (deepest) from the substrate surface. This pattern is expected with soils and sediments containing high amounts of organic matter, such as productive lakes and wetlands. The organic matter present in deeper soils is older and has been subject to microbial processing leaving behind more recalcitrant material being buried in deeper layers and are therefore dominated by the non-mobile pools of P. In contrast, the surface soil layers contain younger organic matter with ongoing microbial processing that releases bioavailable phosphorus (i.e. non-mobile P) through decomposition processes. The Auburn wetland soils are consistent with expectations for vertical gradients of mobile P and non-mobile P (Reddy et al. 1999) in wetland soils. Figures demonstrating concentrations of both mobile and non-mobile P by site can be found in Appendix C.

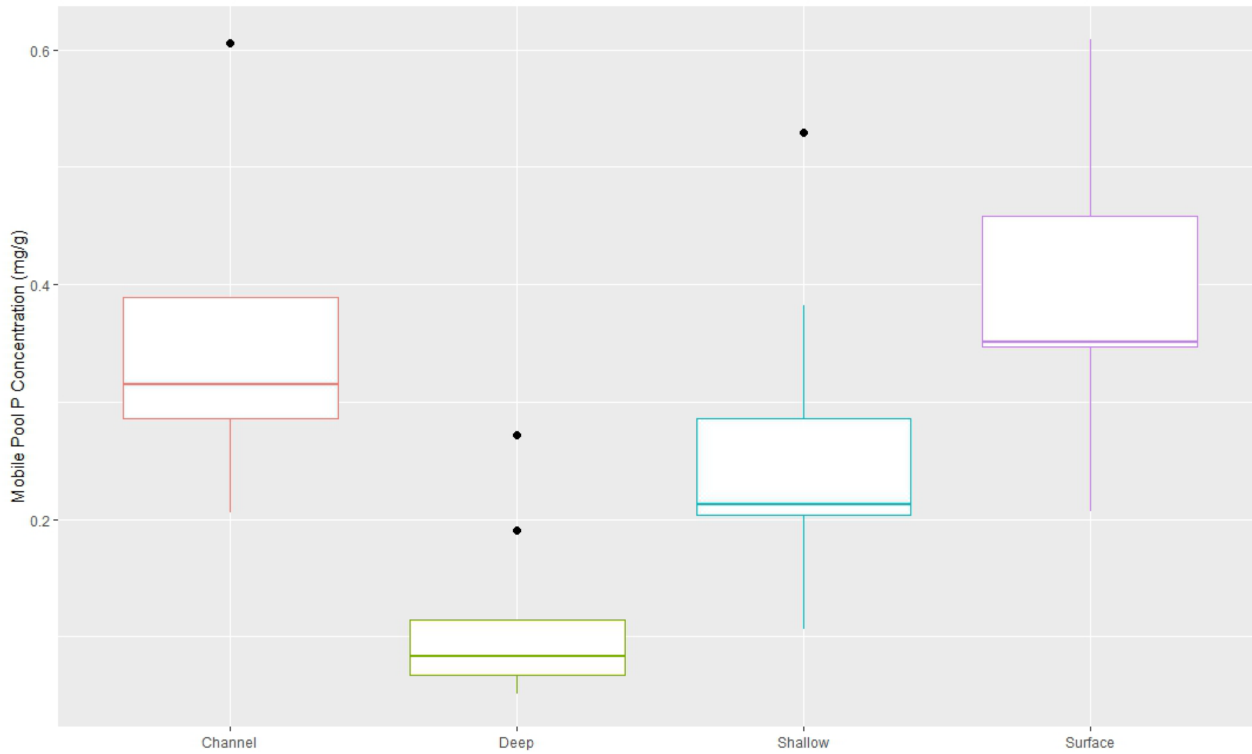


Figure 8. Box plot of mobile pool phosphorus (P) concentration in soil and sediment samples, by sample location. Note that the channel sample location is represented by only four data points, whereas typically five is the minimum requisite number of data points for a box plot. Due to this, the maximum value is also classified as an outlier based on the small distribution, hence there is no whisker between the upper quartile and the maximum value.

SUMMARY

During the monitored period groundwater flow was observed to be dynamic ranging from largely inundated/high groundwater conditions in spring, to low groundwater elevations and low groundwater discharge during the mid-summer, to a series of precipitation driven recharge events in August.

Water quality sampling in the groundwater wells and stream samples indicated that median total phosphorus concentrations in groundwater were approximately 4.5 times higher than median total phosphorus concentrations in the stream channel.

Groundwater flow observations indicated lateral movement towards the channel in the early-mid summer which was then dominated by downward vertical movement as drought conditions persisted through mid-late summer.

Groundwater flow observations indicated the potential for groundwater flux of total phosphorus to the channel

Our findings in the context of our original research questions are briefly summarized below.

1) **Is phosphorus high in the wetland complex (soils, sediments, groundwater, channel water)? *Yes***
    - Phosphorus is generally high in the East Auburn wetland soils and groundwater which is consistent with observations in other wetlands where extensive studies on phosphorus dynamics have been conducted (e.g. Reddy et al. 1999).
    - Total phosphorus concentrations were highly variable spatially and temporally but generally high throughout the site. For a frame of reference on what concentrations are considered high, we compared groundwater total phosphorus to the state standard for streams in Central Minnesota which is ≤ 100 µg/L (or 0.1 mg/L). Groundwater total phosphorus exceeded this standard in nearly all cases.
    - Mobile phosphorus was generally higher in surface soils compared to the deeper soils which is consistent with regional observations in lake sediments that display similar gradients.

2) **If phosphorus is high in the wetland complex, then is it able to mobilize to the stream channel? *Yes***
    - Hydrogeological observations indicate that groundwater was likely contributing flows, and thus total phosphorus, to the stream channel in early to mid-summer. The increase in total phosphorus in the stream observed after flow ceased from the Wasserman Lake outlet support this as a likely pathway for total phosphorus load to the stream.
    - The high concentration of mobile phosphorus in the surface and shallow soil depths indicate high likelihood of transport with groundwater as the mobile phosphorus constituents tend to be more soluble than the non-mobile phosphorus fractions (Reddy et al. 1999).
    - Other pathways for phosphorus transport to the stream channel include:
        - Input from Wasserman Lake via upstream flows
        - Release of mobile phosphorus from channel sediments through redox reactions and/or organic matter processing
        - Overland flow through non-permanent water tracks in wetland complex

Streams and wetlands have high capacity for retention and biological processing of phosphorus, which leads to high temporal and spatial variability in the relative proportion of dissolved vs particulate and organic vs inorganic fractions. There are multiple potential pathways for phosphorus to be delivered to the stream channel from the wetland cell evaluated in this study. Thus, mitigation alternatives that seek to reduce the potential for total phosphorus loads from groundwater to the channel and/or treat or filter water at the end of the channel hold the most promise for reducing phosphorus loads to Auburn Lake.

RECOMMENDATIONS

Through this study, Stantec has identified a few recommendations that could be implemented to better constrain understanding of the hydrology and nutrient dynamics in support of design alternatives to mitigate phosphorus loads from the wetland to Auburn Lake.

- Stream channel data indicated a higher proportion of orthophosphate relative to total phosphorus early in the monitoring period (6/1/2022 and 6/16/2022) with a lower proportion of orthophosphate later in the sample record (6/30/2022 and 7/5/2022). Phosphorus forms in wetlands and streams include not only the dissolved inorganic phosphorus fraction (i.e. orthophosphate) but also dissolved organic phosphorus, particulate inorganic and particulate organic fractions (Dunne and Reddy 2005). The organic dissolved and organic particulate phosphorus components of the stream samples were not directly quantified but could represent a large proportion of the phosphorus. The proportion of particulate versus dissolved fractions has implications for longevity and maintenance requirements for some engineered solutions to capture phosphorus in the stream channel. Therefore, a better understanding of the temporal variability in dissolved versus particulate phosphorus might be needed for advancement of mitigation solution design, especially if reactive media is considered.

- There are additional pathways for phosphorus transport to the stream channel which were beyond the scope of this project. The relative magnitude of these pathways to deliver phosphorus to the stream channel could be investigated further, which includes the following potential mechanisms:
    - Release of mobile phosphorus from channel sediments through redox reactions and/or organic matter processing,
    - Overland flow through non-permanent water tracks in wetland complex

- The magnitude of the groundwater total phosphorus load is uncertain and cannot be estimated in a meaningful way with the available data. Stantec recommends single well instantaneous displacement tests (slug tests) be conducted at a subset of piezometer locations to estimate hydraulic conductivity of the wetland sediments. This data, in combination with hydraulic gradient and porosity may be used to estimate TP flux from groundwater to the channel. These could be compared to early season loads from the Wasserman outlet where total phosphorus samples were paired with flow measurements.

Additional recommendations appear in Appendix A for each of Stantec's conceptual alternatives.

REFERENCES

Dunne E.J. and K.R. Reddy. 2005. Phosphorus biogeochemistry of wetlands in agricultural watersheds pp. 105-119 in Nutrient Management in Agricultural Watersheds: A Wetlands Solution. 288 pages. Wageningen Academic Publishers.

Reddy K.R., R.H. Kadlec, E. Flaig and P.M. Gale. 1999.

Stantec. 2022. Auburn Wetland Targeted Monitoring Plan. Prepared for Minnehaha Creek Watershed District on January 19, 2022.

Appendix B - Hydrographs

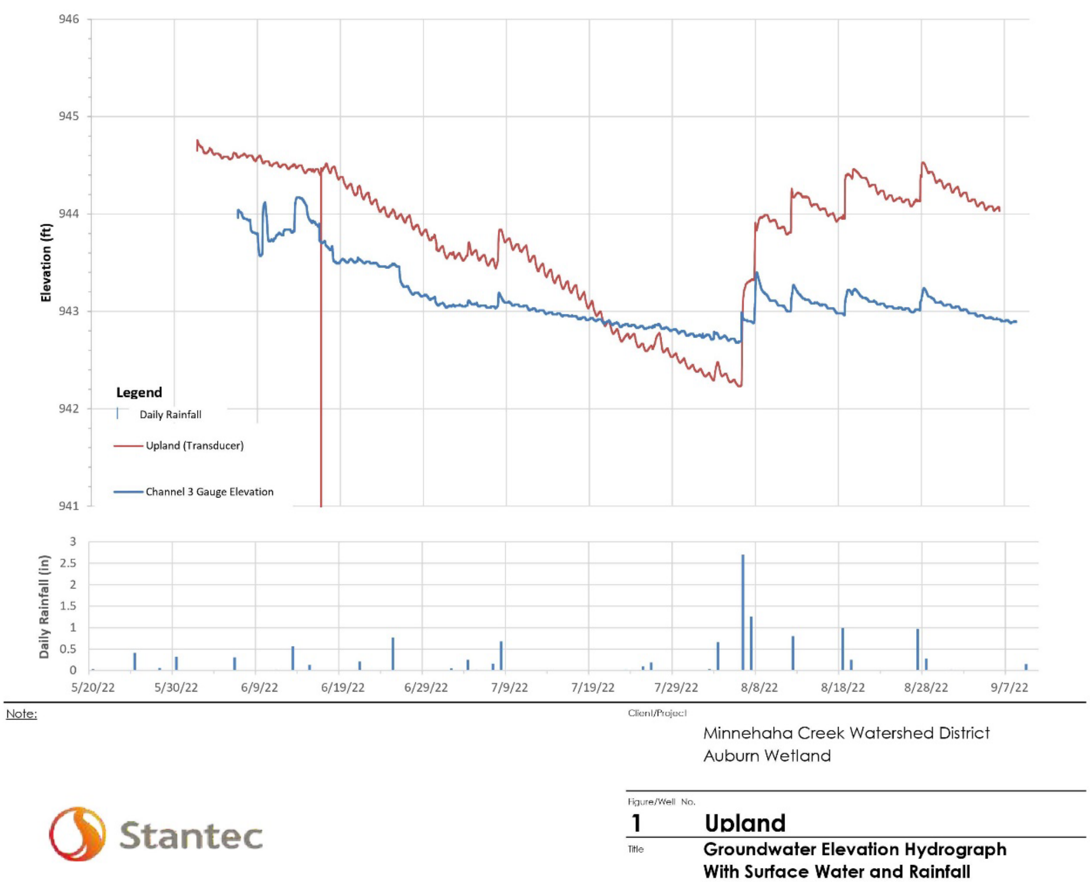
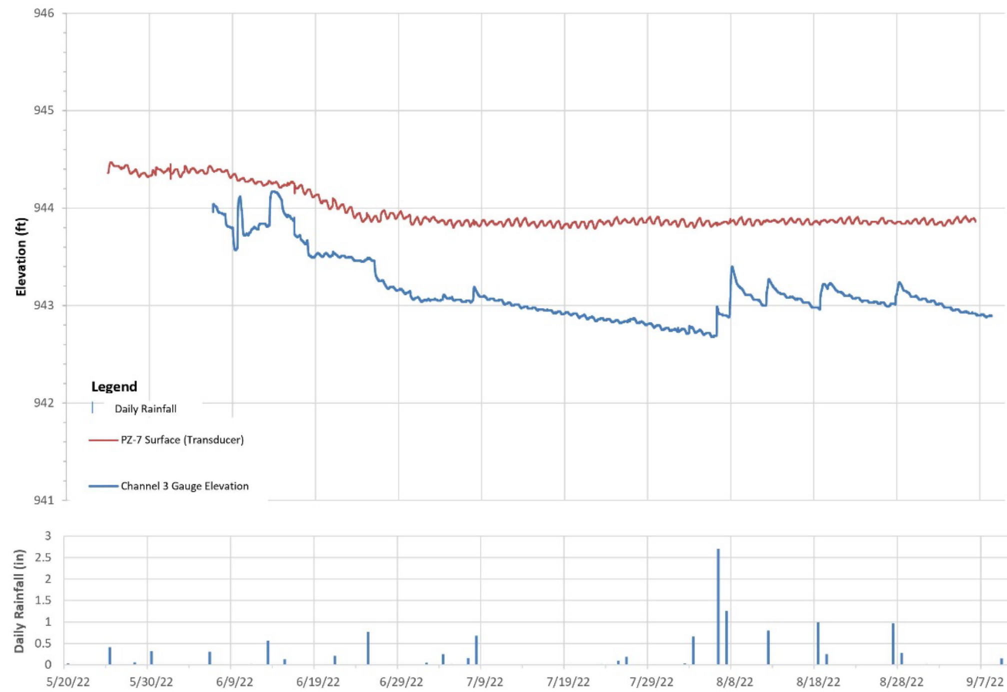


Figure B1. Hydrograph showing groundwater elevation at the upland monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo



Note:

Client/Project
Minnehaha Creek Watershed District
Auburn Wetland

Figure/Well No.
2 **PZ-7 Surface**

Title
Groundwater Elevation Hydrograph With Surface Water and Rainfall

Figure B2. Hydrograph showing groundwater elevation at the surface PZ-7 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo

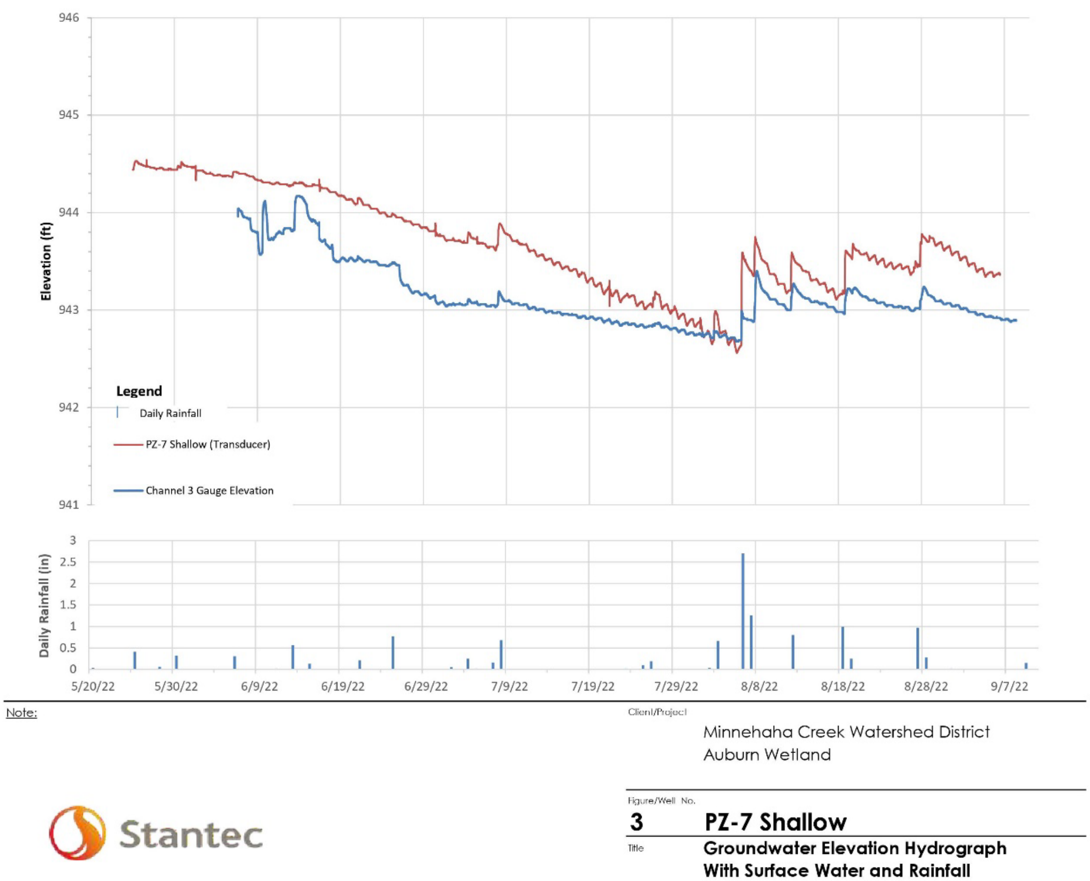


Figure B3. Hydrograph showing groundwater elevation at the shallow PZ-7 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo

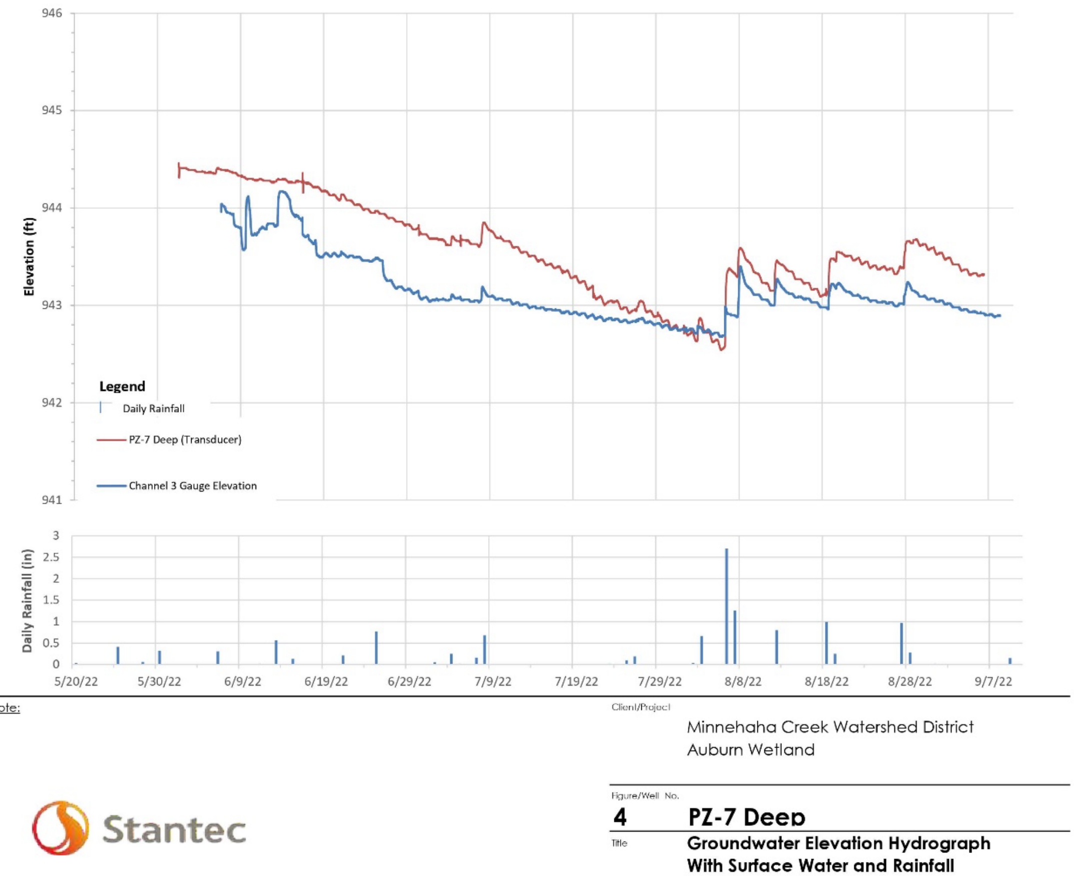


Figure B4. Hydrograph showing groundwater elevation at the deep PZ-7 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo

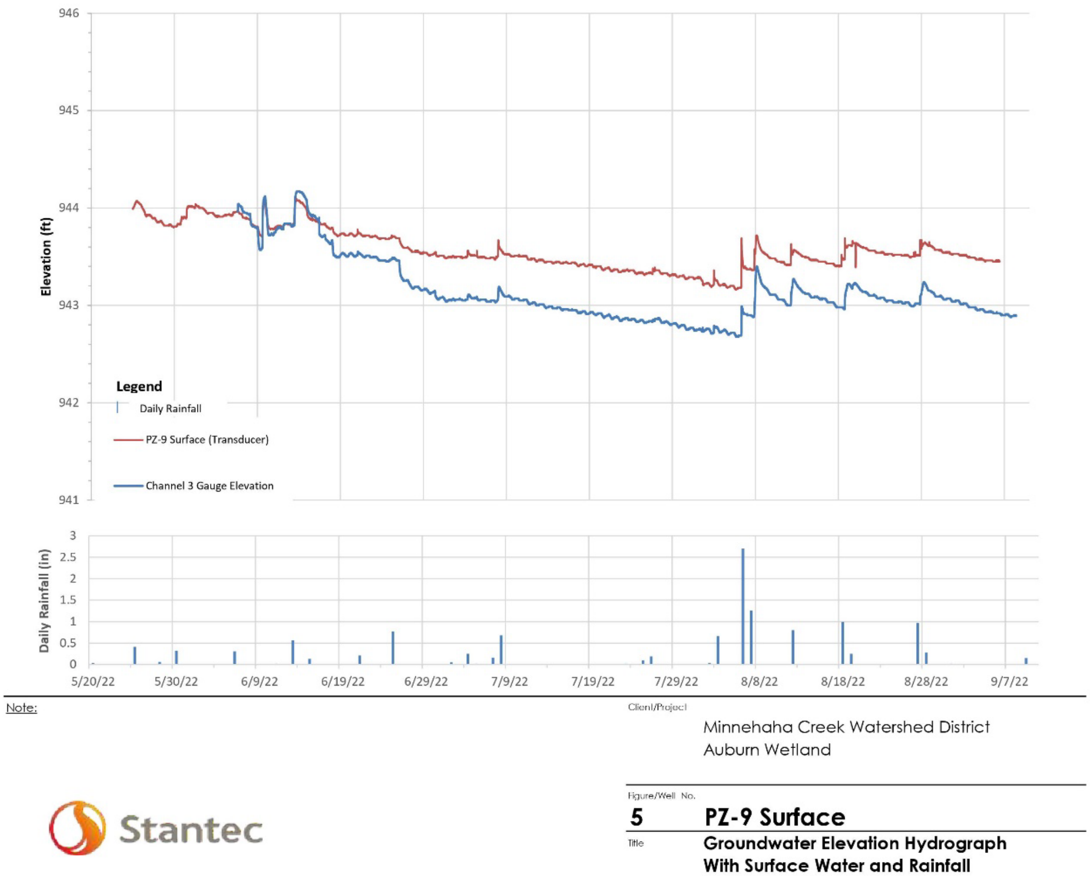
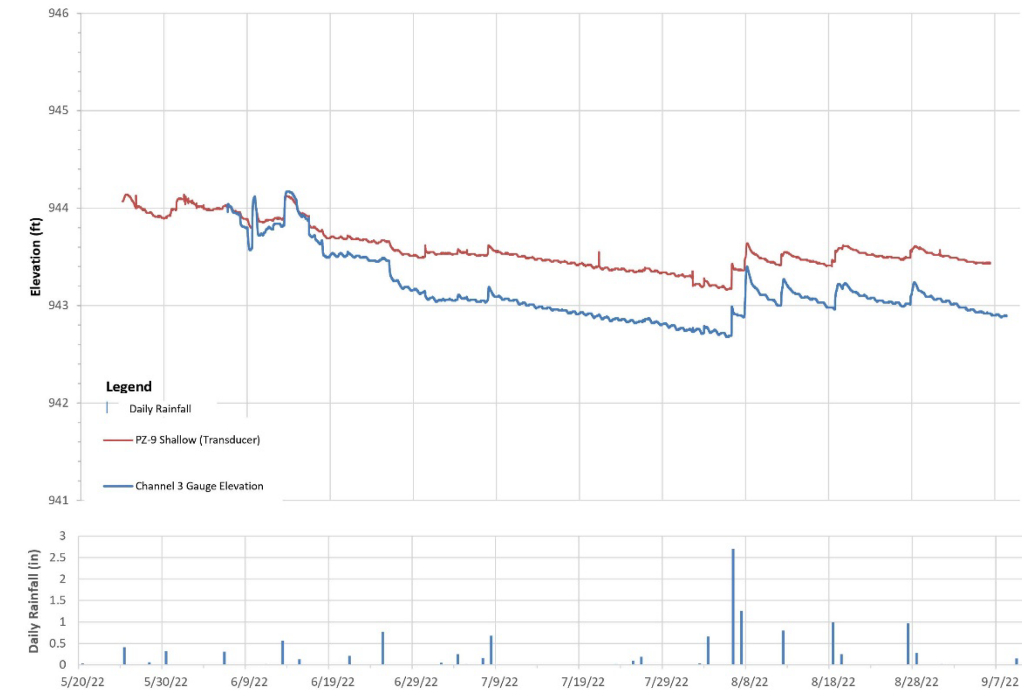


Figure B5. Hydrograph showing groundwater elevation at the surface PZ-9 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo



Note:

Client/Project
Minnehaha Creek Watershed District
Auburn Wetland

Stantec

Figure/Well No.
6 **PZ-9 Shallow**
Title
Groundwater Elevation Hydrograph
With Surface Water and Rainfall

Figure B6. Hydrograph showing groundwater elevation at the shallow PZ-9 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo

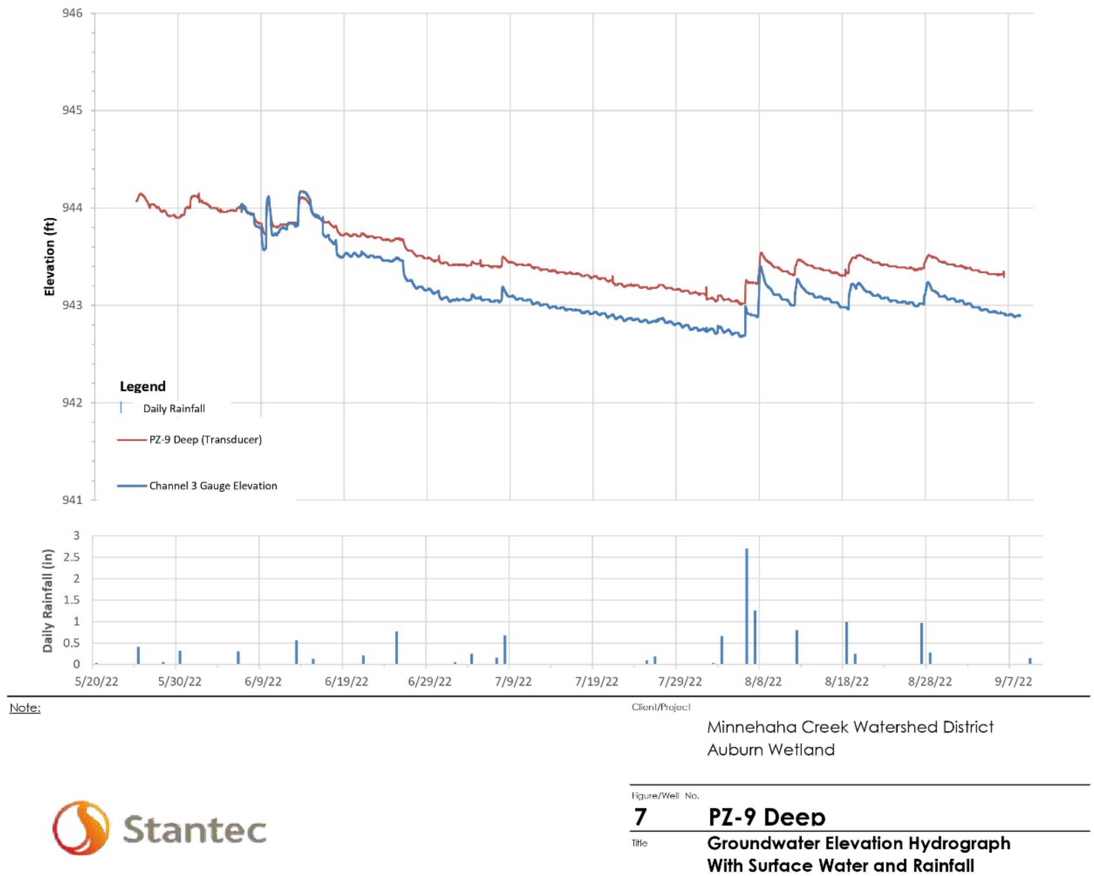
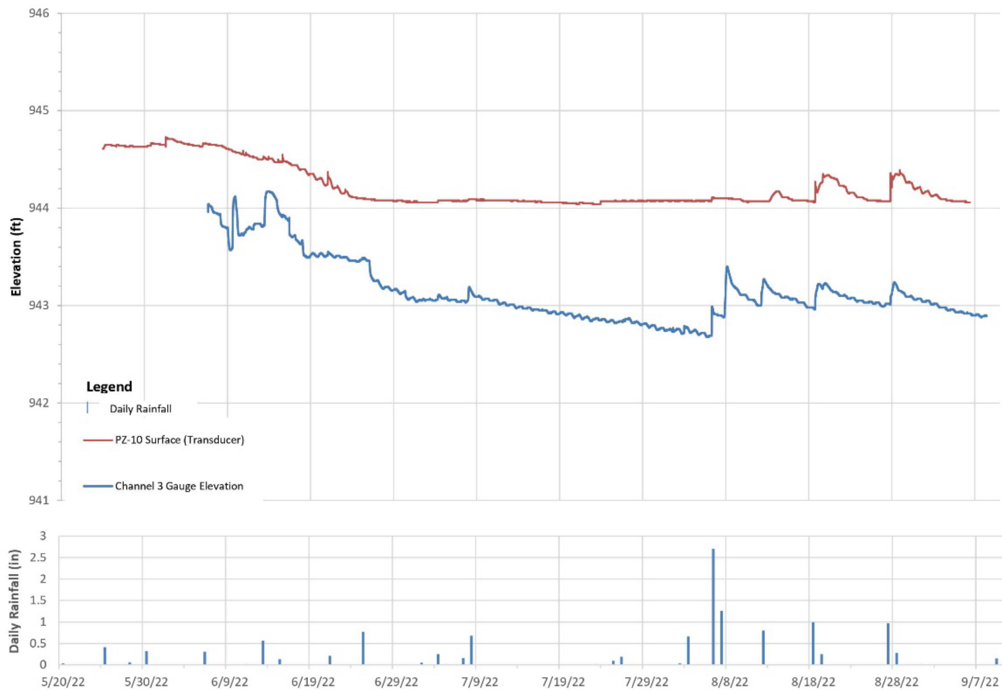


Figure B7. Hydrograph showing groundwater elevation at the deep PZ-9 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo



Note:

Client/Project

Minnehaha Creek Watershed District
Auburn Wetland

Stantec

Figure/Well No.

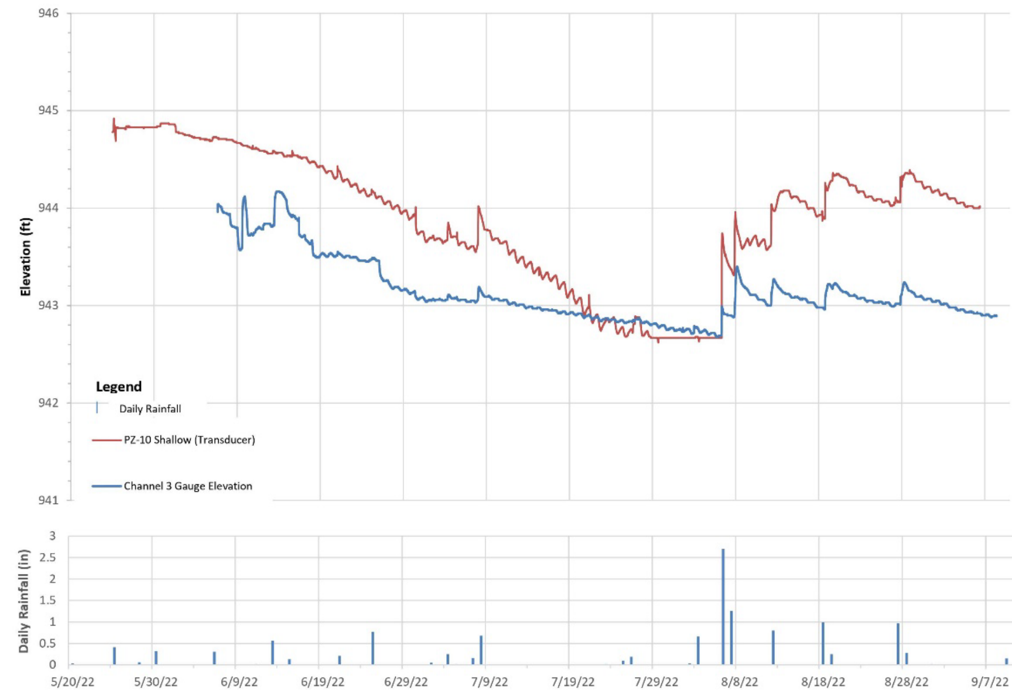
8 **PZ-10 Surface**

Title

Groundwater Elevation Hydrograph
With Surface Water and Rainfall

Figure B8. Hydrograph showing groundwater elevation at the surface PZ-10 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo



Note:

Client/Project

Minnehaha Creek Watershed District
Auburn Wetland

Stantec

Figure/Well No.

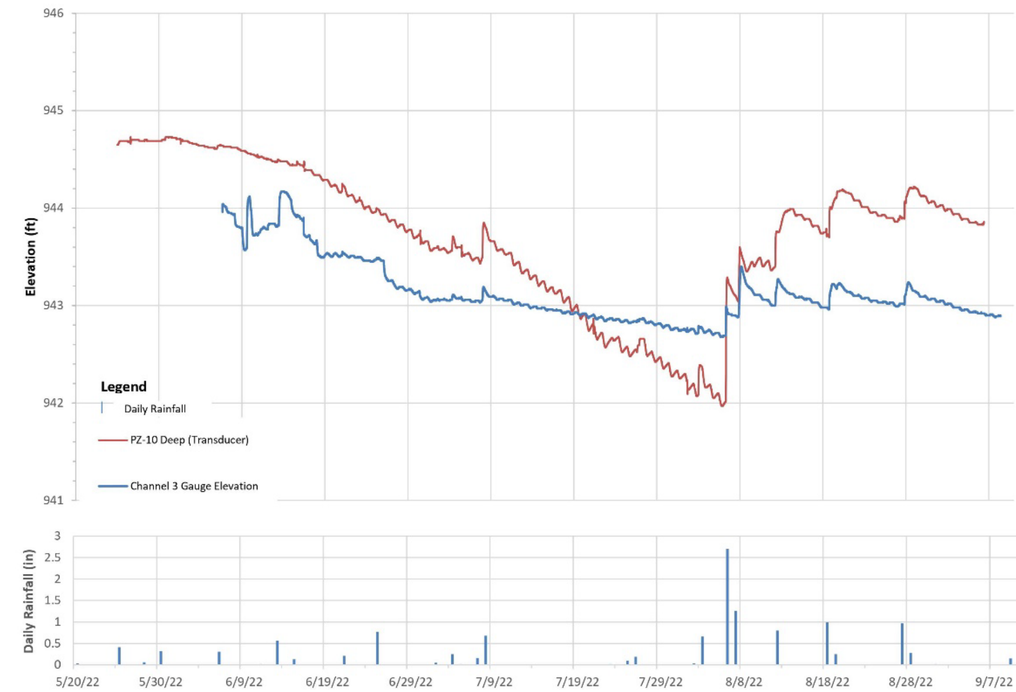
9 **PZ-10 Shallow**

Title

Groundwater Elevation Hydrograph
With Surface Water and Rainfall

Figure B9. Hydrograph showing groundwater elevation at the shallow PZ-10 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Reference: Auburn Wetland Monitoring Project - Technical Memo



Note:

Client/Project
Minnehaha Creek Watershed District
Auburn Wetland

Stantec

Figure/Well No.
10 **PZ-10 Deep**

Title
Groundwater Elevation Hydrograph
With Surface Water and Rainfall

Figure B10. Hydrograph showing groundwater elevation at the deep PZ-10 monitoring well, surface water (Channel 3) elevation, and daily rainfall during continuous monitoring.

Appendix C – Phosphorus Pools in Soils and Sediments

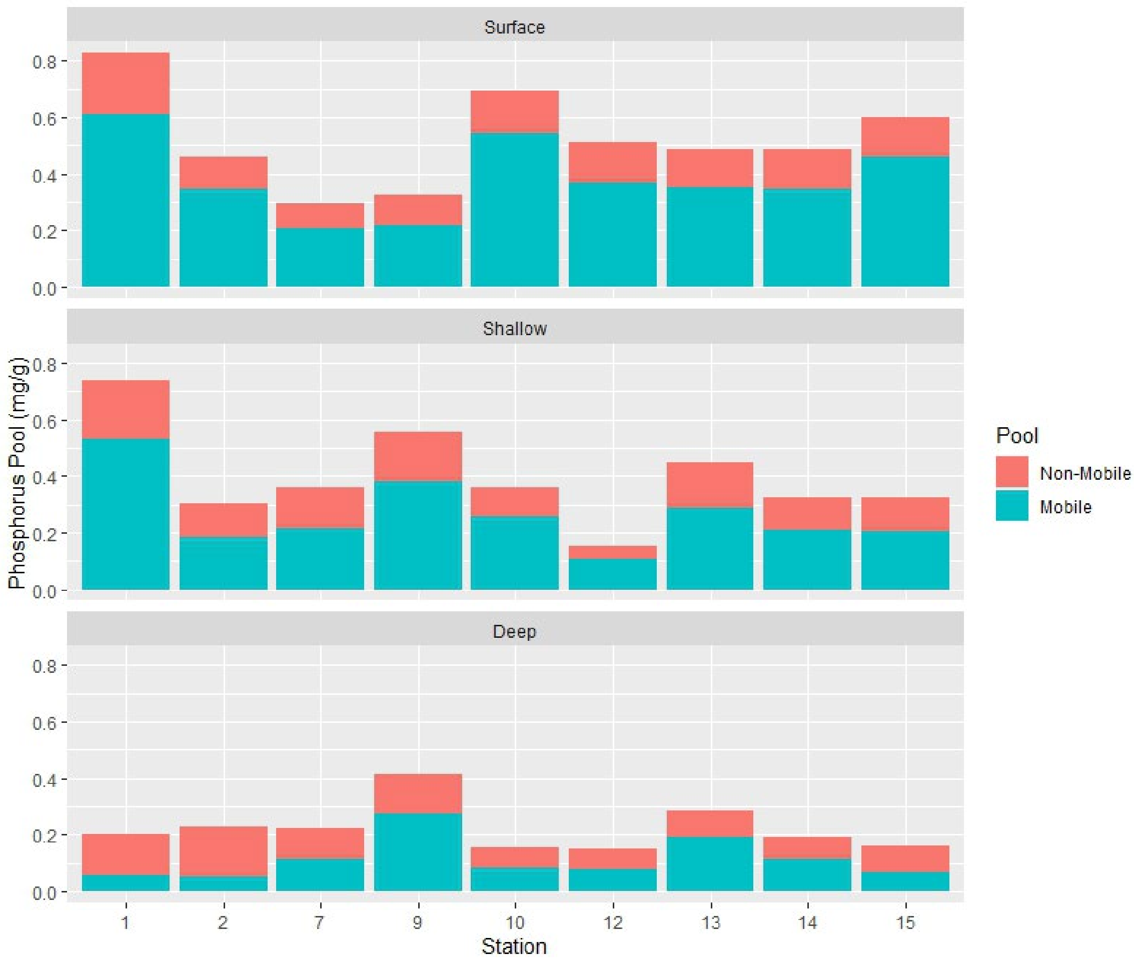


Figure C1. Mobile versus non-mobile pool phosphorus concentrations at monitoring well sites, summarized by surface, shallow, and deep samples.

Reference: Auburn Wetland Monitoring Project - Technical Memo

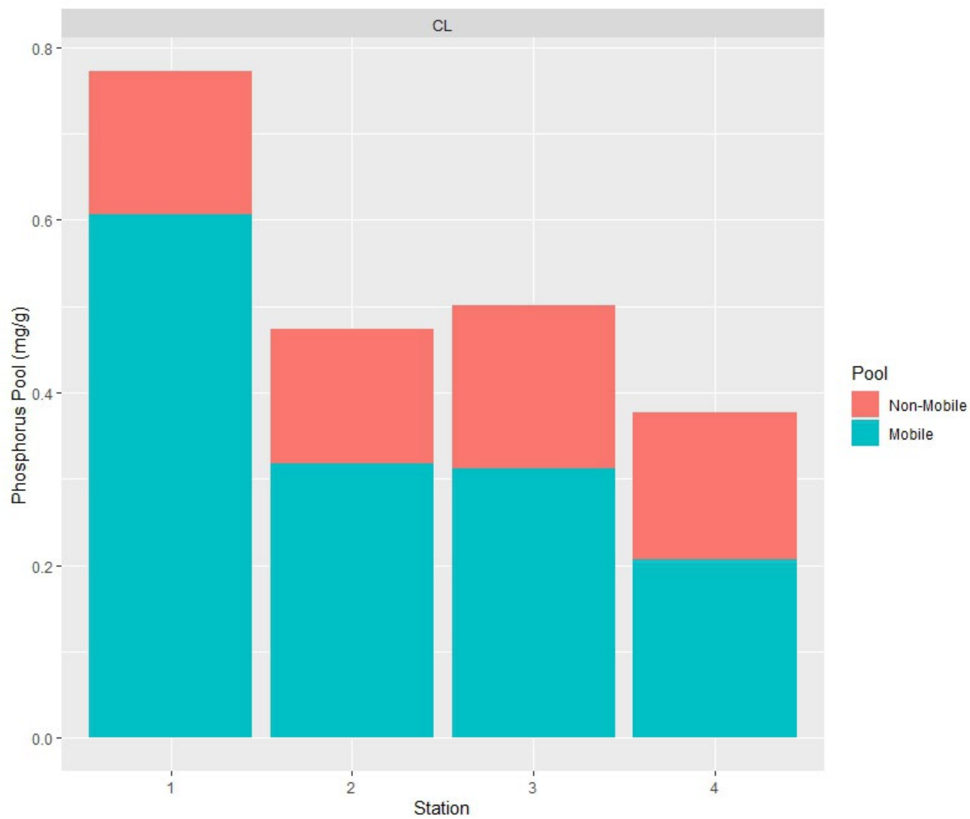


Figure C2. Mobile versus non-mobile pool phosphorus concentrations at stream channel sites. Station 4 corresponds to the most upstream station in the project extent and Station 1 is sited near the boardwalk in the most downstream location of the study site.