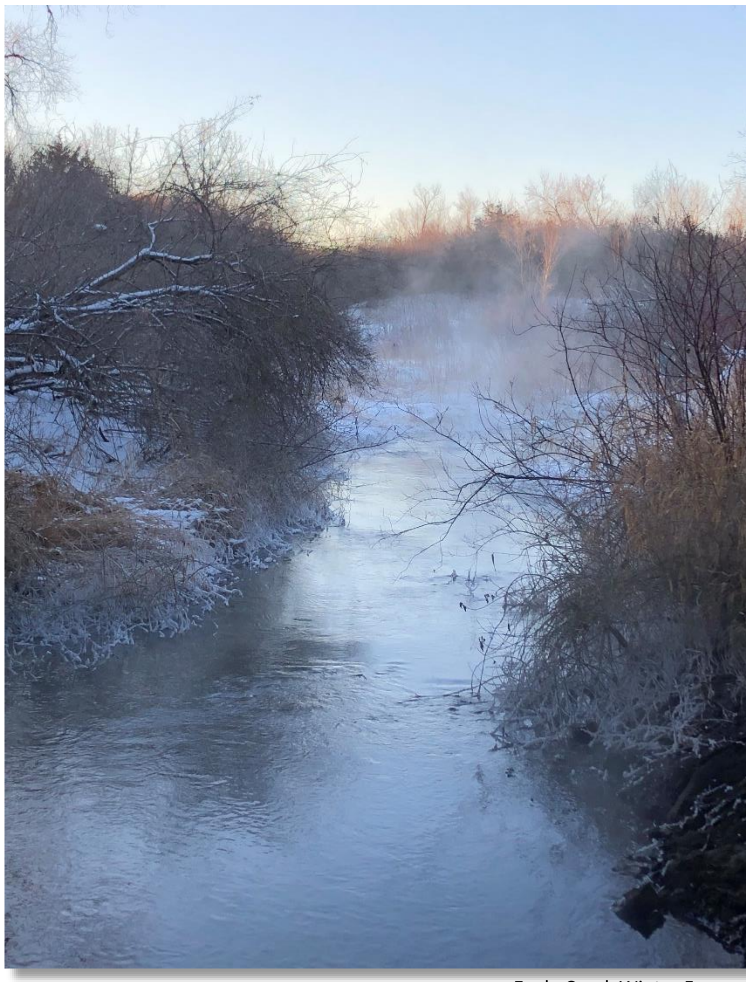
ANNUAL MONITORING REPORT
2021



Eagle Creek Winter Freeze

Prepared for:

Lower Minnesota River Watershed District

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Jordan, MN

LOWER MINNESOTA RIVER WATERSHED DISTRICT

SCOTT SWCD

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Introduction

This report focuses on the summary and comparison of water resources data collected by Scott Soil and Water Conservation District (SWCD) from 2021 and previous monitoring seasons. Like previous years, the monitoring work plan for 2021 included three water temperature logging locations in Eagle Creek and two around the watershed connected to Eagle Creek. One continuous water monitoring station in Eagle Creek (operated in conjunction with Metropolitan Council Environmental Services (MCES) Watershed Outlet Monitoring Program (WOMP). Ground water monitoring at 17 observation wells located in the Savage Fen and surrounding area. Along with one water monitoring station on the inlet to Dean Lake (DLI). The locations of the 2021 monitoring activities are seen in Figure 1.

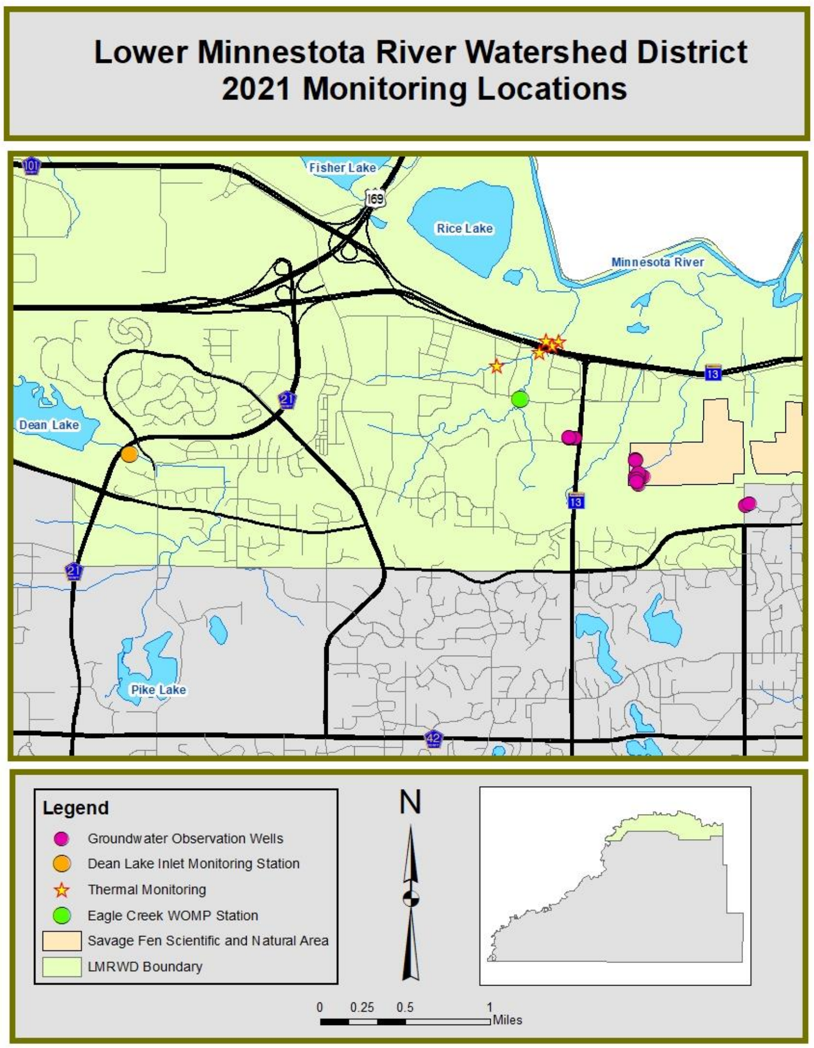

Figure 1. Monitoring locations around the Scott County portion of the Lower Minnesota River Watershed District for the 2021 monitoring season.

I. Thermal Monitoring

This study was initiated by the Lower Minnesota River Watershed District (LMRWD) to evaluate the impact storm water runoff from Highway 101 has on temperatures in Eagle Creek, a Minnesota Department of Natural Resources (MNDNR) designated trout stream. Brown Trout are very sensitive to temperature as it impacts growth rate, habitat, and food resources. The optimal temperature range for adult brown trout is approximately 12.4 – 17.6^{o} Celsius (Bell, 2006).

Methods

Temperature loggers were placed upstream and downstream of Highway 101 in June of 2006 and have been recording stream temperature since that time. In October 2012, a midstream logger was placed just upstream of a pond tributary to monitor its impact on stream temperatures. Three additional loggers (Hwy 101 logger, Schroeder's Park logger and the Creek Way logger) have been placed on the outlets of the ponds adjacent to Eagle Creek in late July of 2018. In 2021 the Creek Way logger was removed because the logger rarely saw any signs of water inundation and was only recording ambient temperatures. The goal of the additional pond loggers is monitor water temperatures leaving the ponds and help identify potential warm thermal sources contributing to the creek. In late June 2021 the METC staff added new equipment to the WOMP station which added continuous temperature sensing at the station. All five loggers and the WOMP temperature recording equipment record continuous temperature data in 15-minute intervals. Scott SWCD contracted with the LMRWD to collect and report the instream temperature data. Rainfall data used for this report is taken from the KMNSAVAG31 wunderground station located approximately three miles East Southeast of the Eagle Creek WOMP monitoring station (https://www.wunderground.com/dashboard/pws/KMNSAVAG31).

Figure 2. Location of temperature loggers and WOMP station. The loggers added in 2018 are represented by the orange triangles. Thermal water data at the WOMP station is collected with METC monitoring equipment.

Results

A logger reset created gap in data was observed in the upstream and pond loggers from April 15th to May 22nd. The downstream logger had failed and was replaced with the Creek Way logger creating a larger gap in data from April 15th to June 23rd. Even with these gaps the creek temperatures trended with atmospheric temperatures under most conditions. The downstream logger shows a deviation from the midstream and upstream loggers during both the winter and summer. A combination of atmospheric temperatures and the inflow of cold and warm water from the inlet near the Hwy 101 logger would influence the deviation.

Similar to other years, the general trend of the upstream logger continues to be the warmest during the winter and coolest in the summer of the three Eagle Creek loggers. The downstream logger shows an opposite trend as it is the warmest in the summer and coolest in the winter (Figure 4). During warm summer days, all three loggers recorded water temperatures that occasionally exceeded the optimal range for trout but for only a few hours at a time (Figure 5). The maximum daily temperatures exceeded the optimal range 8 time in the downstream logger, 11 times in the midstream logger, and 10 times in the upstream. Maximum daily temperatures never exceeded the optimal range at the Eagle Creek WOMP site. A noticable seperation in water temperatures is noticed after rain events. It appears that the downstream loggers tend to peak higher and for an extended period of time when compared with the upstream logger. This is likely due to surface runnoff from the stormwater inlets under Hwy 101 and increased side channel flow from the inlet at the Hwy 101 logger location.

Since the start of the Eagle Creek water temperature monitoring project consistent trends of daily maximum creek temperatures can be observed (Figure 3). The amount of days that the maximum temperature exceeds 17.6°C is always highest at the downstream logger. The midstream and downstream loggers appear to have the most significant relationship with annual precipitation totals while the upstream logger looks to have an inverse relationship with precipitation. All the loggers track well with ambient air temperatures, especially the upstream logger.

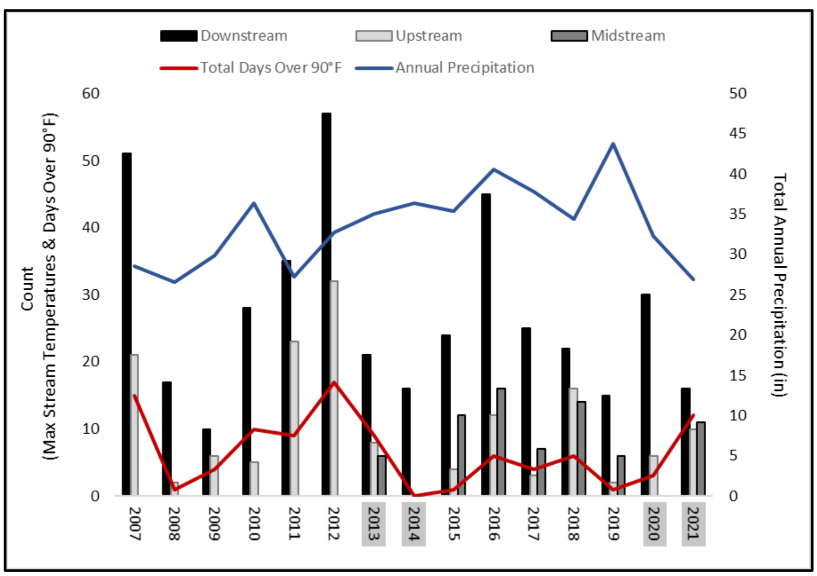

Figure 3. Total number of days maximum water temperature exceeded 17.6°C and air temperatures exceeded 90°F. Annual precipitation is the total received at the NOAA Chanhassen WSFO station. Shaded years have some missing or incomplete data associated with one or more of the thermal loggers.

The additional three loggers at the Creek Way pond outlet, Shroeder's park outlet and the Hwy 101 pond inlet are not a part of the spring fed Eagle Creek main channel. They are more reactive to atmospheric temperature fluctuations (Figure 6). The Creek Way pond logger tracks very close to average air temperatures until it was removed in early June. Shroeder's park and Hwy 101 loggers showed a several degree seperation with one another in the winter and summer months. Examining at how these ponds influence the main channnel of Eagle Creek, it is likely that the Hwy 101 pond inlet has some influence to rising temperatures at the downstream logger as the largest seperation in temperatures between the upstream and downstream logger is observered after the Hwy 101 logger temperatures surpase the main channel temperatures (Figure 7). A slight increase in creek temperatures is seen between the WOMP station and the upstream logger during the summer months especially when the Schroeder's park logger values are the highest (Figure 8). Fluctuations in all loggers are also observed with the atmospheric temperatures and rain events.

Discussion

Similar to previous years, all of the loggers responded to atmospheric and tributary influences as seen in the past. Minimal flooding in the spring did not appear to have any significant impacts to stream temperatures. Minnesota experienced a significant drought throughout the 2021 summer. The precipitation events create instantaneous spikes in temperature, while a lack of preciptation creates longer more sustained warmer water temperatures that are likely due to increased air temperatures. All three loggers within Eagle Creek showed spikes in maximum daily temperatures outside the opitimal range for the Brown Trout. The total numbers of days above 90°F throughout 2021 was three times as what was experienced in 2020. The combination of a hot summer and lack of precipitation caused less variations in the temperatures between the loggers.

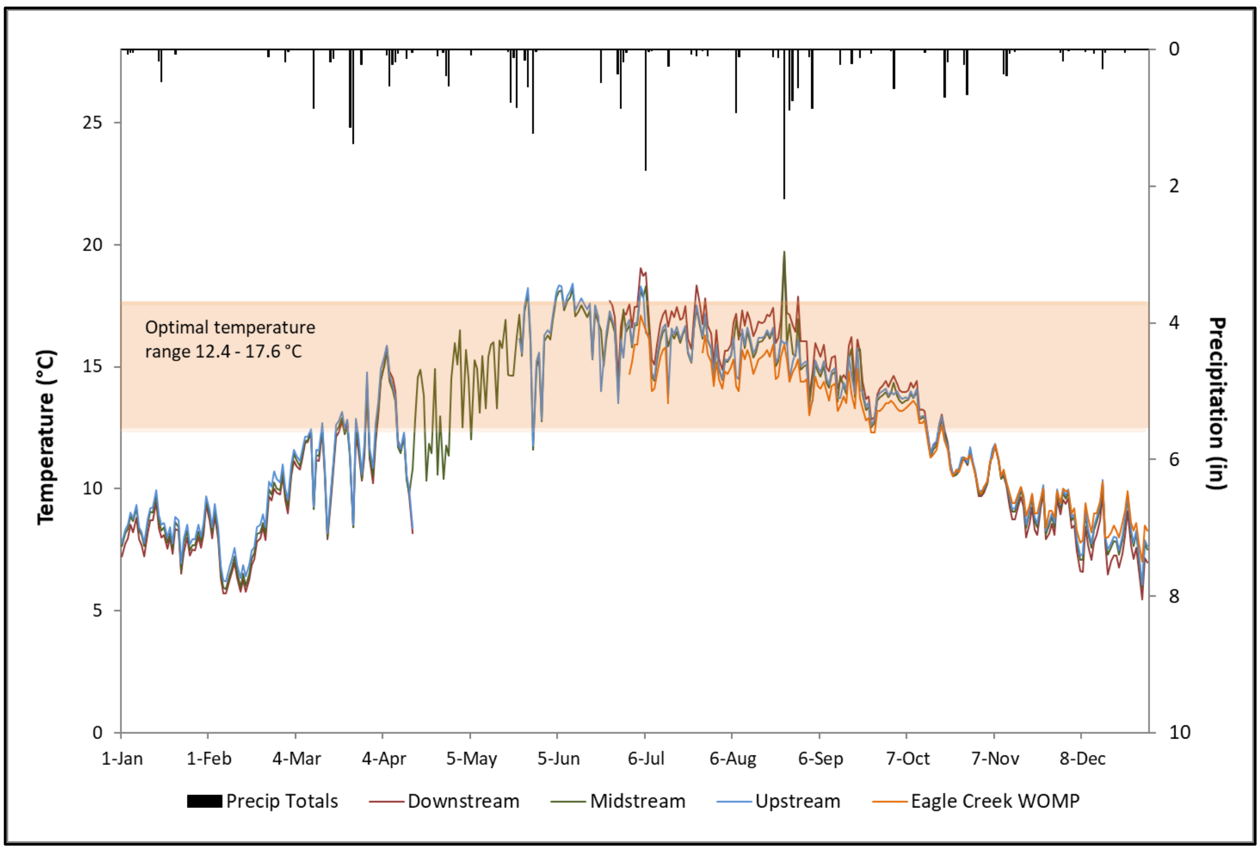

Figure 4. 2021 Maximum daily water temperatures in Eagle Creek.

The pond loggers tracked well with average air temperatures. The Creek Way logger was removed at the beginning of the summer as there was no evidence that it tracked any significant water temperatures since it's deployment in 2018. The Hwy 101 pond logger tracked diurnally with the downstream and midstream loggers. It remained cooler than the main channel in the winter and warmer in the summers. It likely has some influence on the downstream logger temperatures as a noticable seperation is observed between the midstream and downstream loggers after the Hwy 101 logger temperatures surpase the main channel temperatures. The

Schroeders Park logger generally recorded slightly higher temperatures than the Hwy 101 logger. The pond in the park is highly eutrophic and has the ability to absorb more radiational heat from the sun increasing the temperatures at the outlet. Schroeders Park funnels through a few wetlands before entering Eagle Creek just upstream of the upstream logger location.

An investigation was conducted on August 19, 2009 during a 2-inch rain event at numerous temperature monitoring locations on Eagle Creek. Termperatures were recorded upstream and downstream of the pond tributary and in the tributary itself. The temperature of Eagle Creek rose almost 2°C directly after the tributary discharged into Eagle Creek. The tributary was almost 5°C higher than Eagle Creek. According to that study, temperature spikes in Eagle Creek appear to be from large volumes of solar heated pondwater and warm surface runoff dishcarhging from the pond. The temperature of the pond may not actually increase during storm events, but rather the volume of water discharging into Eagle Creek is perhaps the stronger influence on temperature rise. This greatly exceeds the small increase in temperature that typically occurs during dry periods that could be attributed to atmospheric warming of the stream. The thermal loggers at the outlets of the ponds provide a longer record of the actual influence of temperature increases from the ponds. Even though the temperature exceeds the optimal range for trout by only a few degrees and for only a short period, these rapid temperature increases could be stressful to fish. The state water quality standard for Class 2A waters maintain there shall be “no material increase” in temperature.

Being a groundwater fed stream, the stream temperatures often track with ambient temperatures but the groundwater keeps the stream warmer in cold months and cooler in warm months. Other factors that show influence to fluctuating Eagle Creek temperatures are Spring flooding, and precipitation events. Flooding usually occurs as early as March and can last up to June. This can artificially increase or surpress temperature fluctuations during these periods. Additionally, precipitation events are seen to have impacts to the logger temperatures, especially in the midstream and downstream loggers. These loggers have the greatest potential for influence from highway runoff and pond overflow discharge.

Continually monitoring of Eagle Creek and the adjacent ponds will allow the tracking of temperature shifts. It also allows for historical background for past and future restoration projects, similar to the MNDNR habitat improvement project in 2013. An unexpected geomorphic shift occurred in the streambed during 2020 which created sediment build up and deep pools between the Hwy 101 culvert and the downstream logger. The creek is very sandy and unstable in this section and it is no surprise that the stream channel could change in this manner. The rate of this change was a surprise, especially with no significant hydrogeologic influences observed throughout the year.

The METC’s addition of the continuous water temperature data at the Eagle Creek WOMP location will provide valuable insight as to the potential impact of the Schroeders Park pond discharge. Prior to the WOMP data there was no continuous data upstream of the confluence where the park water would enter the creek. Now there is a baseline temperature record to compare against the rest of the loggers downstream of the WOMP station.

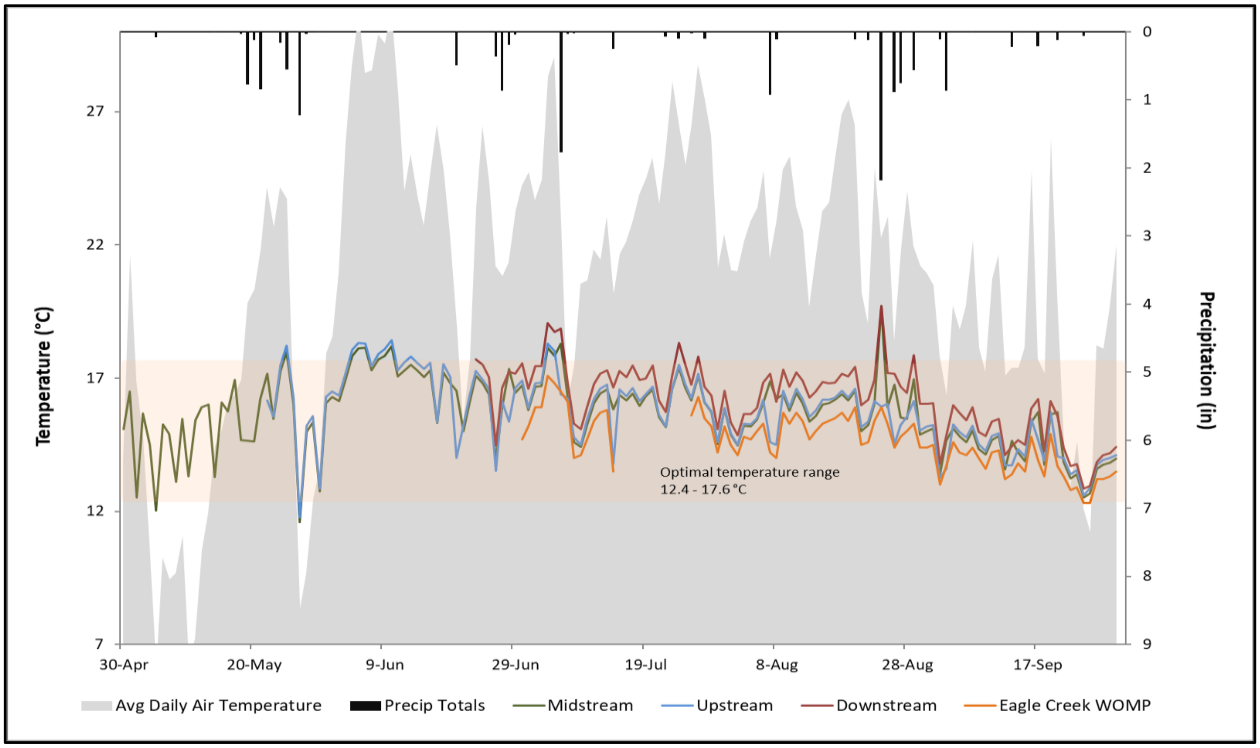

Figure 5. Maximum daily temperatures for the 2021 summer.

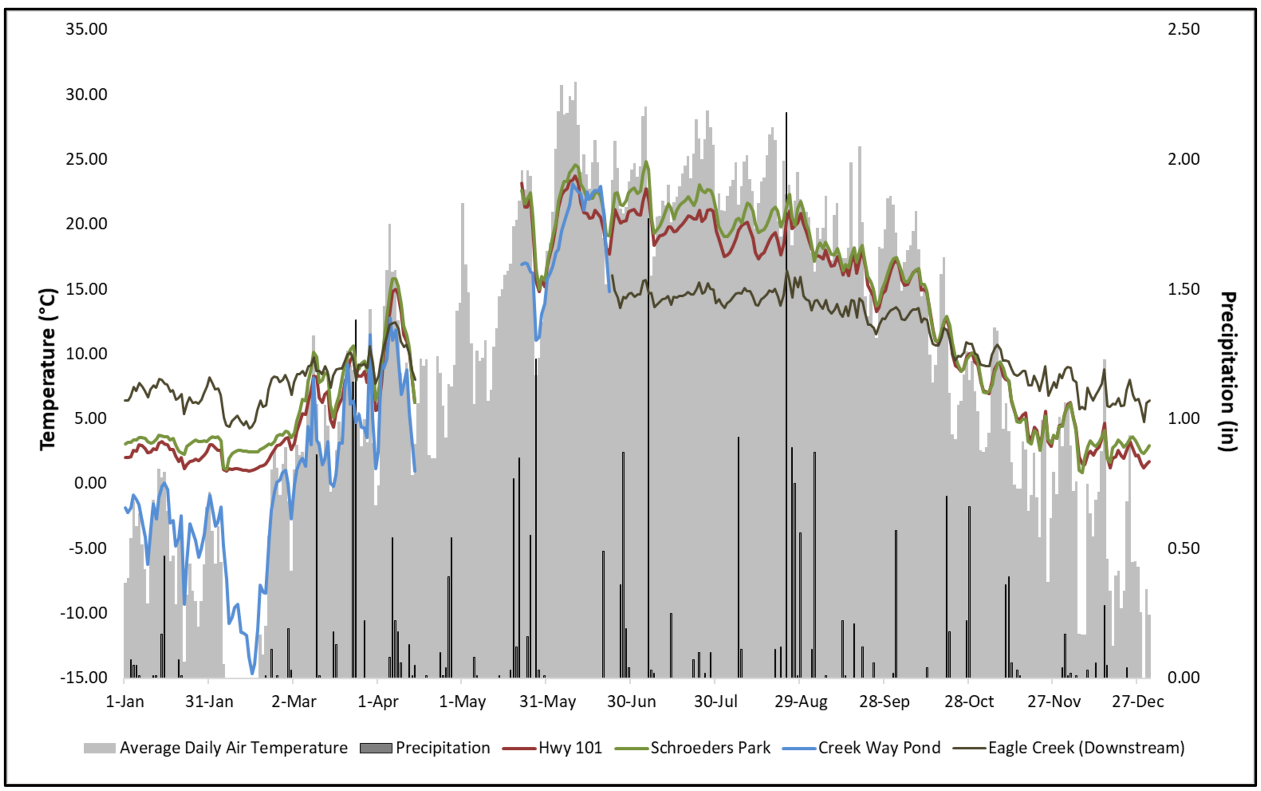

Figure 6. Pond outlet loggers 2021 average daily water temperatures. The Eagle Creek downstream logger is shown for reference.

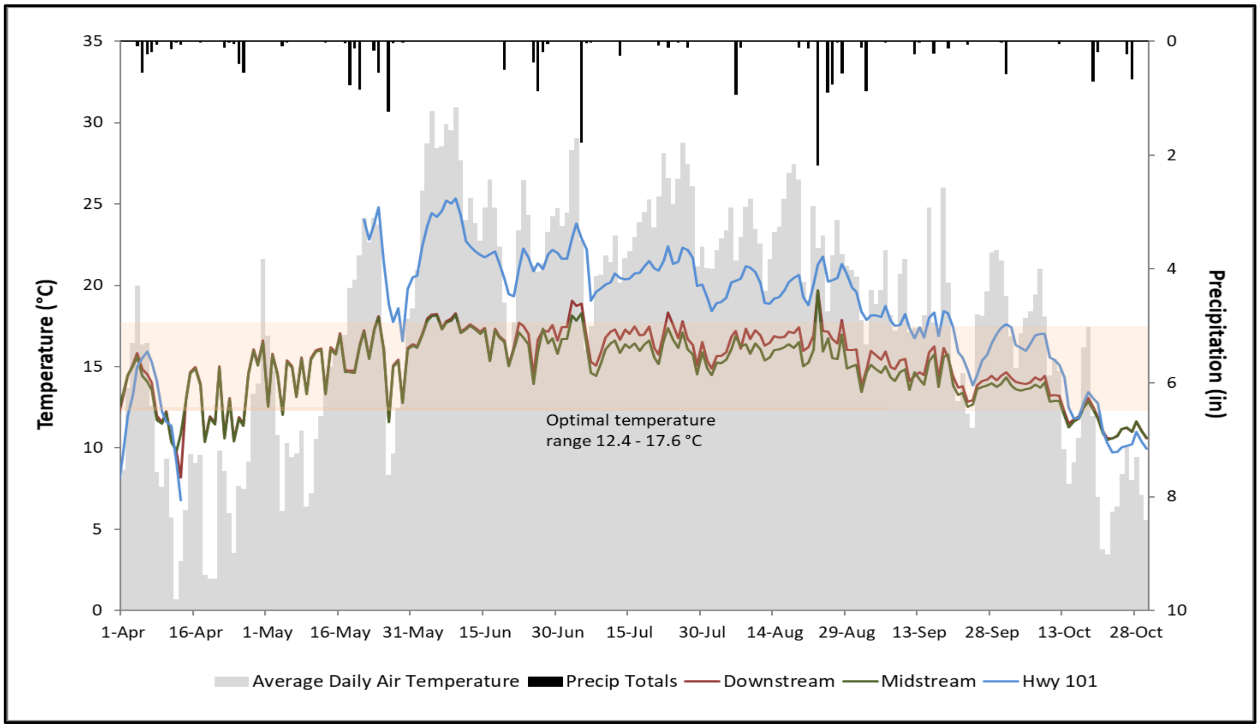

Figure 7. Comparison of 2021 water temperatures at the Hwy 101 pond and Eagle Creek upstream and downstream of pond confluence.

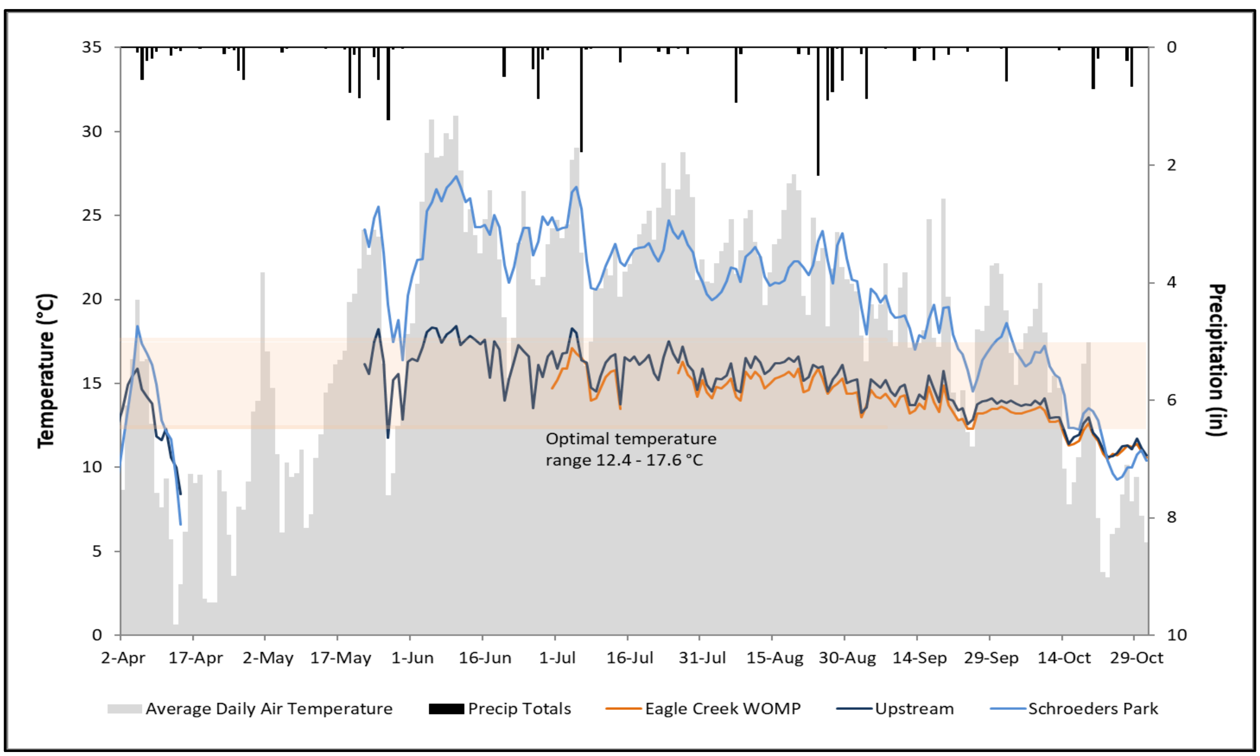

Figure 8. Comparison of 2021 water temperatures from the Schroeder's Park water temperature logger and the Eagle Creek WOMP and upstream water temperature data.

II. Eagle Creek Monitoring

Eagle Creek is a Class 2A self-reproducing trout stream, a unique water resource in the metropolitan area. The Creek originates at the Boiling Springs (an area considered sacred by the Mdewakanton Sioux Community) and outlets into the Minnesota River. Significant measures have been taken over the past couple of decades to prevent degradation of Eagle Creek, including diverting storm water from the stream, the establishment of a 200-foot natural vegetative buffer along each side of the bank, and most recently in 2013, a habitat improvement project along the west branch of Eagle Creek. These and other steps have helped to significantly minimize impacts from this rapidly growing suburban area.

Watershed Outlet Monitoring Program (WOMP)

The Eagle Creek monitoring station began in 1999 as part of the Metropolitan Council's Watershed Outlet Monitoring Program (WOMP). This program was designed and is currently managed by the Metropolitan Council, for the primary purpose of improving the ability to calculate pollutant loads to the Minnesota River. The Lower Minnesota River Watershed District (LMRWD) is the local funding partner for this station, and contracts with the Scott Soil and Water Conservation District (SWCD) to perform field-monitoring activities. The monitoring station is located in the City of Savage near Highway 13 and Highway 101, approximately 0.8 miles upstream of the confluence with the Minnesota River.

The following water quality and flow data is preliminary and is subject to change until the Metropolitan Council submits the final report for this period.

Table 1: Precipitation near Eagle Creek WOMP Station.

Month	2021 Precipitation Jordan* (inches)	2021 Precipitation Savage** (inches)	30 Year Record ***		
			Average	Minimum	Maximum
January	1.03	0.92	0.87	0.08	4.00
February	0.54	0.32	0.86	T	2.18
March	2.71	3.95	1.72	0.34	4.26
April	3.23	2.36	2.95	0.42	7.51
May	2.94	3.85	4.48	1.08	11.08
June	1.14	1.95	5.10	1.14	12.30
July	1.74	2.36	3.97	0.87	8.48
August	6.16	5.66	5.14	1.11	10.86
September	1.51	1.61	2.83	0.21	6.88
October	1.89	2.39	2.66	0.52	5.83
November	0.85	0.89	1.56	T	4.99
December	1.93	0.67	1.26	T	3.40
Total	**25.67**	**26.93**	**34.24**	**23.47 (2000)**	**41.99 (2019)**

* Precipitation data obtained from the NOAA Jordan 1SSW site.
** Precipitation data obtained from wunderground station KMNSAVAG31
*** The 30-year average (normal) is from 1991-2021, NOAA National Weather Service Forecast Office: site Jordan 1SSW Minimum annual average is from 2000 and maximum is from 2019.
Records indicated with a "T" represent a trace of precipitation.
(https://www.wunderground.com/dashboard/pws/KMNSAVAG31)
(https://w2.weather.gov/climate/xmacis.php?wfo=mpx)

Methods

Sampling

Many parameters are recorded continuously at the Eagle Creek WOMP station including stage, velocity, conductivity, precipitation, and stream temperature. Samples are collected and analyzed for multiple water quality parameters (Table 3) during base flow conditions and storm events. Base flow samples are taken bi-weekly during periods of time unaffected by rainfall or snowmelt events. Samples are taken directly from the stream and then transported to the Metropolitan Council Environmental Services Laboratory for analysis. In 2021 the site was upgraded with an automated sample collector designed to collect individual samples throughout the rise, peak and fall of the stream during a precipitation event. The event samples are treated similar to base flow samples and the grab samples are brought to the lab for analysis. The site was visited, and samples were collected twenty-nine times during the 2021 monitoring season, three of which were event-based samples.

Flow

There are two means of measuring stage and flow at the WOMP station: A WaterLOG bubbler system and Sontek Argonaut Shallow Water (SW) system. The bubbler system has been used since 1999 to measure stage. To determine the amount of flow related to stage, flow measurements are taken manually by MCES staff with a flow meter while the creek is at different stages and a rating curve is developed. With this data, a stage-flow relationship can be applied to the datalogger program, which then calculates continuous flow values as determined by the measured stage.

The Sontek Argonaut-SW was installed by the Metropolitan Council in 2008. This equipment calculates instantaneous flow based on the cross-section area, stage, and velocity of the water. This equipment was determined necessary because of occasional backwater conditions caused by beaver dams or flooding of the Minnesota River. The bubbler system is not able to determine that the water is moving slower, so it automatically calculates higher flow as the stage rises. The Argonaut is able to adjust the flow as velocity changes, making the flow values more accurate during backwater conditions.

Results

The range of sampled water quality parameters are reported in table 3. The minimum, 25^{th} percentile, median, mean, 75^{th} percentile and maximum values are reported along with any state standard or comparable ecoregion range or mean for comparison purposes. Individual TSS and E. coli samples are plotted in figures 10 and 12 respectively. The 5-year trend of monthly TSS values and monthly geometric mean of all E. coli samples taken over the past 10 years are reported in figure 11 and 13 respectively.

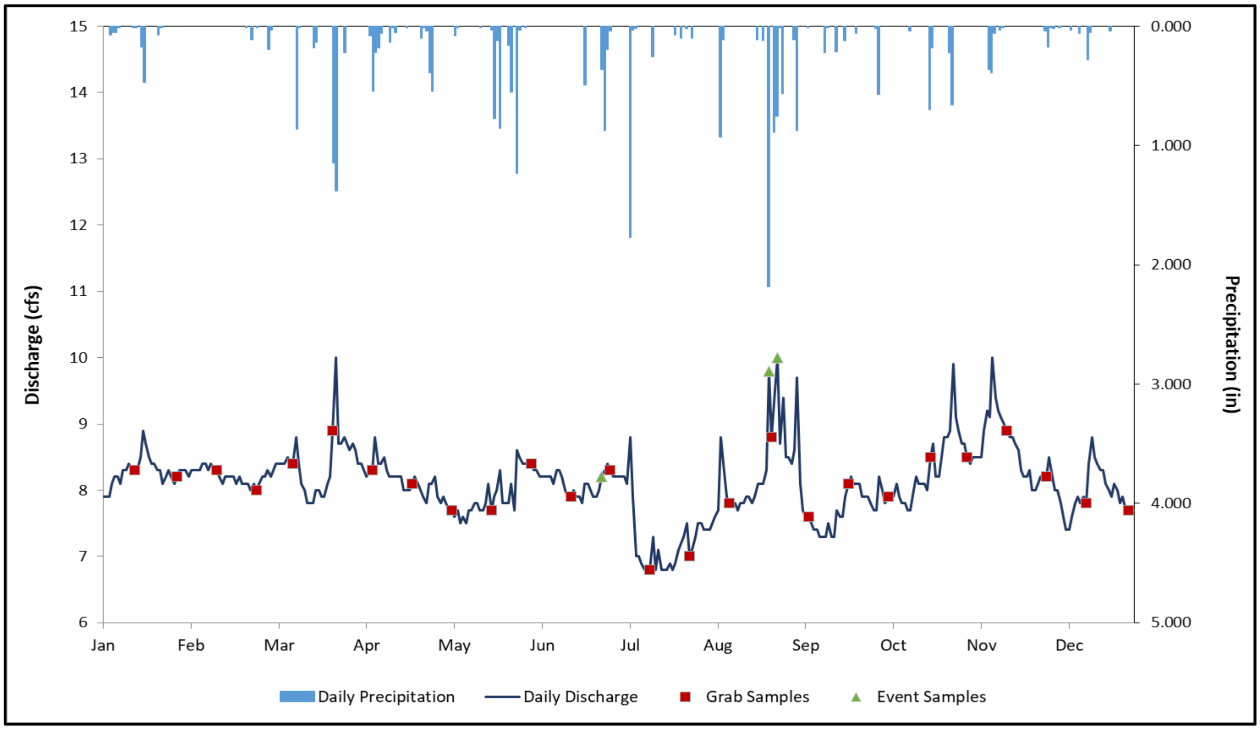

Figure 9. 2021 Eagle Creek WOMP discharge, precipitation, and samples collected. Discharge data is provided by METC and is preliminary.

Table 2. 2021 *In situ* water quality measurements taken by YSI EXO 1 multi-probe mini sonde during 2021 sampling.

Parameter	Min	25th %	Median	Avg	75th%	Max	N	Notes
Temp (deg C)	5.24	8.57	11.03	10.40	12.45	14.38	27	
DO (mg/L)	7.62	8.14	8.56	8.55	8.97	9.72	27	Standard = > 7 mg/L
pH (Units)	7.13	7.42	7.53	7.50	7.64	7.76	27	Standard = 6.5-8.5
Conductivity (umho/cm)	671.2	680.4	683.4	682.8	685.6	688.3	27	

Table 3. 2021 Water quality preliminary lab results. Red text indicates exceedance of the noted standard limit.

Parameter	Min	25th %	Median	Avg	75th%	Max	N	Notes
Alkalinity (mg/L_CaCO3)	261	262	266	268	277	280	4	No standard: 20-200 mg/L typical
Chloride (mg/L)	40.5	49.9	51.6	51.5	53.2	66.9	33	Standard = 230 mg/L
Hardness (mg/L_CaCO3)	288.0	292.8	313.5	310.0	323.8	325.0	4	
Ammonia (mg/L)	0.06	0.06	0.06	0.07	0.07	0.10	33	
Sulfate (mg/L)	15.6	16.1	17.6	17.4	18.5	18.8	4	

Nitrate (mg/L)	0.20	0.20	0.20	0.21	0.20	0.26	33	Ecoregion mean = 0.04-0.26 mg/L
Nitrite (mg/L)	0.06	0.06	0.06	0.06	0.06	0.06	33	Ecoregion mean = 0.04-0.26 mg/L
Total Kjeldahl Nitrogen (mg/L)	0.10	0.23	0.27	0.36	0.33	2.20	33	
Total Phosphorus filtered (mg/L)	0.020	0.020	0.020	0.026	0.020	0.081	33	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Total Phosphorus unfiltered (mg/L)	0.020	0.020	0.028	0.059	0.073	0.460	33	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Ortho Phosphate (mg/L)	0.010	0.010	0.010	0.011	0.010	0.032	28	
Total Organic Carbon (mg/L)	1.9	2.0	2.3	2.3	2.5	2.5	4	
Suspended Solids (mg/L)	1	3	6	18	19	234	33	Ecoregion mean = 4.8-16 mg/L Standard = 10 mg/L
Volatile Suspended Solids (mg/L)	1	2	2	5	6	68	33	
E. Coli (#/100ml)	6	27	54	105	149	579	29	Standard = 126 CFU/100ml as geometric mean

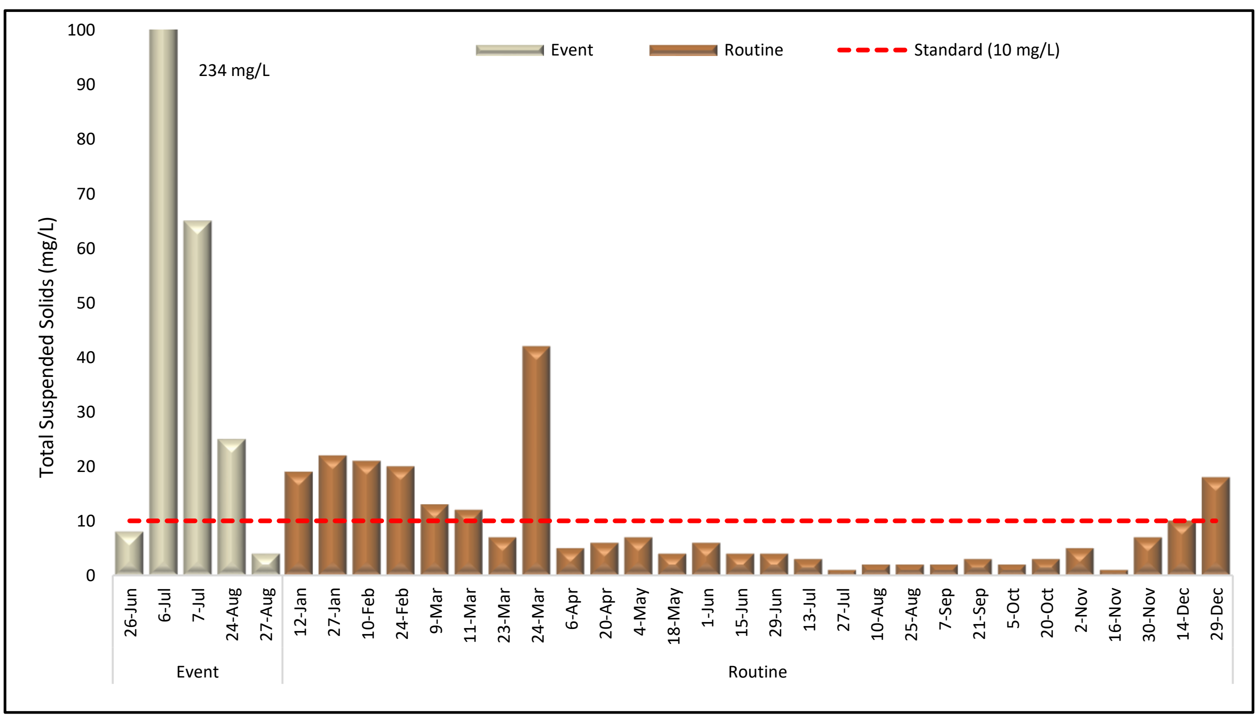

Figure 10. Total Suspended Solids (2021). State Standard for Class 2A Waters = 10 mg/L (indicated by the red dashed line and the shaded areas in the graph) with no more than 10% exceedance between 1 April and 30 September.

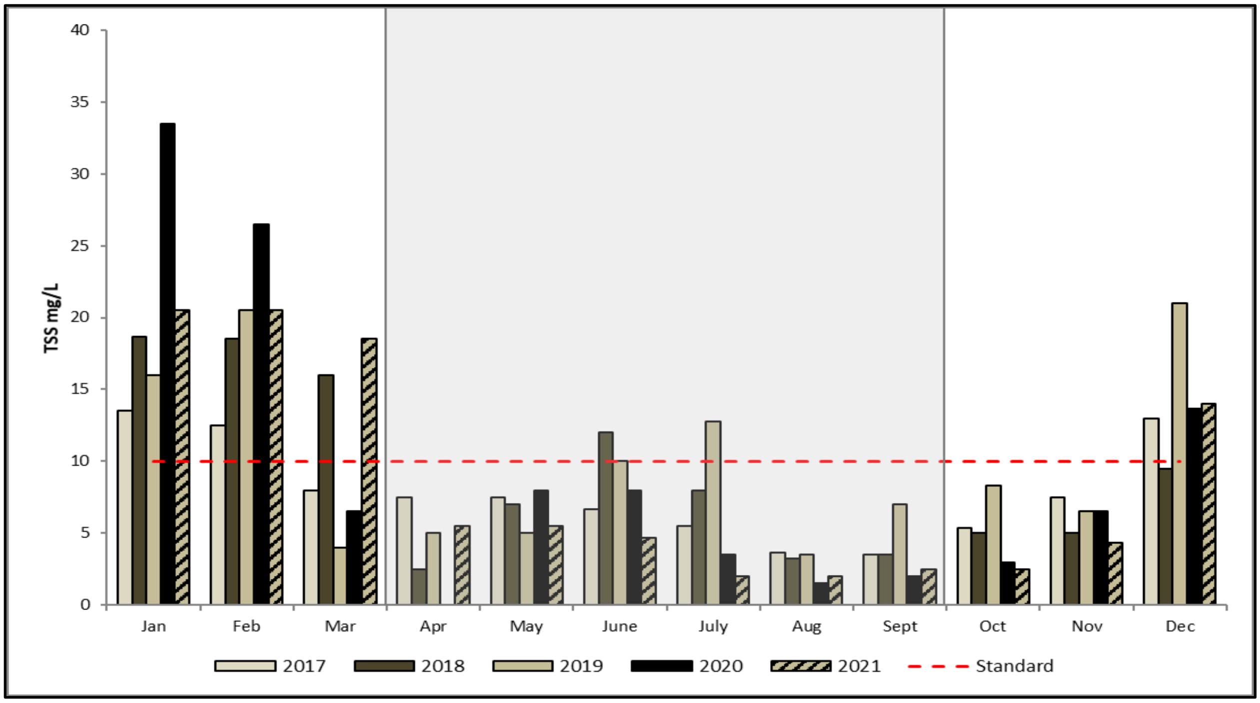

Figure 11. Total suspended solid monthly average over the last 5 years for non-event samples. The state standard is 10mg/L indicated by the dashed red line. No more than 10% exceedance shall occur between 1 April and 30 September (shaded area).

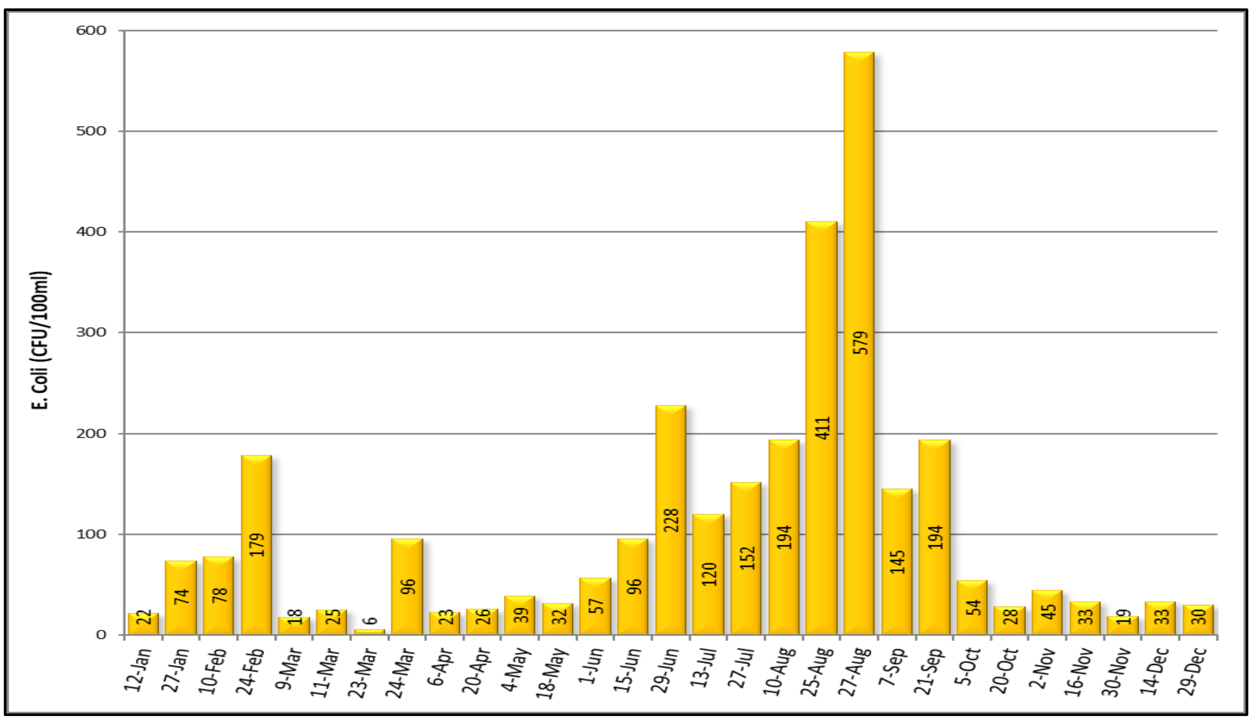

Figure 12. *E. coli* samples (2021). *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative of conditions within any calendar month. Nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml. The standard applies only between April 1 and October 31.

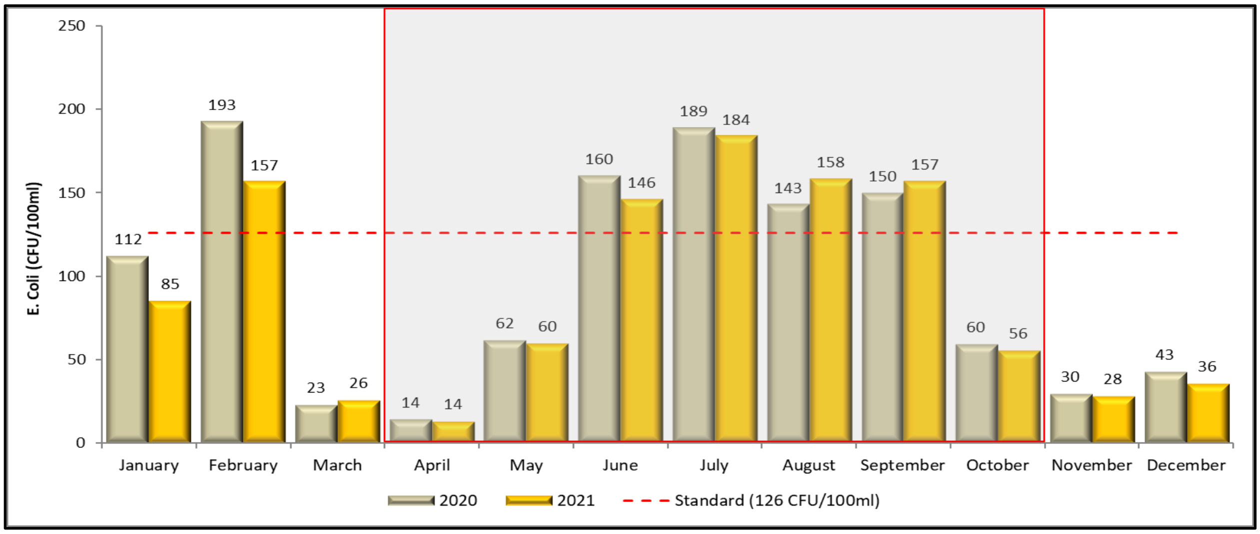

Figure 13. Geometric mean of *E. coli* at Eagle Creek. The geometric mean was calculated using all samples over the past 10 years (2011-2021) for any given month. *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative of conditions within any calendar month. Nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml. The standard applies only between April 1 and October 31.

Discussion

In general, the monitoring data suggests that Eagle Creek consistently meets state water quality standards and ecoregion means[1], with the exceptions being bacteria and suspended solids (Figure 10, Figure 13, and Table 3). The elevated levels of these parameters in winter are a result of the creek being spring fed and not freeze over in the winter. The open water attracts a large number of waterfowl and other animals, which results in historically higher bacteria, sediment, and turbidity levels than observed in summer months. Elevated levels during the summer are a result of continual animal use and runoff from significant rain events.

The *E. coli* standard is applicable from April 1 – October 31 and is exceeded when greater than 10% of the samples exceed 1260 Colony Forming Units (CFU) per 100 ml *or* the geometric mean of no fewer than five samples in a calendar month exceed 126 CFUs. No samples exceeded 1260 CFU's from April through October in 2021. Additionally, the geometric mean of the previous ten years of *E. coli* samples resulted in the exceedance of 126 CFU's for June thru September (Figure 13). February also exceeded the 126 CFU threshold leaving seven months below the standard. Compared to 2020, eight months showed a lower geometric mean, one month stayed the same and three months increased by an average of 8 CFU's.

The previous state turbidity standard was replaced with a Total Suspended Solids (TSS) standard. The new TSS standard for Class 2A waters state that no more than 10% of samples shall exceed 10 mg/L between April 1 and September 30. This year, Eagle Creek exceeded 10 mg/L in 11 of 33 (33%) lab samples during the 2021 monitoring season, down 3% from 2020 (Figure 10). For all of the samples collected from April thru September, 3 of 18 (16.7%) exceeded the state standard. All of the samples that exceeded the standard were collected during "event" based sampling. The other eight samples that exceeded the 10 mg/L were during the winter months when waterfowl is constantly seen using the body of water.

[1] There are seven ecoregions in Minnesota. Ecoregions are classified by geographic areas with similar plant communities, land use, soil, and geology. Eagle Creek is located in the North Central Hardwood Forest (NCHF) ecoregion. Each ecoregion has unique water quality goals as determined by historical monitoring of representative and minimally impacted reference streams within that ecoregion.

III. Dean Lake Inlet Monitoring

Dean Lake Inlet was once on the Minnesota Pollution Control Agency (MPCA) 303 (d) list of impaired waters from 2006-2016. It was impaired for aquatic recreation due to excess nutrients causing eutrophication. In 2016 the body of water was re-assessed and reclassified as a wetland in the MPCA's Lower Minnesota River Watershed Monitoring and Assessment Report of June 2017. Although the reclassification removes the body of water from the 303 (d) list the nutrient loading still remains. Scott SWCD continues to provide monitoring data on the inlet to Dean Lake to document nutrient loading. The monitoring site is located where CR21 passes over the Prior Lake Outlet Channel to the southeast of Dean Lake. The SWCD monitors water chemistry and continuous stage and flow at this location. This site has been monitored from 2014 to present.

Methods

In-stream field measurements of dissolved oxygen, temperature, turbidity, pH, and conductivity were taken using an YSI EXO 1 multiparameter Sonde. Field transparency is measured with a 1-meter secchi tube. Bi-weekly scheduled samples and additional event grab samples taken after rain events are taken while the stream channel is open (March-November). In 2021, 17 base grab samples and 2 event grab samples were collected totaling 19 samples. In addition to water quality samples, periodic flow measurements are typically taken throughout the monitoring season. No flow measurements were taken in 2021 due to the over-abundance of invasive aquatic vegetation near the flow monitoring location and the lack of flow from drought conditions. With flow measurements from previous years a discharge rating curve is developed for the site. This rating curve is applied to the continuous 15-minute stage measurements collected by Campbell Scientific SR50 Ultrasonic Distance Sensor and CR1000 data logger to calculate continuous discharge data at the site (Figure 14).

Results

The 2021 monitoring data suggest that the inlet to Dean Lake continues to fall outside of ecoregion mean and EPA recommendations for phosphorus, nitrate, and suspended solids (Table 5). Historically, the inlet has seen spikes in nitrate and phosphorus. During the 2021 sampling season the total unfiltered phosphorus fell beyond the EPA recommended level 32% of the time and measured below and above the Ecoregion mean 53% and 5% of the time respectively. This is a 19% increase in EPA exceedance and Ecoregion highs compared to 2020. The nitrates exceeded the Ecoregion high 53% of the time, up 15% from 2020 and 39% from 2019. Additionally, the suspended solids were at or exceeded the state standard 16% of the time and went above the Ecoregion high 11% of the time. This showed a 28% decrease in state standard exceedance and a 1% increase in Ecoregion high exceedance when compared with the 2020 data. Finally, a total of 8 dissolved oxygen measurements fell below 5 mg/L (acceptable limits for most aquatic life). The last time low dissolved oxygen levels were observed was in 2018 when two measurements fell below the 5 mg/L threshold.

Table 4. 2021 *In situ* water quality measurements taken by a YSI EXO1 multi-probe mini sonde for Dean Lake Inlet.

Parameter	Min	25th %	Median	Avg	75th%	Max	N	Notes
Temperature (°C)	6.33	12.09	15.42	14.85	12.09	23.15	19	
Dissolve Oxygen (mg/L)	1.72	3.49	5.37	5.87	8.18	11.00	19	
pH (Units)	6.96	7.30	7.36	7.39	7.45	7.91	19	
Conductivity (umho/cm)	545.4	602.8	670.8	659.8	703.0	796.3	19	

Table 5. 2021 water quality data from Dean Lake Inlet. Red text indicates exceedance of the state standard, North Central Hardwood Forest ecoregion means, or EPA recommendations.

Parameter	Min	25th %	Median	Avg	75th%	Max	N	Notes
Chloride (mg/L)	48.00	49.5	52.9	57.1	59.3	84.6	19	Standard = 230 mg/L
Nitrate (mg/L)	0.20	0.20	0.26	0.31	0.40	0.64	19	Ecoregion mean = 0.04-0.26 mg/L
Nitrite (mg/L)	0.06	0.06	0.06	0.06	0.06	0.06	19	Ecoregion mean = 0.04-0.26 mg/L
Total Kjeldahl Nitrogen (mg/L)	0.32	0.43	0.62	0.64	0.69	1.40	19	
Total Phosphorus filtered (mg/L)	0.020	0.020	0.028	0.064	0.054	0.504	19	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Total Phosphorus unfiltered (mg/L)	0.031	0.042	0.055	0.074	0.119	0.175	19	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Lab Turbidity (NTRU)	2	2	3	7	7	45	19	
Suspended Solids (mg/L)	1	2	4	8	7	62	19	Ecoregion mean = 4.8-16 mg/L Standard = 30 mg/L
Volatile Suspended Solids (mg/L)	1	1	2	3	3	20	19	

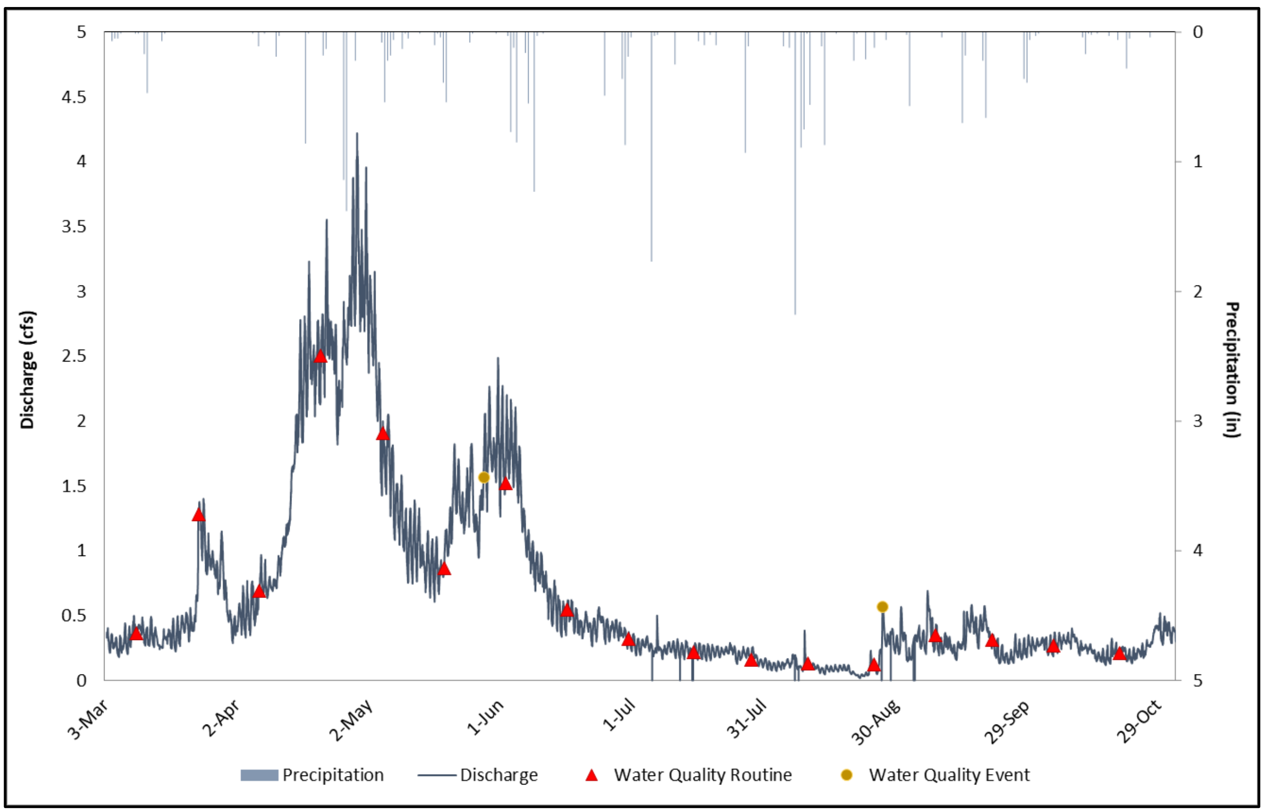

Figure 14. Dean Lake Inlet continuous 15min discharge data, precipitation, and water quality samples collected in 2021.

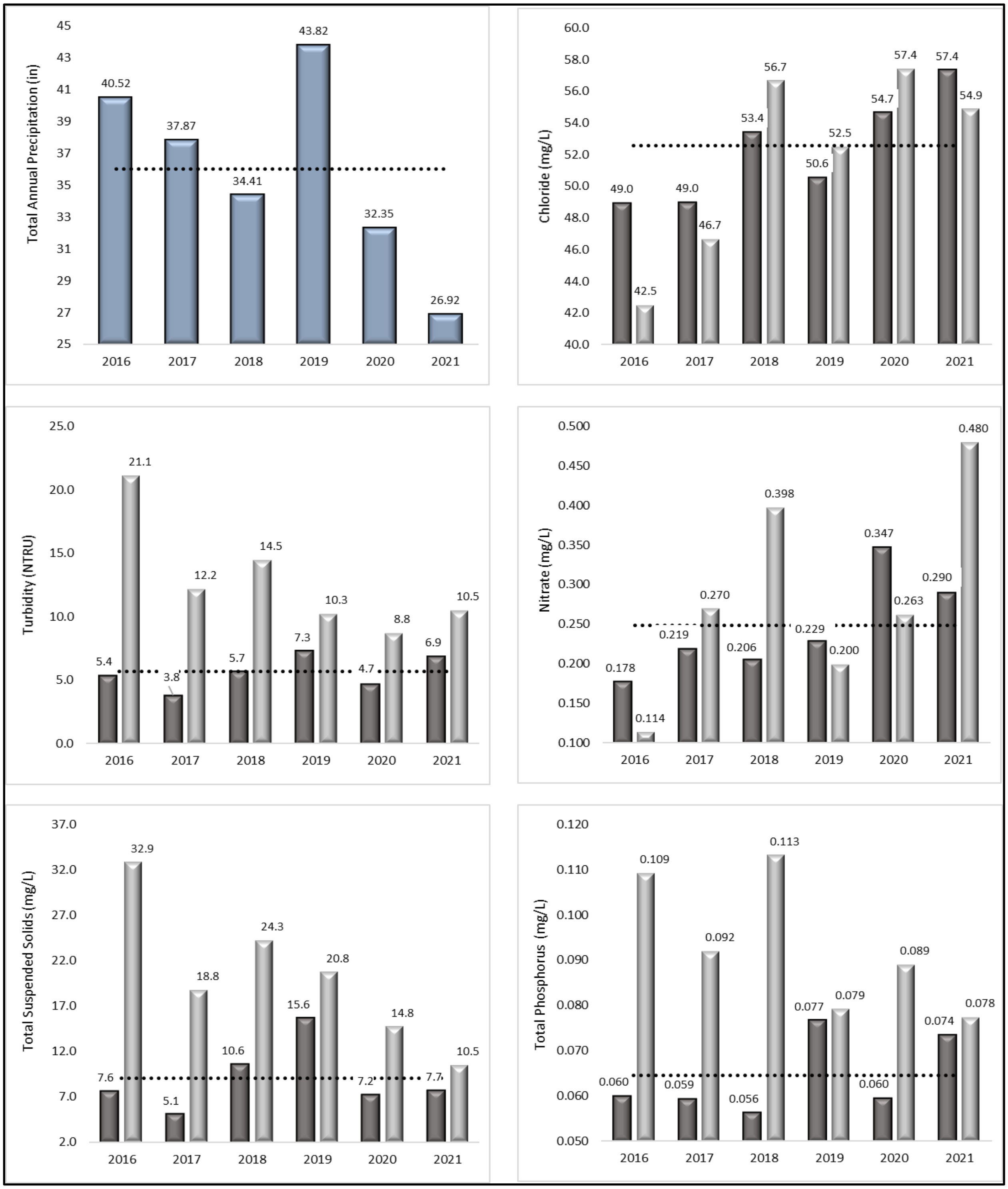

Figure 15. Graphs comparing the annual averages from routine (bi-weekly) monitoring (dark gray bars) and event-based annual averages (light gray bars). The graphs represented are total annual precipitation (top left), chloride concentration (top right), turbidity (middle left), Nitrate concentration (middle right), total suspended solids (bottom left), and total phosphorus – unfiltered (bottom right). The black dashed line in each graph represents the average of all years combined from routine monitoring data only.

Discussion

The discharge at the Inlet mostly trended with precipitation and atmospheric trends. Due to the dry season, the Prior Lake outlet channel was only open during the beginning of the season. Even though Dean Lake is now considered a wetland, it is still prudent to compare annual water quality results to its previous standards to track any water quality improvements or degradations at the site. Minnesota still requires that the quality of wetlands be maintained even if it does not follow previously identified lake standards. Most of the water quality parameters at the Dean Lake Inlet are within the recommended standards and ecoregion averages. In most cases those parameters that exceeded standards were up when compared with 2020. With all of the exceeding parameters, most exceedance is occurring after precipitation events, droughts, or seasonally influence. Monitoring these levels should continue to track any potential increases or decreases in these levels. Throughout the years general trends can be observed in several of the parameters monitored (Figure 15). For example, chloride concentrations appear to track diurnally with annual precipitation totals, and total concentrations have been increasing throughout the years. In general nitrate levels also follow this pattern. Phosphorus levels have been more inconsistent with increased concentrations observed in the routine samples throughout the years and a decrease in event-based samples. The turbidity and total suspended solids are typically driven by precipitation amounts and event frequency which can be observed throughout the monitoring years. Although Dean Lake Inlet is no longer on the 303 (d) list because of its reclassification, it is important to track the amount of nutrients at the site to maintain historical data and track nutrient/pollutant loading downstream.

IV. Well Monitoring

In 2005 the LMRWD contracted with Scott Soil and Water Conservation District to collect groundwater measurements from 13 wells in the Savage Fen, 4 wells in the Eagle Creek area and 2 Bluff wells. Additionally, two artesian wells are located in the Fens and are a part of the MNDNR's observation well (OBWELL) program. The data from all of the well recordings is used to assess groundwater resources, determine long-term trends, and interpret the impacts of pumping and climate. The wells in the Savage Fen were installed by the DNR to monitor development effects and water usage from the City of Savage on the water level in the Fen. All well data is entered into the DNR's groundwater level database and can be accessed at (http://www.dnr.state.mn.us/waters/cgm/index.html).

The MNDNR continually assesses the validity and necessity of monitoring wells around the state. In 2018 the bluff wells sealed, and the MNDNR is currently investigating the need for the Eagle Creek wells and a few of the Savage Fen wells.

Savage Fen Area Wells

The Savage Fen is a rare wetland complex at the base of the north-facing bluffs in the Minnesota River Valley, the largest calcareous fen of its kind in Minnesota. A plant community of wet, seepage sites with an internal flow of groundwater rich in calcium, magnesium bicarbonates and sulfates result in a thick peat base that is able to support a unique diversity of plants. More than 200 various plant species have been found in the Savage Fen, some of which are rare.

Methods

The Scott SWCD is contracted to monitor 13 wells in the Savage Fen monthly between April and October. Additional well levels were recorded into December at three of the wells from outside agencies as part of their requirements for adjacent construction/maintenance projects near the Fens. The water levels in the Fens fluctuate throughout the year and the artesian wells record water levels above ground level. Field measurements of the artesian wells record values in pounds per square inch (psi). The psi measurements are converted to feet of head by multiplying the psi value by -2.31, basically representing how high the water would shoot up in the air if the well was not capped. One of the artesian wells was damaged over the 2020 winter and did not become operational until the middle of the monitoring season. The eleven "normal" and two artesian wells are reported in this annual report. In addition, four wells are monitored in the Eagle Creek portion of Savage Fen on the other side of highway 13 (Figure 19).

In the past, the SWCD had monitored two additional wells in the Savage Bluff area. In 2010 the Savage Post Office and Fire Department was constructed near the bluff wellheads and as a result, the wellheads were reconstructed and placed below the street, accessible beneath a manhole cover. The SWCD did not read these two wells in 2011 or 2012 as a result of the construction. In 2013, the SWCD resumed monitoring these wells with the City of Savage staff providing access. The Bluff wells were sealed during the 2019 season and are no longer accessible. There are two MNDNR observation wells (70024 & 70025) are roughly 300ft southwest of the bluff wells that will continue to monitor groundwater levels in that area but will not be reported in this report. Previous bluff well measurements can be found in annual monitoring reports up to 2019.

In total, the SWCD recorded 136 water level measurements for the LMRWD in 2021 from the 17 wells.

Results

The Savage Fen water levels showed a consistent drop in water levels throughout the 2021 summer and started to rebound at the end of the monitoring season (Figure 16 & 22). Overall, the average water levels for the non-artesian wells decreased 0.83 feet throughout 2021, with some wells dropping more than others (Figure 18, 19 & 20). Historically, the Fens have shown signs of fluctuation, and have generally been slightly increasing in water levels to recover from a dip in 2012. Recently with warmer temperatures and less precipitation over the growing season the water levels have once again shown a decline in levels. This year the wells levels decreased with an average 0.58-foot drop in water levels over the last 10 years (Figure 17). The 2021 Eagle Creek well levels generally showed a decrease throughout the year with all the wells averaging a 0.47-foot drop throughout the year (Figure 24). The wells were 0.24ft lower on average when compared to the 10-year average. This was due to the fact that all four wells were 0.07-0.38ft lower than average. Even with the drop in well levels in 2021 the EC3 and EC5 wells continue to show a downward trend over the last 10 years, while EC4 and EC6 show an upward trend (Figure 25).

In 2021 all the Savage Fen wells showed a decrease in water levels when compared with 2020 and also a decreased over the 10-year average (Figure 21). All of the Eagle Creek wells decreased in water levels when compared with 2020 data, except for EC3 which recorded a slight increase. The Eagle Creek wells also showed a decrease when compared with 10-year averages in all wells (Figure 26).

All figures in this section are reported in depth to water (DTW) which is a product of the wells measuring point elevation minus the elevation of the recorded observed elevation, or feet above ground for the artesian wells.

Savage Fen Well Graphs

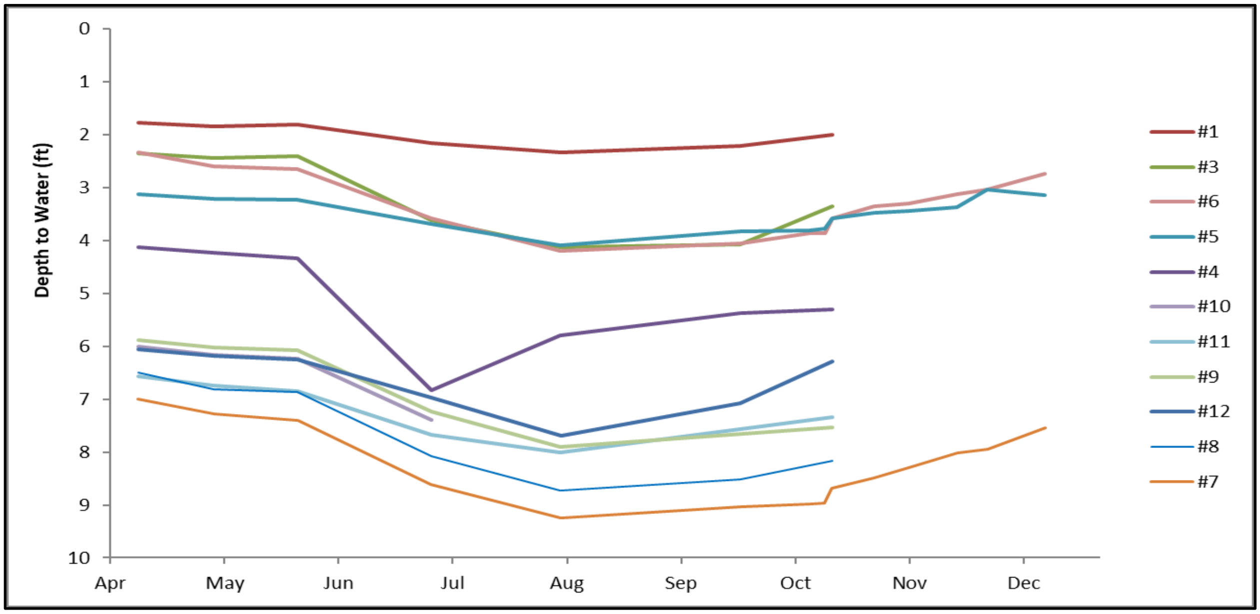

Figure 16. Savage Fen Wells (2021)

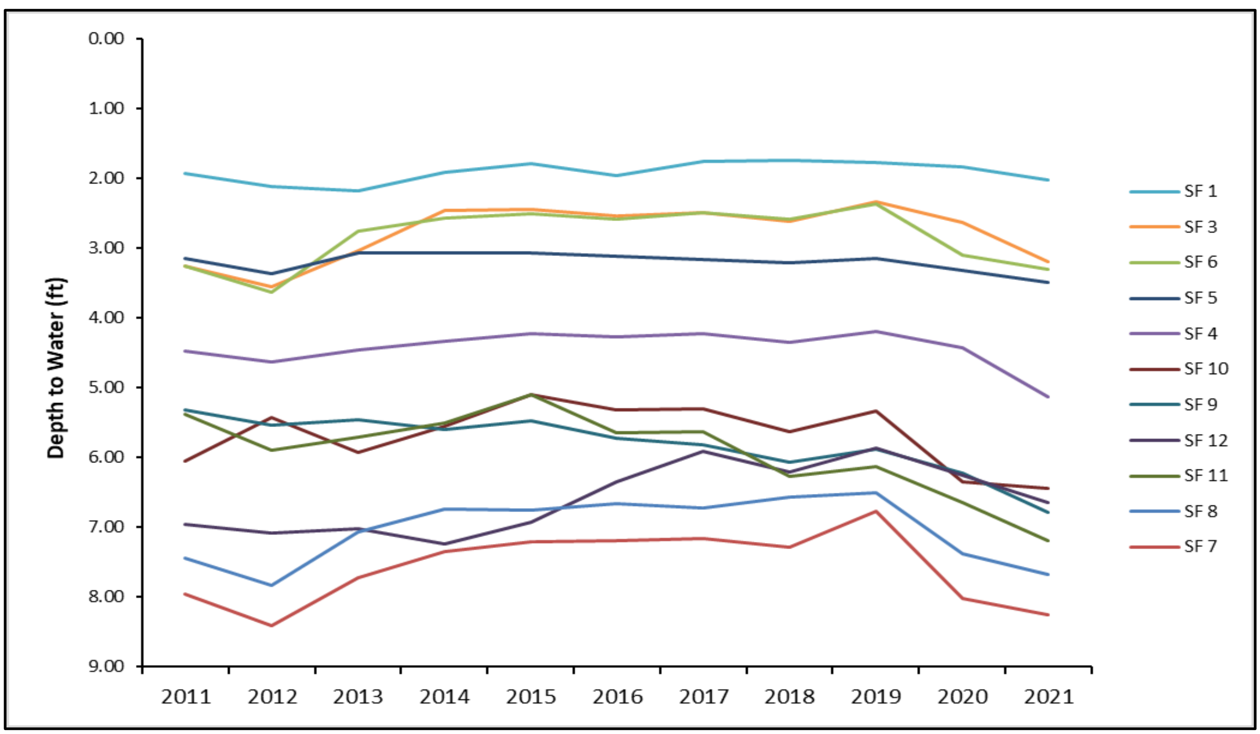

Figure 17. Average annual water level in Savage Fen wells (2011-2021). Averages include all observation in a calendar year.

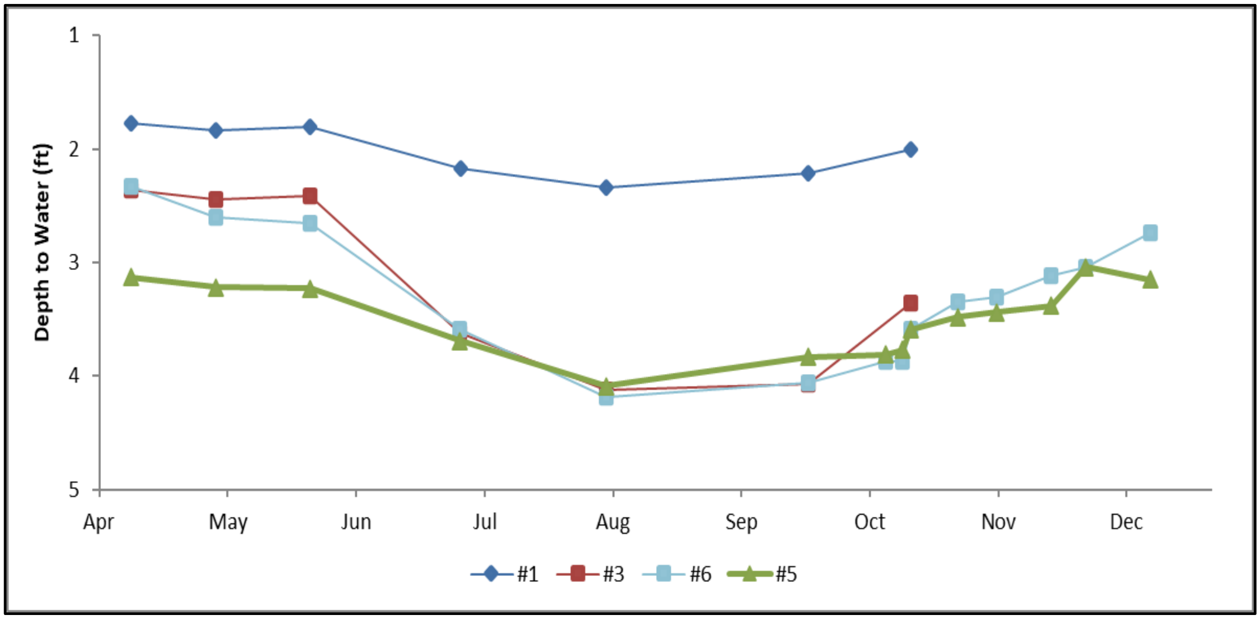

Figure 18. The four Savage Fen wells with the shallowest depth to water (DTW) values for 2021.

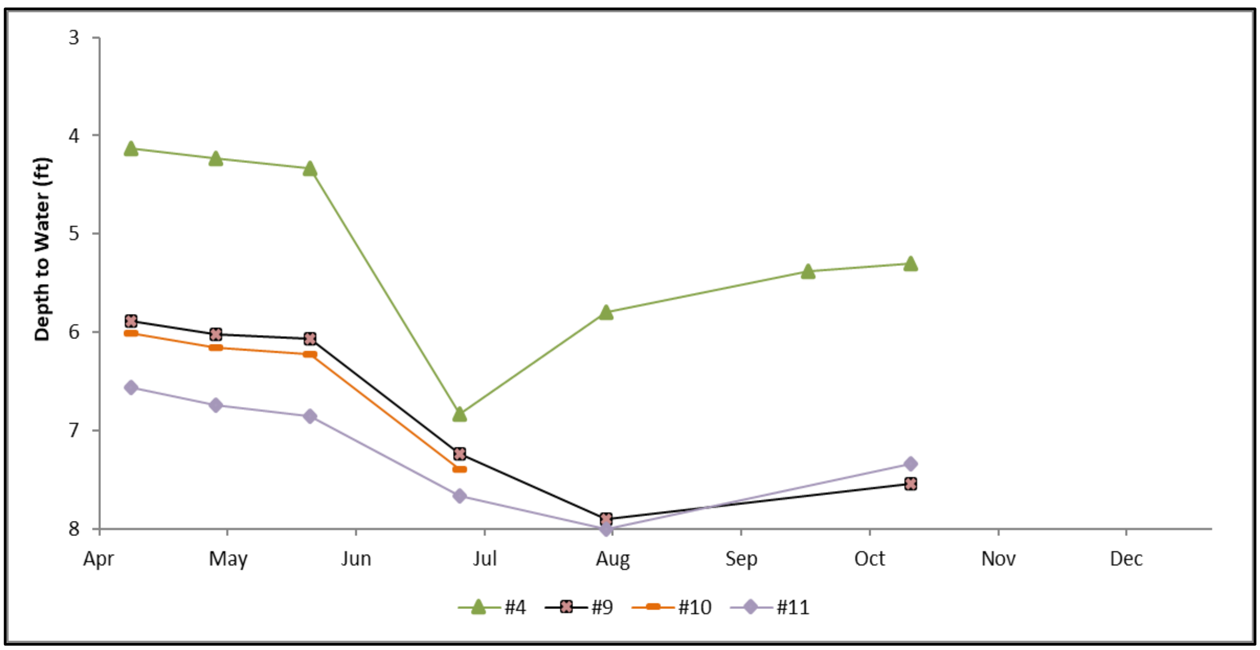

Figure 19. The four Savage Fen wells with the mid-level depth to water (DTW) values for 2021.

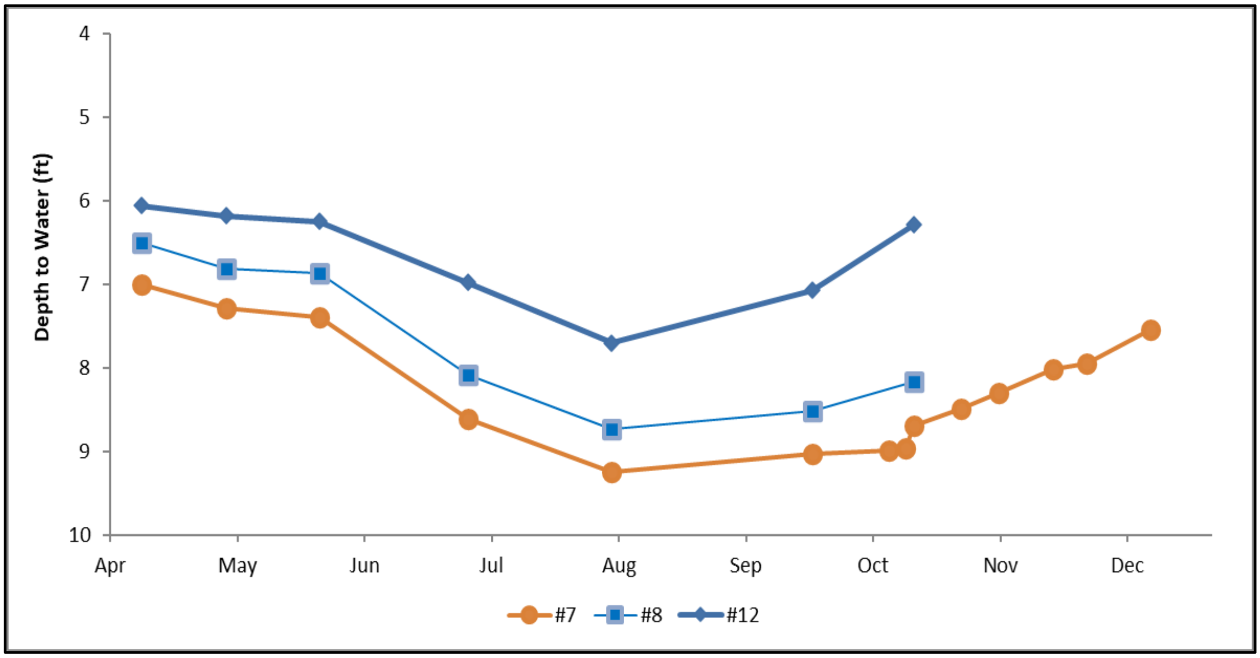

Figure 20. The three Savage Fen wells with the deepest depth to water (DTW) values for 2021.

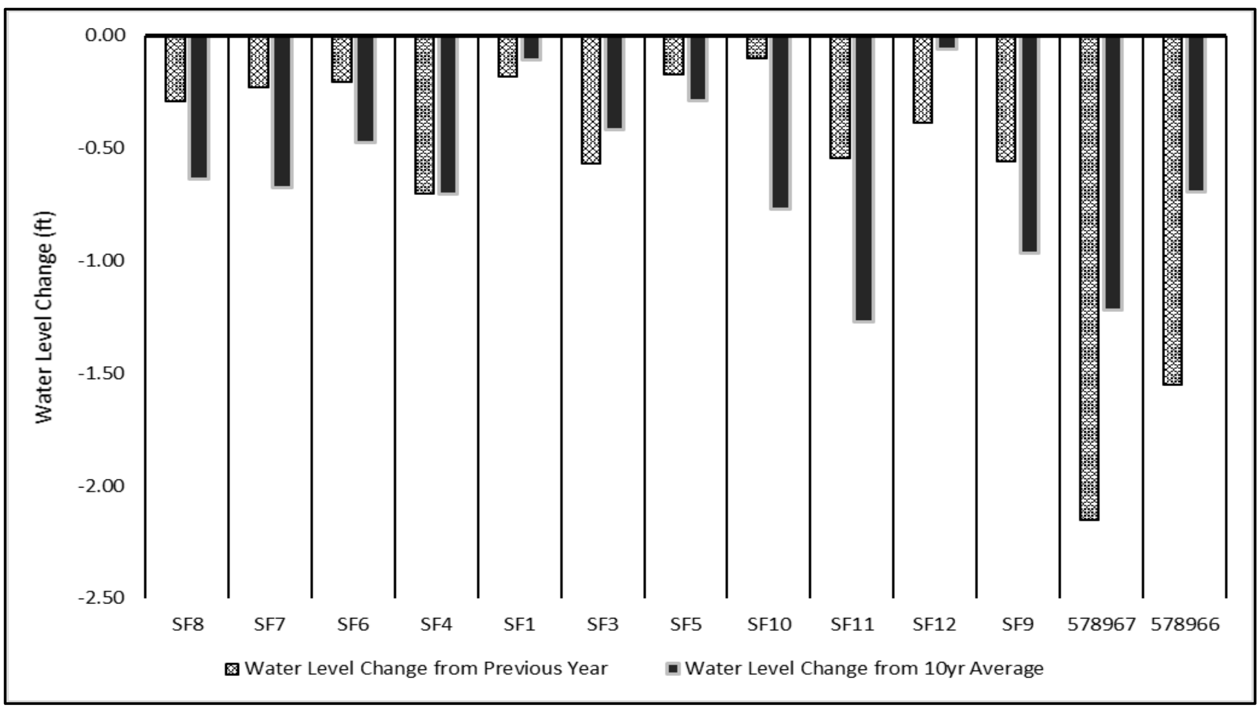

Figure 21. The water level changes at each Savage Fen well when compared with the previous year and the 10yr average depth to water. Average 2021 depth to water levels were used to compare with average 2020 values and 10yr historical average.

Savage Artesian Well & Historical Trend Graphs

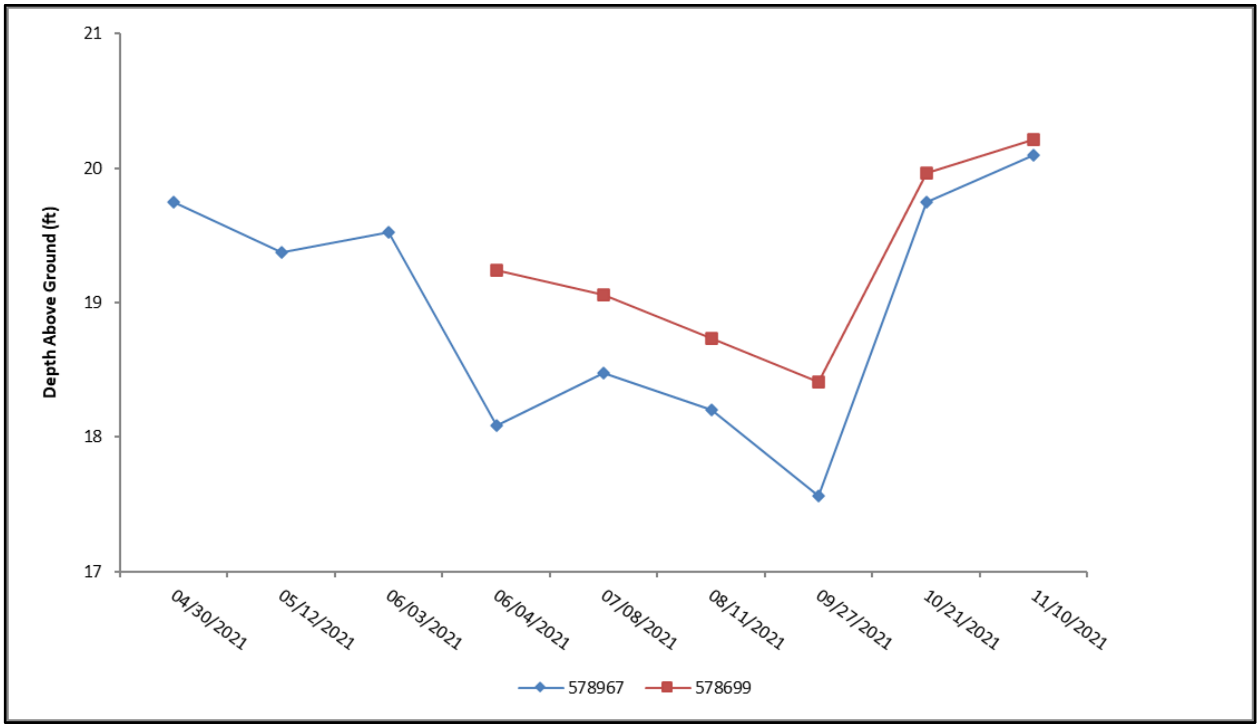

Figure 22. Savage Fen artesian wells (2021). Values are represented in feet above the ground.

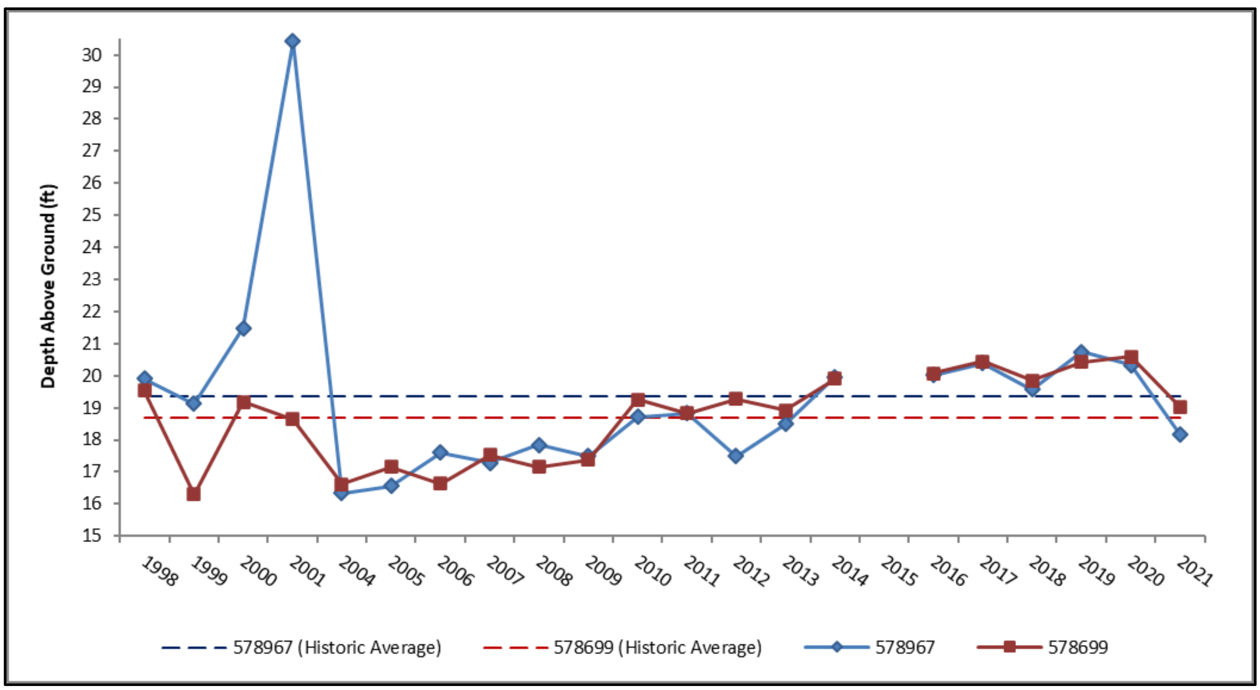

Figure 23. Average annual water level for the Savage Fen artesian wells (2011-2021). Averages include all observation in a calendar year. Historic averages are an average of all years sampled. Values are represented in feet above ground.

Eagle Creek Area Wells

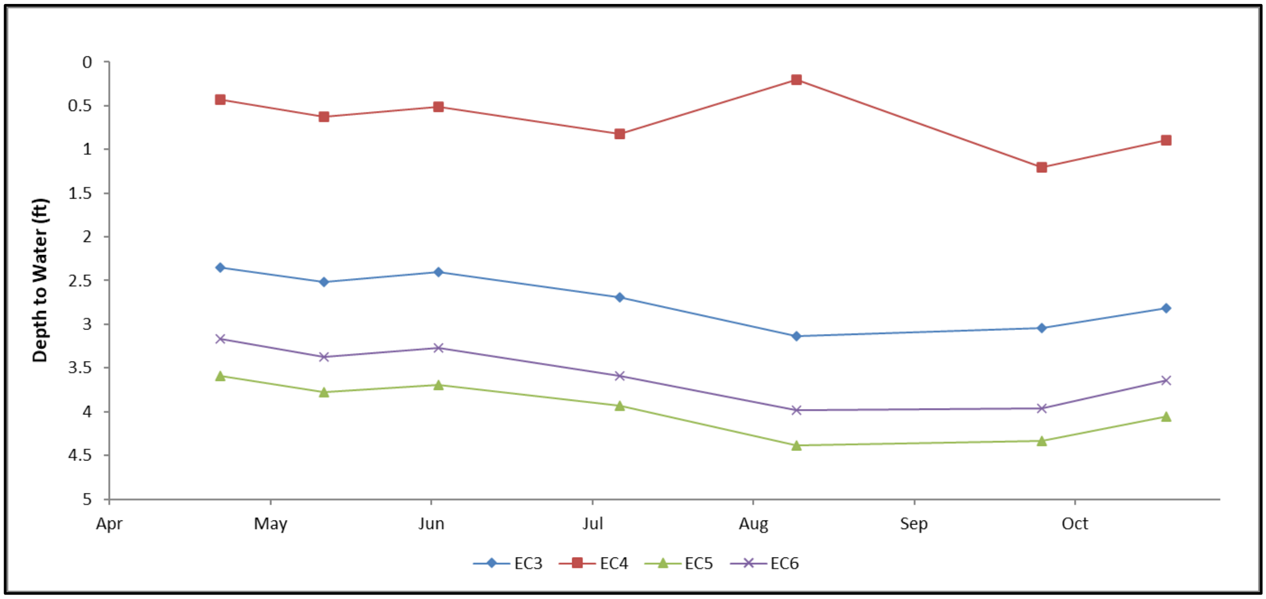

Figure 24. Eagle Creek well measurements for 2021.

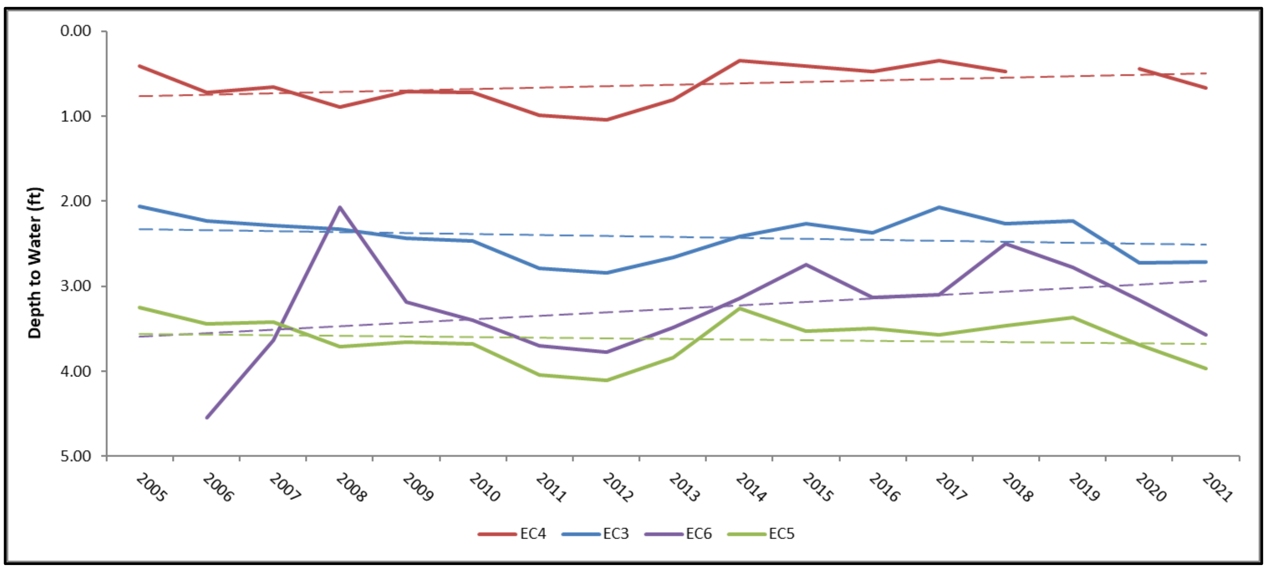

Figure 25. Eagle Creek historical trends. Values are annual averages based on all DTW measurements collected within each year.

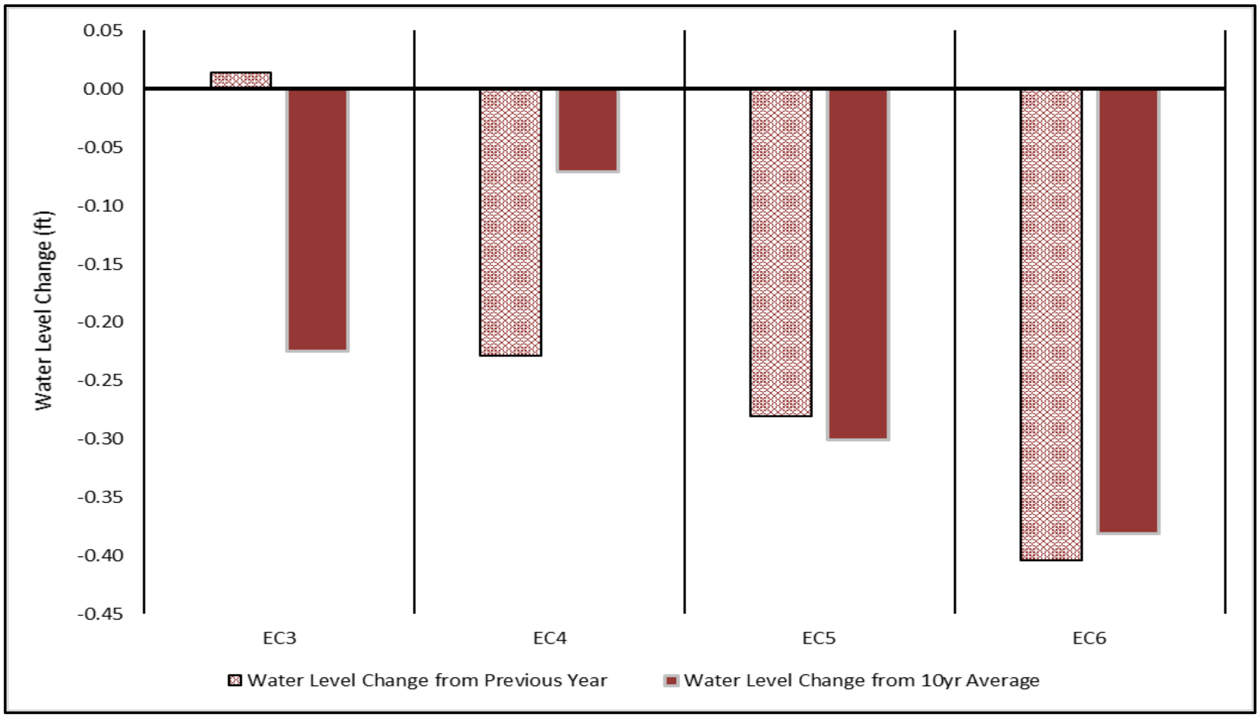

Figure 26. The water level changes at each Eagle Creek well when compared with the previous year and the 10yr average depth to water. Average of all 2021 DTW measurements collected were used to compare with average 2020 values and 10yr historical averages.

Discussion

Similar to the 2020 the monitoring season in 2021 was seasonably dry which led to a continued decrease in water levels in all of the monitored wells. The total precipitation values increased near the end of the monitoring season allowing the wells to recharge prior to the winter freeze. Although lower seasonal precipitation values can show a change in surface wells, decreased groundwater levels can amplify the lower levels in all the wells. A continual annual increase in the wells from 2012 allowed for the drop in 2020 and 2021 without having significant implications to historical groundwater levels. There are many factors that can impact groundwater levels in northern Scott County. Seasonally, the amount of snowpack and precipitation throughout the year will determine recharge levels and rates. Other factors like groundwater consumption and surface water re-direction will also impact groundwater levels. Looking forward to the 2022 monitoring season, the MNDNR is still considering sealing the Eagle Creek wells and a few of the Savage Fen wells. Depending on their monitoring needs some wells may be limited to the number of measurements available. Extending well monitoring measurements for an additional couple of months would help capture recharge values and show the most current well levels prior to the winter freeze. Continual monitoring of all the available wells in the LMRWD area will provide information on groundwater levels that can provide information on the impacts of water usage and recharge capabilities. It also tracks water levels in a valuable resource to ensure water levels remain sufficient for the soils and rare plant communities in the Savage Fens.

V. References

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