# U.S Steel Minntac

# Twin Lakes Wild Rice Restoration

# Opportunities Plan

# 2016 Annual Report

**December 30, 2016**

# U. S. Steel Minntac

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**December 30, 2016**

**Prepared For**

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# EXECUTIVE SUMMARY

The third full year of work related to the Twin Lakes Wild Rice Restoration Opportunities Plan (Plan) was completed during 2016. The Plan was developed and undertaken to satisfy Special Condition 10 of the United States Army Corps of Engineers Wetland Permit 2011-00823-JCB.

Plan activities were initiated prior to freeze-up in 2013. The first full year of Plan activities to begin the process of assessing the potential for restoring healthy stands of wild rice in the Twin Lakes was completed in 2014. A majority of these activities were continued during 2015. At the end of 2015, wild rice was planted in six separate plots, three each on both Little Sandy and Sandy Lakes. After finding five out of the six plots growing wild rice in late June of 2016, a majority of the work effort was focused on the wild rice plots, as well as water and sediment pore water quality in these areas. Although minimal beaver activity was observed during 2016, above average rainfall, beginning in May and continuing through September, resulted in high lake levels throughout the growing season. Current physical conditions, such as water depth increases and fluctuations, within the Twin Lakes system may not be conducive to wild rice growth and development throughout the majority of the Twin Lakes system. Peepers were once again used to measure sediment pore water quality in various portions of the Twin Lakes system. Overall, the pore water in the Twin Lakes sediment showed low hydrogen sulfide and high iron concentrations; however, the sediment pore water on the west end of Little Sandy Lake (specifically the Inflow 2 location) was found to have very high sulfide and corresponding low iron levels. These topics, along with the regular water quality and quantity characterizations, are discussed in more detail in their specific sections of this report. Work on the Plan will continue through 2017, as required by permit.



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# 1.0 INTRODUCTION

On December 10, 2012, the United States Army Corps of Engineers (Corps) issued Wetland Permit 2011-00823-JCB for wetland impacts resulting from the United States Steel (U. S. Steel) Minntac Western Progression Project. Special Condition 9 of Wetland Permit 2011-00823-JCB required U. S. Steel to submit a Twin Lakes Wild Rice Restoration Opportunities Plan (Plan) within 120 days of permit issuance. U. S. Steel submitted the Plan in final form (Revision 1) to the Corps on August 6, 2013. Special Condition 10 of the permit required implementation of the Plan no later than October 31, 2013. Activities related to the Plan were initiated on October 9, 2013. On November 22, 2013, the Corps approved Revision 1 of the Plan. Plan activities completed during 2014 and 2015 are provided in annual reports submitted to the Corps for each of those two years.

During 2016, a number of activities were completed in support of the Plan and / or in preparation for initiation, continuation, and / or completion of components of the Plan during subsequent monitoring seasons. The following provides the details of Plan activities undertaken during 2016, in partial fulfillment of Special Condition 10 contained in Corps Wetland Permit 2011-00823-JCB, and represents the culmination of three full years of work related to the required five-year work plan. It should be noted that, at this time, it is premature to draw any definitive conclusions with respect to any specific wild rice restoration opportunities for the Twin Lakes. However, discussion of preliminary results will be included in individual sections as appropriate.

# 2.0 WORK COMPLETED IN 2016

## 2.1 TWIN LAKES RAINFALL, WATER DEPTH, AND TEMPERATURE MONITORING

To evaluate the effect of natural hydrologic inputs to and outputs from the Twin Lakes system, and implementation of various aspects of the Plan, the depth of water at the northwest side of the steel bridge which separates the two lakes has been monitored. To facilitate continuous water level measurements, an OTT / Hach pressure transducer (PT) was purchased and deployed for approximately 1.5 months in 2013, 6 full months in 2014 and 6.5 months in 2015. On April 21, 2016, immediately following ice-out, the PT was re-deployed at the same location and continued operating until removal on November 17, 2016. Typically, the PT had data downloaded once a month during the water sampling/monitoring event. The PT performed well with no lost data during the 2016 deployment. Daily precipitation totals were collected at the USS Minntac Tailings Basin weather information collection site approximately two miles southwest of the PT location and was compiled for comparative purposes. The results of the 2016 monitoring for rainfall, water depth, and temperature can be found in Appendix A.

The graph in Appendix A does indicate that the Twin Lakes water depth is greatly affected by rainfall. The local weather service has stated that 2016 was one of the wettest summers on record and even with the elimination of the beaver along Sand River, the water remained elevated for most of the summer. There was one period, in late May 2016, where the water dropped below 2.5'. The rest of the period never saw that level again until mid-November. Further discussion concerning the water level will



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be made in Section 2.6 Twin Lakes Inflow / Outflow Flow Measurements and Section 2.8 Sand River (and Twin Lakes) Beaver and Dam Removal Activities.

In an effort to better detail water depth fluctuations within the Twin Lakes system, six bathymetric maps of Little Sandy and Sandy Lakes (April – September 2016) were constructed using water depth measurements from the Twin Lakes bridge pressure transducer (Appendix A) and water depth measurements obtained during the 2016 aquatic plant survey. See Section 2.7 (Figure 5) for additional details.

## 2.2 Twin Lakes Sediment Bioassay

During October 2013, multiple sediment sampling events were completed to collect sediment samples from each lake for use in a wild rice bioassay. During 2013 and 2014, initial wild rice bioassays were completed using bulk sediment sampled from Sandy Lake. Initial results of the wild rice sediment bioassay support the conclusion that wild rice seed (obtained from Whitefish Lake, Ontario) successfully germinated and developed into viable seedlings during exposure to sediment sampled from Sandy Lake.

The 2016 wild rice bioassay using Twin Lakes sediment and surface water was scheduled to be completed during late summer or early fall (2016). This component of the Twin Lakes work plan was postponed due to the July 2016 observance of wild rice growth in areas that were planted with wild rice seed during Fall 2015. In general, previously completed wild rice bioassays during 2013 and 2014 correctly predicted how wild rice seed may respond when exposed to sediment from Sandy Lake. Additionally, wild rice seed germinated and grew into floating leaf and / or mature aerial stage plants in multiple locations on Little Sandy Lake.

During October 2015, wild rice seed was broadcast over six test plots within the Twin Lakes system; three plots in Little Sandy Lake and three plots in Sandy Lake. During August 2016, mature seed-producing wild rice plants were observed growing in four of the six test plots; all three plots in Sandy Lake and one test plot in Little Sandy Lake. Any future efforts towards bioassay development will focus on using sediment obtained from the two areas in Little Sandy Lake in which mature seed-producing wild rice plants were not observed.

## 2.3 Twin Lakes Sediment Peeper Pore Water

During October 2013, multiple sediment sampling events were completed to obtain a sufficient number of samples to characterize Little Sandy and Sandy Lake sediment conditions. Dr. Peter Lee has previously provided an evaluation of sediment pore water characteristics including a comparison between Little Sandy Lake and Sandy Lake, previous MPCA pore water data, and a Canadian wild rice producing lake (Whitefish Lake) (see Appendix B in 2015 Annual Report).

During the 2015 field season, a total of six peepers were deployed in the Twin Lakes; two in Sandy Lake and four in Little Sandy Lake. The reasons for the uneven distribution between the two lakes were efforts to measure pore water characteristics near inflows to the Twin Lakes system, measure any



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changes in sediment pore water as distance from inflows increased, and measure pore water characteristics at the outflow from the Twin Lakes system (Figure 1). The 'Little Sandy Lake Out,' and 'Sandy Lake Mid' peeper locations were chosen to measure sediment pore water characteristics in a location that also had a sufficient penetrable depth of sediment for secure peeper deployment. Three, one-month deployments of each of the six peepers were completed: July – August; August – September; and September – October 2015. Peepers were constructed to obtain representative sediment pore water samples from the top 10 cm of sediment; approximately 200 mL of sample were obtained from each peeper during each deployment.

During the 2016 field season, six peepers were deployed in the Twin Lakes; two in Sandy Lake and four in Little Sandy Lake – in the same locations as during the 2015 field season (Figure 1). Peepers were deployed for four, one-month durations: April – May; May – June; June – July; and July – August 2016. In addition to these pore water samples, peepers were deployed for one-month durations in locations in each lake where wild rice was observed growing in test plots seeded in October 2015 (Figure 1). These above-and-beyond peeper deployments were completed to characterize sediment pore water within observed wild rice growth areas; with specific emphasis on hydrogen sulfide and extractable iron.

During 2016, the highest sediment pore water hydrogen sulfide concentrations were measured from samples obtained at the Inflow 2 monitoring location. Concurrently, the lowest extractable iron concentrations were measured in samples also obtained at this monitoring location. These data tend to indicate that as hydrogen sulfide is produced in the pore water, available iron is bound as iron sulfide; thus decreasing the pore water extractable iron available to bind with (hydrogen) sulfide. The increasing hydrogen sulfide concentrations throughout most of the summer suggest that hydrogen sulfide generation exceeded the available iron for iron sulfide formation at this monitoring location.

## 2.4 Twin Lakes Sediment 100 Year Pollen Count

Sediment core samples were obtained for completion of a '100 Year Pollen Count' on May 30, 2014. During 2015, sediment from the two cores selected for the 100 Year Pollen Count (LSL2 and SL1) was analyzed using scanning electron microscopy (SEM) observation. Pollen grains that were likely derived from wild rice were observed in the Sandy Lake sediment (see Figure 2). Details of this analysis were provided in the 2015 Annual Report.

Although these do appear to be wild rice pollen grains, currently a verification process is being completed. Pollen from known wild rice plants is being imaged to confirm that the pollen grains imaged from Sandy Lake sediment are wild rice pollen grains. During August 2016, pollen was sampled from wild rice plants growing in Sandy Lake, which were growing in plots as a part of a wild rice test seeding event completed during October 2015. Preparation and imaging of pollen samples obtained during August 2016 is currently in progress and are scheduled to be available for the 2017 Annual Report.



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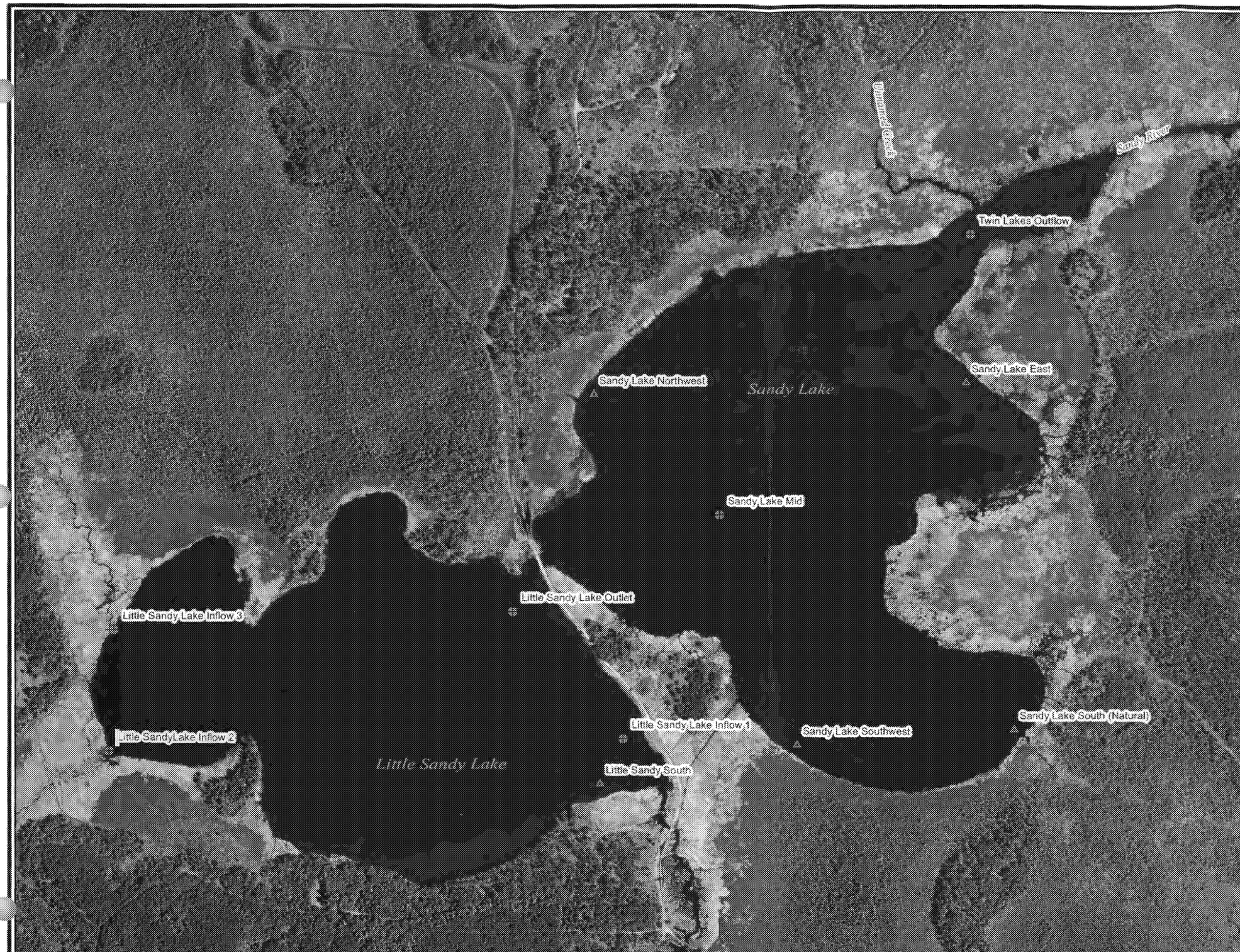


N

0 250 500 1,000

Feet

1 Inch = 500 Feet

**Legend**

Peeper Deployment

Wild Rice Peeper Deployment

# Figure 1
# 2016 Peeper Deployment Locations

Twin Lakes
US Steel Corporation -
Minnesota Ore Operations
Mt. Iron, Minnesota (St. Louis County)

NTS Environmental Science & Engineering
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| | |
|---|---|
| Date Drawn : December 7, 2016 | 1 |
| Drawn By : Evan Johnson | |
| NTS Project #: 10170E | |

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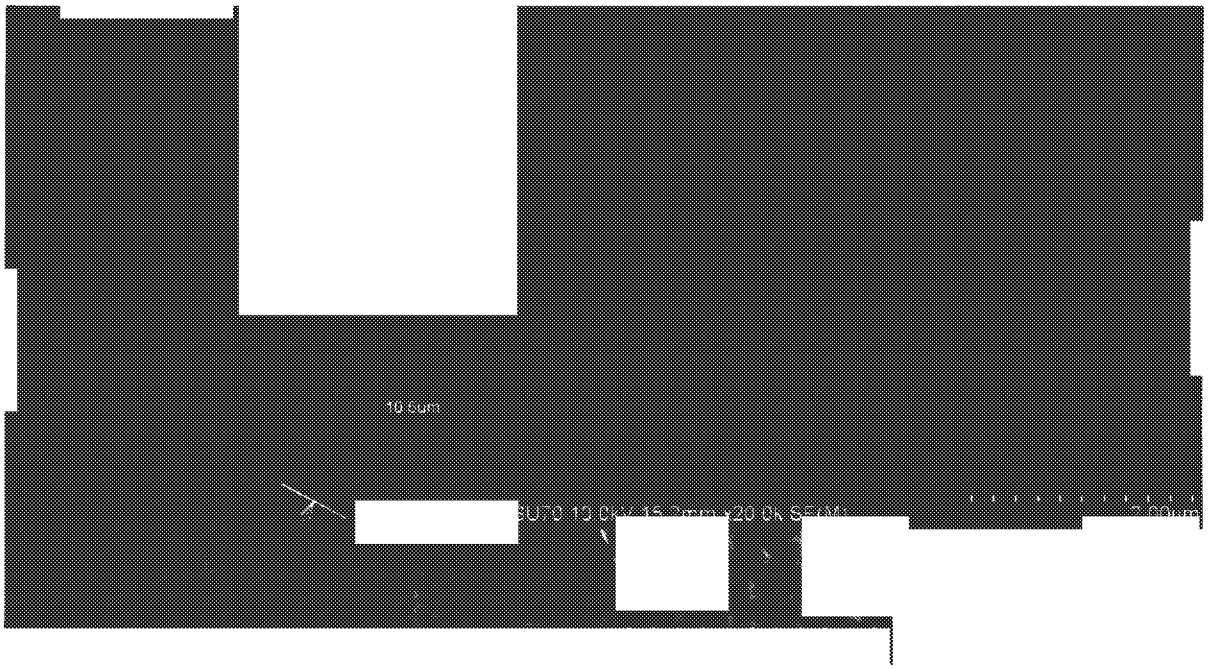
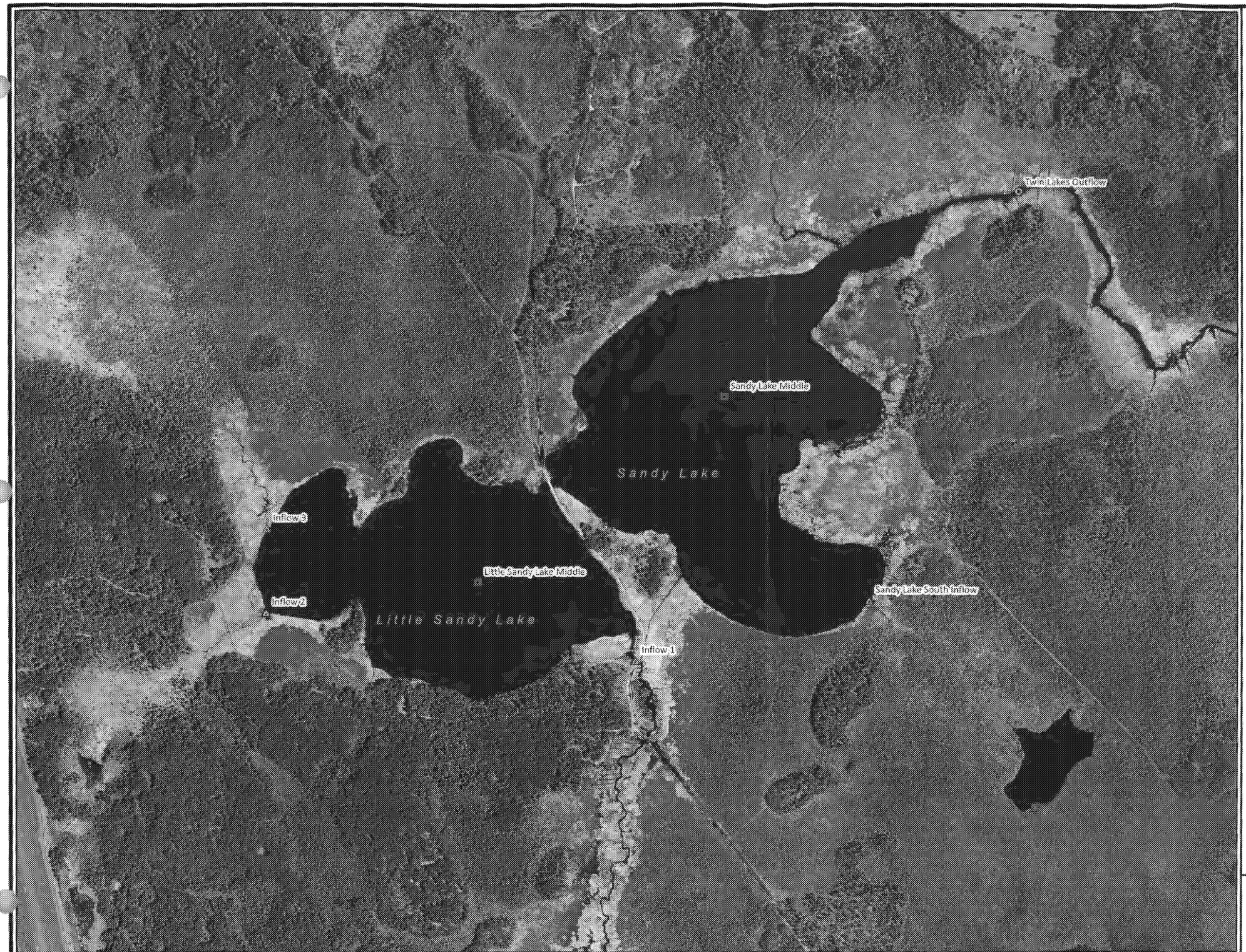


**Figure 2.** Scanning electron microscope (SEM) image of likely wild rice (WR) pollen grain obtained from a 2013 Sandy Lake sediment core sample. WR pollen grains were sampled in 2016 from WR plants growing in Sandy Lake test plots seeded in 2015. Additional images of sampled WR pollen will be used to aid in identifying the above pollen grain image.

## 2.5 Twin Lakes Inflow / Outflow Water Characterization

Beginning May 26, 2016, monthly water quality sampling and flow monitoring of inflow and outflow from the Twin Lake system was [redacted] sources (see Figure 3) included the inflows to Little Sandy Lake, a tributary to Sandy Lake from the north into its northeast arm (Culvert [redacted]), another [redacted] tributary to Sandy Lake from the south (Sandy Lake South Inflow), and the Twin [redacted] system outflow [redacted] in Lakes Outflow, previously referred to as Outflow 2 Sand River). It should be noted that the inflow samples [redacted] above were collected either from active, measurable inflow (Inflow 1, the Culvert Inflow and the Sandy Lake South Inflow) or from areas at the periphery of the lake in close proximity to what appears to be inflow channels from aerial photos (Inflow 2 and Inflow 3). The Inflow 2 and Inflow 3 "channels" were not accessible by canoe during 2016 due to reduced water levels and/or vegetation, and therefore, samples were collected at the mouth of the inflow channels. Water was also sampled periodically from the center of each lake. These samples were collected to evaluate the general water quality [redacted] description of each of the sampling sources, with the exception of the lake [redacted] provided here:

<u>Inflow 1</u> – corresponds to the discharge of the Sand River into [redacted] of Little Sandy Lake. Water quality samples are collected from the inflow channel [redacted] feet downstream of a wooden suspension snowmobile bridge crossing the Sand [redacted]




N

0 375 750 1,500

Feet

1 Inch = 750 Feet

## Legend

- Inflow Water Sample
- Outflow Water Sample
- Lake Middle Water Sample

**Figure 3**
**Twin Lakes 2016 Inflow/Outflow Water Sampling Locations**

Twin Lakes
US Steel Corporation -
Minnesota Ore Operations
Mt. Iron, Minnesota (St. Louis County)

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| | |
|---|---|
| Date Drawn: December 7, 2016 | 3 |
| Drawn By: Evan Johnson | |
| NTS Project #: 10170E | |

Inflow 2 – represents flow entering Little Sandy Lake from a wetland complex to the west southwest that originates near the northeast corner of the Minntac tailings basin perimeter dike. The Inflow 2 sampling location is situated on the west side of Little Sandy Lake at the mouth of an east / west trending wetland flow channel.

Inflow 3 – represents discharge to the system from general wetlands present north of Little Sandy Lake. The Inflow 3 sampling location is situated on the northwest side of Little Sandy Lake at the mouth of a north / south trending flow channel running through this wetland complex.

Culvert Inflow – represents tributary flow from the north entering the east end of Sandy Lake near the discharge into the Sand River. A culvert was identified in 2014 on a stream that appeared to be the main source of flow to this tributary (previously referred to as "Outflow Trib 1"). The culvert is located roughly 1080 meters upstream from where the tributary discharges into Sandy Lake. Water quality sampling results from 2014 showed that there were no significant differences between the Outflow Trib 1 and Culvert Inflow samples, and therefore all subsequent sampling for this source has been conducted at the culvert.

Sandy Lake South Inflow – represents tributary inflow from the south entering the southeast arm of Sandy Lake. This sampling point was identified during the aquatic plant survey (see Section 2.7), after which water quality sampling was implemented.

Twin Lakes Outflow – is located in the Sand River channel approximately 450 meters downstream from the mouth of the north tributary (characterized by Culvert Inflow / Outflow Trib 1). Water sampled at this location is representative of the total outflow from the Twin Lakes system.

As described in the Plan and detailed below, water samples were routinely obtained from the three inflow sources to Little Sandy Lake, the inflow to Sandy Lake (Culvert Inflow) and outflow from the system (Twin Lakes Outflow). Analytical results from these monthly sampling events, as well as the mid lake samples and data from the Sandy Lake South Inflow, were tabulated by Event Date, as well as by Sample Location, and are presented in Appendix C. In addition, summaries of the sampling results from selected monitoring locations for each of the three years of Plan implementation are presented in Tables 1 – 3 below.

## 2.6 Twin Lakes Inflow / Outflow Flow Measurements

Flow measurements were collected concurrent with Twin Lakes water quality sampling events at the Inflow 1, and Culvert Inflow sample locations. Sand River flow was also monitored at the Station 701 monitoring location, i.e., the point at which the Sand River crosses under County Road 306 immediately upstream of U.S. Highway 53, during each sampling event. Discharge through each of the three monitoring locations was gauged using a Marsh-McBirney Model 2000 Flo-Mate to obtain current velocity values at specific cross-sectional intervals. The results of the 2016 monthly discharge monitoring can be found in Table 4.

It should be noted that flow rates for Inflow 1 are measured at the downstream (north) side of the snowmobile bridge crossing the Sand River at the inlet to Little Sandy Lake. It should also be noted that even though it appears from aerial photographs that defined flow channels exist in the two wetlands

## Table 1. Twin Lakes Water Quality 2016

| | Reporting | Little Sandy Inflow 1 | | | Little Sandy Inflow 2 | | | Little Sandy Inflow 3 | | | Little Sandy Middle | | | Sandy Middle | | | Twin Lakes Outflow | | | Culvert Inflow | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Analytes - Cations** | Units | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max |
| Aluminum | µg / L | 96 | <50.0 | 284 | 28 | <50.0 | 111 | 11.5 | <50.0 | 69.1 | <50.0 | <50.0 | <50.0 | <50.0 | <50.0 | <50.0 | 19.0 | <50.0 | 57.3 | 16.4 | <50.0 | 132 |
| Calcium | mg / L | 55.9 | 39.4 | 69.6 | 39.0 | 30.7 | 47.4 | 34.4 | 30.1 | 40.0 | 35.0 | 28.2 | 46.0 | 36.3 | 31.5 | 38.7 | 27.8 | 24.3 | 33.4 | 12.0 | 10.0 | 14.2 |
| Iron | µg / L | 4842 | 1150 | 20700 | 1155 | 442 | 2320 | 1060 | 268 | 3270 | 388 | 388 | 388 | 650 | 650 | 650 | 1553 | 502 | 3280 | 5498 | 1560 | 10700 |
| Magnesium | mg / L | 75.1 | 45.6 | 99.3 | 54.4 | 41.9 | 69.1 | 50.9 | 47.5 | 56.0 | 32.0 | 38.3 | 67.2 | 49.7 | 42.9 | 55.6 | 36.0 | 31.2 | 46.5 | 4.2 | 3.7 | 4.9 |
| Manganese | µg / L | 177 | 81.3 | 429 | 121 | 51.9 | 214 | 127 | 77.2 | 220 | 63.3 | 63.3 | 63.3 | 38.4 | 38.4 | 38.4 | 85.6 | 46.8 | 138 | 233 | 62.9 | 419 |
| Potassium | mg / L | 6.0 | 2.6 | 9.5 | 3.4 | 2.3 | 4.6 | 2.7 | 1.5 | 4.3 | 3.5 | 2.9 | 4.1 | 3.3 | 3.0 | 3.6 | 2.9 | 2.2 | 3.5 | 1.4 | 0.94 | 1.8 |
| Sodium | mg / L | 29.6 | 17.1 | 39.0 | 17.3 | 14.3 | 23.0 | 13.5 | 9.2 | 16.8 | 16.6 | 13.5 | 23.0 | 17.1 | 15.2 | 20.1 | 13.1 | 11.5 | 17.1 | 3.8 | 3.1 | 4.2 |
| **Analytes - Anions** | | | | | | | | | | | | | | | | | | | | | | |
| Chloride | mg / L | 43.6 | 20.9 | 56.5 | 23.9 | 17.9 | 33.7 | 18.0 | 12.5 | 21.7 | 23.8 | 17.8 | 34.7 | 24.3 | 18.4 | 30.2 | 19.2 | 15.4 | 26.1 | 9.1 | 7.1 | 10.6 |
| Nitrogen, Kjeldahl, Total | mg / L | 0.93 | <0.60 | 2.6 | 1.2 | 0.70 | 2.1 | 1.0 | 0.60 | 1.6 | 0.72 | <0.50 | 1.4 | 0.70 | 0.79 | 1.3 | 0.87 | <0.50 | 1.5 | 0.49 | <0.50 | 1.3 |
| Ammonium as Nitrogen | mg / L | 0.06 | <0.10 | 0.36 | 0.09 | 0.15 | 0.29 | 0.06 | <0.10 | 0.16 | 0.05 | <0.10 | 0.15 | 0.04 | <0.10 | 0.11 | 0.11 | <0.10 | 0.32 | 0.02 | <0.10 | 0.12 |
| Sulfate | mg / L | 251 | 120 | 338 | 155 | 96.7 | 216 | 112 | 39.6 | 163 | 145 | 104 | 176 | 148 | 125 | 183 | 92.3 | 64.3 | 114 | 0.4 | <2.0 | 2.3 |
| **Analytes - Other** | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg / L | 660 | 431 | 836 | 465 | 407 | 561 | 409 | 367 | 473 | 439 | 363 | 548 | 421 | 389 | 460 | 330 | 276 | 392 | 133 | 113 | 155 |
| Total Suspended Solids | mg / L | 4.7 | 1.5 | 14 | 7.5 | <2.5 | 22.0 | 3.5 | <2.5 | 6.5 | 2.5 | 2.0 | 3.2 | 0.9 | <1.0 | 1.6 | 2.0 | <1.0 | 3.6 | 9.4 | 3.2 | 26 |
| Alkalinity, Total as CaCO3 | mg / L | 196 | 149 | 278 | 192 | 120 | 251 | 198 | 140 | 255 | 148 | 106 | 222 | 151 | 127 | 179 | 128 | 92.4 | 152 | 39.7 | 34.8 | 48.4 |
| Dissolved Organic Carbon | mg / L | 25.7 | 10.5 | 63.7 | 27.8 | 15.6 | 38.9 | 28.2 | 16.2 | 38.2 | 21.6 | 21.6 | 21.6 | 25.1 | 25.1 | 25.1 | 24.9 | 14.8 | 39.1 | 21.8 | 11.7 | 35.4 |
| Total Hardness | mg / L | 449 | 286 | 582 | 322 | 249 | 402 | 295 | 280 | 330 | 287 | 228 | 392 | 295 | 255 | 326 | 230 | 189 | 349 | 47.1 | 40.4 | 55.5 |
| **YSI Probe Plus Data** | | | | | | | | | | | | | | | | | | | | | | |
| pH | Units | 7.1 | 6.7 | 7.3 | 7.2 | 6.9 | 7.8 | 7.2 | 7.2 | 7.4 | 7.8 | 7.3 | 8.2 | 7.8 | 7.3 | 8.1 | 7.5 | 7.3 | 7.6 | 6.8 | 6.5 | 7.3 |
| Temperature | °C | 15.2 | 5.8 | 21.4 | 16.9 | 6.0 | 24.2 | 16.0 | 5.4 | 23.6 | 18.4 | 7.6 | 25.1 | 18.0 | 7.3 | 24.8 | 16.7 | 6.5 | 25.0 | 15.4 | 5.8 | 20.0 |
| Specific Conductance | uS / cm | 915 | 547 | 1141 | 628 | 572 | 781 | 560 | 517 | 644 | 655 | 567 | 732 | 534 | 459 | 619 | 439 | 359 | 527 | 160 | 102 | 417 |

Note: Little Sandy Middle and Sandy Middle Locations were sampled only once for Aluminum, Iron, Manganese, Potassium and Dissolved Organic Carbon and there were three monthly events where Total Suspended Solids, Nitrogen-Kjeldahl and Ammonium as Nitrogen were analyzed. For the sampling frequency at each location, please review the Twin Lakes 2016 Inflow/Outflow Water Sampling Data in Appendix C.

## Table 2. Twin Lakes Water Quality 2015

| | Reporting | Little Sandy Inflow 1 | | | Little Sandy Inflow 2 | | | Little Sandy Inflow 3 | | | Little Sandy Middle | | | Sandy Middle | | | Twin Lakes Outflow | | | Culvert Inflow | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Analytes - Cations** | Units | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max |
| Aluminum | µg / L | 69 | 29.7 | 124 | 15.4 | 10.1 | 54.3 | <10.0 | <10.0 | 16.4 | <0.10 | <0.10 | <0.10 | 8.0 | <50.0 | 18.1 | 14.3 | <50.0 | 35.8 | 25.4 | <50.0 | 53.0 |
| Arsenic | µg / L | <0.05 | <0.05 | <0.05 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 | NM | NM | NM | NM | NM | NM | <0.50 | <50.0 | <0.50 | 0.38 | <0.50 | 0.76 |
| Barium | µg / L | 19.0 | 19.0 | 19.0 | 23.7 | 23.7 | 23.7 | 26.5 | 26.5 | 26.5 | NM | NM | NM | NM | NM | NM | 24.4 | 24.4 | 24.4 | 17.5 | 17.5 | 17.5 |
| Calcium | mg / L | 64 | 38.4 | 91.7 | 45.7 | 27.9 | 68.0 | 40.0 | 30.5 | 53.1 | 49.6 | 40.7 | 59.1 | 39.4 | 33.4 | 47.4 | 33.6 | 15.6 | 42.2 | 12.1 | 9.0 | 15.4 |
| Iron | µg / L | 963 | 407 | 2030 | 995 | 218 | 4170 | 235.7 | 80.0 | 448.0 | 121 | 121 | 121 | 268 | 171 | 315 | 583 | 287 | 1200 | 2600 | 1180 | 3800 |
| Magnesium | mg / L | 90 | 53 | 133 | 65.7 | 38.2 | 97 | 60.2 | 46.5 | 79.8 | 71.7 | 57.7 | 83.9 | 57.2 | 47.2 | 69.5 | 45.6 | 14.3 | 59.1 | 4.3 | 3.2 | 5.3 |
| Manganese | µg / L | 154 | 28.5 | 309 | 76.5 | 32.8 | 128 | 93.9 | 14.8 | 258 | 98.7 | 98.7 | 98.7 | 68.2 | 40.1 | 129 | 52.1 | 32.6 | 67.5 | 134 | 46.1 | 210 |
| Phosphorus | mg / L | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | NM | NM | NM | NM | NM | NM | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Potassium | mg / L | 7.6 | 5.6 | 11.6 | 4.1 | 1.78 | 5.73 | 3.2 | 1.6 | 4.4 | 5.1 | 5.1 | 5.1 | 4.4 | 4.1 | 4.8 | 4.2 | 1.8 | 6.0 | 1.5 | 1.2 | 1.9 |
| Rubidium | µg / L | 2.9 | 2.8 | 2.9 | 3.0 | 3.0 | 3.0 | 2.5 | 2.4 | 2.6 | NM | NM | NM | NM | NM | NM | 2.8 | 2.8 | 2.8 | 1.3 | 1.2 | 1.4 |
| Sodium | mg / L | 36.3 | 21.3 | 52.4 | 21.6 | 13.7 | 30.6 | 17.8 | 11.1 | 25.5 | 26.0 | 20.2 | 31.3 | 21.9 | 17.9 | 26.5 | 18.1 | 6.9 | 23.2 | 4.2 | 3.7 | 4.7 |
| Strontium | µg / L | 152 | 129 | 175 | 130.5 | 128 | 133 | 102 | 101 | 102 | NM | NM | NM | NM | NM | NM | 122 | 107 | 136 | 39.7 | 34.3 | 45.1 |
| **Analytes - Anions** | | | | | | | | | | | | | | | | | | | | | | |
| Chloride | mg / L | 54 | 31.4 | 85.4 | 30.7 | 23.6 | 43.5 | 23.2 | 13.2 | 33.9 | 37.8 | 31.4 | 47.6 | 32.2 | 28.5 | 39.1 | 27.0 | 12.1 | 35.4 | 10.5 | 8.2 | 13.4 |
| Nitrogen, Kjeldahl, Total | mg / L | 0.68 | <0.50 | 0.98 | 1.1 | 0.73 | 1.6 | 0.90 | 0.59 | 1.2 | 0.85 | 0.72 | 1.1 | 0.85 | 0.65 | 1.1 | 0.71 | 0.57 | 1.0 | 0.40 | <0.50 | 0.83 |
| Ammonium as Nitrogen | mg / L | 0.02 | <0.10 | 0.10 | 0.03 | <0.10 | 0.17 | 0.05 | <0.10 | 0.12 | <0.10 | <0.10 | <0.10 | 0.2 | 0.2 | 0.2 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Sulfate | mg / L | 326 | 191 | 498 | 227 | 157 | 340 | 179 | 52.5 | 250 | 240 | 219 | 279 | 187 | 162 | 223 | 146 | 33.8 | 200 | 2.5 | <2.0 | 2.8 |
| **Analytes - Other** | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg / L | 747 | 457 | 1040 | 549 | 399 | 737 | 473 | 309 | 623 | 572 | 475 | 649 | 467 | 399 | 546 | 388 | 174 | 473 | 121 | 95.0 | 166 |
| Total Suspended Solids | mg / L | 1.8 | <1.0 | 3.6 | 1.7 | <1.0 | 3.5 | 1.3 | 1.6 | 2.0 | 1.2 | 1.2 | 3.2 | 1.6 | <1.0 | 4.0 | 1.9 | <1.2 | 4.0 | 3.3 | 1.2 | 5.2 |
| Alkalinity, Total as CaCO3 | mg / L | 162 | 93.1 | 233 | 143 | 105 | 221 | 148 | 92.6 | 201 | 145 | 110 | 178 | 117 | 93.7 | 153 | 97.5 | 47.4 | 134 | 36.7 | 24.6 | 46.2 |
| Dissolved Organic Carbon | mg / L | 14.3 | 9.4 | 18.4 | 19.4 | 12.9 | 28.5 | 20.5 | 14.7 | 30.7 | 18.3 | 17.0 | 20.1 | 18.8 | 17.0 | 20.3 | 16.2 | 10.8 | 19.3 | 12.8 | 7.5 | 16.3 |
| Total Hardness by 2340B | mg / L | 529 | 314 | 776 | 385 | 227 | 569 | 348 | 268 | 461 | 419 | 339 | 493 | 334 | 278 | 405 | 272 | 97.9 | 349 | 47.9 | 35.7 | 60.6 |
| UV Absorbance @ 254 nm | $cm^{-1}$ | 0.466 | 0.429 | 0.502 | 0.476 | 0.408 | 0.544 | 0.574 | 0.468 | 0.679 | NM | NM | NM | NM | NM | NM | 0.422 | 0.360 | 0.484 | 0.525 | 0.478 | 0.572 |
| SUVA | L / mg*m | 3.5 | 3.4 | 3.5 | 3.3 | 3.3 | 3.3 | 3.4 | 3.3 | 3.4 | NM | NM | NM | NM | NM | NM | 3.4 | 3.3 | 3.5 | 4.5 | 4.4 | 4.6 |
| **YSI Probe Plus Data** | | | | | | | | | | | | | | | | | | | | | | |
| pH | Units | 7.3 | 6.9 | 7.7 | 7.5 | 7.0 | 7.8 | 7.5 | 6.9 | 8.1 | 8.1 | 7.9 | 8.4 | 8.0 | 7.8 | 8.2 | 7.7 | 7.0 | 8.1 | 6.9 | 6.7 | 7.1 |
| Temperature | °C | 13.6 | 6.9 | 19.7 | 15.5 | 6.3 | 22.1 | 13.9 | 7.3 | 21.6 | 16.4 | 7.3 | 22.3 | 16.1 | 6.6 | 22.7 | 15.4 | 6.4 | 23.1 | 13.5 | 7.3 | 18.8 |
| Specific Conductance | uS / cm | 1038 | 632 | 1435 | 842 | 703 | 1150 | 698 | 476 | 943 | 831 | 730 | 949 | 670 | 610 | 746 | 554 | 219 | 698 | 112 | 85.0 | 130 |

Note: To find each location's frequency of sampling, please review the 2015 Twin Lakes WRROP Annual Report under Twin Lakes Inflow/Outifow Water Sampling Data.

## Table 3. Twin Lakes Water Quality 2014

| Analytes - Cations | Reporting Units | Little Sandy Inflow 1 | | | Little Sandy Inflow 2 | | | Little Sandy Inflow 3 | | | Little Sandy Middle | | | Sandy Middle | | | Twin Lakes Outflow | | | Culvert Inflow | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max | Average | Min | Max |
| Aluminum | µg / L | 27.0 | <20.0 | 52.0 | 15.8 | <20.0 | 41.7 | <20.0 | <20.0 | <20.0 | 30.6 | 30.6 | 30.6 | 37.7 | 37.7 | 37.7 | 20.2 | 22.8 | 35.1 | NM | NM | NM |
| Arsenic | µg / L | 0.75 | <0.50 | 0.75 | 0.4 | <0.50 | 1.1 | 0.60 | <0.50 | 0.69 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 | <0.50 | 0.60 | 0.51 | 0.92 | 0.72 | <0.50 | 1.10 |
| Barium | µg / L | 37.9 | 23.1 | 58.9 | 26.6 | 19.4 | 35.4 | 29.2 | 22.3 | 35.5 | 23.3 | 23.3 | 23.3 | 21.4 | 21.4 | 21.4 | 25.5 | 18.9 | 31.2 | 31.2 | 23.9 | 38.2 |
| Calcium | mg / L | 66.9 | 37.5 | 95.0 | 32.5 | 25.4 | 40.5 | 33.4 | 24.6 | 44.4 | 29.5 | 29.5 | 29.5 | 25.3 | 25.3 | 25.3 | 24.1 | 19.1 | 34.8 | 13.1 | 11.0 | 15.5 |
| Iron | µg / L | 860 | 229 | 1980 | 543 | 169 | 1100 | 258 | 173 | 459 | 717 | 717 | 717 | 800 | 800 | 800 | 975 | 409 | 1470 | 4646 | 1870 | 7520 |
| Magnesium | mg / L | 92.5 | 44.3 | 140 | 42.8 | 34.4 | 52.8 | 44.7 | 36.1 | 62.3 | 36.5 | 36.5 | 36.5 | 30.5 | 30.5 | 30.5 | 27.4 | 19.7 | 44.9 | 4.4 | 3.9 | 5.2 |
| Manganese | µg / L | 142 | 54.4 | 347 | 56.5 | 23.9 | 92.2 | 75.4 | 25.5 | 127 | 42.7 | 42.7 | 42.7 | 42.5 | 42.5 | 42.5 | 64.8 | 27.6 | 138 | 183 | 82.3 | 300 |
| Phosphorus | mg / L | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Potassium | mg / L | 6.1 | 2.5 | 11.4 | 3.3 | 1.7 | 4.0 | 3.2 | 2.2 | 3.7 | 3.7 | 3.7 | 3.7 | 3.5 | 3.5 | 3.5 | 2.9 | 2.2 | 3.4 | 1.4 | 0.93 | 1.9 |
| Rubidium | µg / L | 2.9 | 2.0 | 4.0 | 2.3 | 1.5 | 2.6 | 2.6 | 2.3 | 3.0 | 2.6 | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 | 2.1 | 1.6 | 2.5 | 0.90 | 1.1 | 1.4 |
| Sodium | mg / L | 38.3 | 18.4 | 58.2 | 15.5 | 12.0 | 19.5 | 14.3 | 9.3 | 23.1 | 12.9 | 12.9 | 12.9 | 11.8 | 11.8 | 11.8 | 10.9 | 8.3 | 17.8 | 4.0 | 3.2 | 4.5 |
| Strontium | µg / L | 238 | 133 | 327 | 112 | 85.5 | 142 | 114 | 78.2 | 154 | 98.5 | 98.5 | 98.5 | 86.3 | 86.3 | 86.3 | 85.8 | 66.5 | 123 | 54.6 | 44.2 | 63.4 |
| **Analytes - Anions** | | | | | | | | | | | | | | | | | | | | | | |
| Chloride | mg / L | 57.3 | 9.5 | 103 | 21.3 | 15.8 | 28.5 | 21.3 | 8.0 | 30.1 | 17.1 | 17.1 | 17.1 | 15.7 | 15.7 | 15.7 | 16.6 | 13.3 | 25.8 | 10.3 | 6.4 | 13.1 |
| Nitrogen, Kjeldahl, Total | mg / L | 0.4 | <0.50 | 0.75 | 0.92 | 0.66 | 1.2 | 1.0 | 0.59 | 1.8 | 0.72 | 0.72 | 0.72 | 0.74 | 0.74 | 0.74 | 0.70 | <0.50 | 1.2 | 1.1 | 0.9 | 1.2 |
| Ammonium as Nitrogen | mg / L | <0.50 | <0.50 | <0.50 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.50 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| Sulfate | mg / L | 328 | 107 | 540 | 125 | 89.3 | 162 | 104 | 9.9 | 156 | 121 | 121 | 121 | 98.6 | 98.6 | 98.6 | 80.3 | 44.6 | 124.0 | 0.60 | <2.0 | <2.0 |
| **Analytes - Other** | | | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg / L | 829 | 431 | 1170 | 403 | 333 | 465 | 407 | 318 | 489 | 366 | 366 | 366 | 315 | 315 | 315 | 299 | 221 | 375 | 151 | 114 | 192 |
| Alkalinity, Total as CaCO3 | mg / L | 191 | 95.7 | 259 | 142 | 69.0 | 253 | 132 | 90.2 | 188 | 95.3 | 95.3 | 95.3 | 74.1 | 74.1 | 74.1 | 85.9 | 53.4 | 129 | 38.2 | 32.1 | 45.9 |
| Dissolved Organic Carbon | mg / L | 16.6 | 10.3 | 20.5 | 22.7 | 15.6 | 26.5 | 24.3 | 20.2 | 28.6 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 21.8 | 16.7 | 26.2 | 20.5 | 8.5 | 30.4 |
| Total Hardness by 2340B | mg / L | 548 | 276 | 814 | 257 | 207 | 317 | 267 | 210 | 368 | 224 | 224 | 224 | 189 | 189 | 189 | 173 | 132 | 272 | 50.8 | 43.7 | 60.0 |
| UV Absorbance @ 254 nm | mg / L | 0.672 | 0.320 | 0.930 | 0.896 | 0.561 | 1.20 | 1.01 | 0.781 | 1.40 | 0.958 | 0.958 | 0.958 | 0.938 | 0.938 | 0.938 | 0.890 | 0.570 | 1.10 | 1.02 | 0.360 | 1.90 |
| SUVA | $cm^{-1}$ | 3.9 | 3.1 | 4.5 | 3.9 | 3.6 | 4.6 | 3.8 | 2.3 | 4.7 | 4.4 | 4.4 | 4.4 | 4.3 | 4.3 | 4.3 | 4.2 | 3.6 | 5.0 | 3.9 | 1.3 | 5.2 |
| **YSI Probe Plus Data** | | | | | | | | | | | | | | | | | | | | | | |
| pH | Units | 7.4 | 7.0 | 8.6 | 7.5 | 6.6 | 8.4 | 7.8 | 6.9 | 8.5 | 7.6 | 7.6 | 7.6 | 7.7 | 7.7 | 7.7 | 7.6 | 7.0 | 8.6 | 6.6 | 6.6 | 6.8 |
| Temperature | °C | 16.3 | 7.2 | 21.7 | 16.3 | 7.7 | 23.4 | 19.7 | 7.3 | 25.2 | 23.6 | 23.6 | 23.6 | 22.6 | 22.6 | 22.6 | 17.5 | 7.9 | 23.1 | 16.6 | 7.3 | 23.9 |
| Specific Conductance | uS / cm | 1098 | 569 | 1620 | 546 | 261 | 689 | 542 | 364 | 678 | 504 | 504 | 504 | 387 | 387 | 387 | 381 | 307 | 561 | 117 | 96.0 | 137 |

Note: To find each location's frequency of sampling, please review the 2014 Twin Lakes WRROP Annual Report under Twin Lakes Inflow/Outlfow Water Sampling Data.

## Table 4. 2016 Twin Lakes Measured Inflows & Outflows (gpm)

| Date Measured | Inflow 1 to LSL | Tributary to SL Culvert Inflow | Total Measured Flow into Twin Lakes | Sand River (Station 701) | Measured In vs. Total Out |
|---|---|---|---|---|---|
| 5/26/2016 | 1,047 | 327 | 1,374 | 5,075 | 27% |
| 6/24/2016 | 2,893 | 466 | 3,359 | 13,977 | 24% |
| 7/22/2016 | 3,920 | 568 | 4,488 | 11,859 | 38% |
| 8/25/2016 | 1,257 | 440 | 1,697 | 6,083 | 28% |
| 9/28/2016 | 5,000 | 568 | 5,568 | 10,341 | 54% |
| 10/20/2016 | 1,450 | 466 | 1,916 | 7,877 | 24% |

Notes:
1) During the August 25th monitoring event, a separate tributary stream was identified on the south side of Sandy Lake. The flow was estimated to be 15 gpm at that time.
2) Flow was not measured at the Inflow 2 or Inflow 3 monitoring locations - to date no defined flow channel has been identified.

terminating at Inflow 2 and Inflow 3, it was not possible to gauge flow rates into Little Sandy Lake at these selected monitoring locations. Efforts to establish flow monitoring stations were negated by the absence of a defined channel and / or safe access issues. It appears that during the majority of the year, there is little concentrated flow within the two wetland channels feeding the Inflow 2 and Inflow 3 monitoring locations, and overall inputs are diffuse, entering the lake at multiple points across the width of the wetland complexes. Readily measurable flow in the defined wetland channels likely only occurs during larger precipitation and runoff events.

Unlike Inflow 2 and Inflow 3, flow from the Sandy Lake South Inflow is contained in a defined channel. However, safe access to this tributary is limited, and therefore, gauging of input flows via flowmeter was not possible. Instead, a visual estimate of inflow was recorded during each water quality sampling event.

As can be seen in the flow summary table presented above, the measurable sources of inflow that contribute to discharge of the Sand River at the outlet of Sandy Lake did not match concurrent discharges measured at Station 701. In general, there is considerably more discharge downstream in the Sand River than can be accounted for from the five main inflow sources. Of the six flow measurement events completed in 2016 all but two (July 22 and September 28) represented roughly 24 – 28% of the known flows to Station 701. The discrepancies in the flow balances for July and September (38% and 54% respectively) can be attributed to the inability to measure flow rates from the wetland channels discharging into Little Sandy Lake at the Inflow 2 and Inflow 3 sampling locations, as well as the contributions from the Sandy Lake South Inflow. However, it is believed that the discharge from these inputs is relatively minor in comparison to Inflow 1. A much more significant factor is the unnamed stream that is tributary to the Sand River between the outlet of Sandy Lake and Station 701, which drains a relatively large area to the east and south of the Twin Lakes. Monitoring of this source is currently outside the scope of the Plan. It is likely that during wetter periods of the year this tributary represents a significant contribution to the discharge through Station 701, but only a minor contribution during drier periods.

Opportunities for measuring the flow out of Sandy Lake at the Twin Lakes Outflow sampling location were evaluated early in the 2016 monitoring season. However, no obvious alternatives were identified. The rate of outflow at this location remains a significant gap in the data set and therefore, additional efforts will be directed at establishing a safe means of gauging flow through the channel at this or an alternative nearby downstream location.

## 2.7 Twin Lakes Aquatic Plant Survey

The Twin Lakes Aquatic Plant Survey that took place in August 2016 marks the third year the type of vegetation growing in Sandy and Little Sandy Lake was determined.

The sampling method used is a part of the United States Environmental Protection Agency (EPA) 2012 National Lakes Assessment and there were two references used to categorize the various aquatic plants: 1) Borman, Susan, et al. *Through the Looking Glass...A Field Guide to Aquatic Plants Second Edition,* Wisconsin Lakes Partnership, 1997. 2) Eggers, Steve D., and Donald M. Reed. *Wetland Plants and Plant Communities of Minnesota and Wisconsin.* U.S. Army Corps of Engineers, St. Paul District, 1997. First, four transects were defined in different areas of each lake. Between four and seven locations were



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sampled on each of the transects. Sampling locations were randomly located along each transect. Aquatic plant samples along each transect were collected (see Appendix D) until about the middle of the lake was reached. The GPS location of each sample site was obtained. Figure 4 details the vegetation sampling transects and sampling locations.

A double headed sampling rake on a rope was tossed off the left side of the canoe and retracted. The percent plant density on the rake was recorded along with the plant taxa and the percent of the sample of each taxon. Aquatic macrophytes were field-identified and listed in Appendix D. Photos of aquatic plants retrieved during the survey are contained in Appendix E.

Below is a summary of the aquatic macrophytes collected on both lakes:

| Common Name | Scientific Name |
|---|---|
| Coontail | *Ceratophyllum demersum* |
| White Water Lily | *Nymphaea odorata* |
| Fries Pondweed | *Potamogeton robbinsii* |
| Northern Water Milfoil | *Myriophyllum exalbescens* |
| Musk grass | *Chara spp.* |
| Sago pondweed | *Stuckenia pectinata* |
| Clasping pondweed | *Potamogeton richardsonii* |
| Stiff pondweed | Potamogeton strictifolius |
| Common (American) Bur-reed | *Sparganium eurycarpum* |
| Filamentous algae | |
| Wild Celery | *Vallisneria americana* |
| Northern Bladderwort | *Utricularia intermedia* |
| Spatterdock | *Nuphar variegata* |

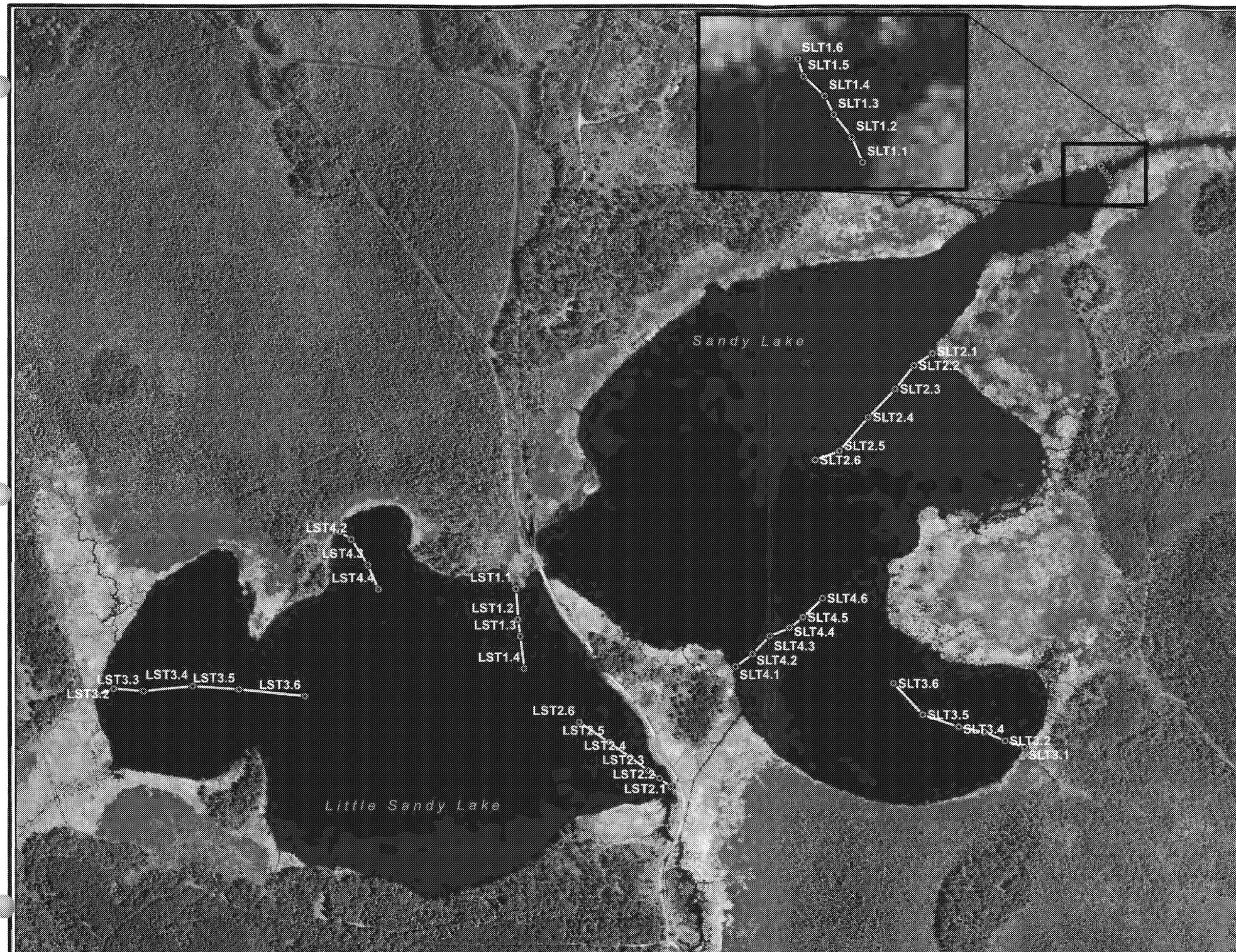
Note: wild rice was observed naturally growing at the SLT3 station 1 survey location, but was not sampled as part of the Aquatic Plant Survey.

The water depth ranged from 1.0 feet to 4.75 feet depending on where the narrow leaved cattail (*Typha angustifolia*) beds started around the inner periphery of each lake. The deepest location sampled on Sandy Lake was 4.5 feet. Not much vegetation was sampled at this depth. The deepest location sampled on Little Sandy was 4.75 feet. However, after 4.0 feet not much vegetation was found. Very little 'die back' of vegetation was observed due to the time of year that the lakes were surveyed. All of the aquatic macrophytes sampled are taxa native to Minnesota.

Water depth measurements obtained during the 2016 aquatic plant survey were used to construct bathymetric maps of Little Sandy and Sandy Lakes (Figure 5).



ED_005586A_00004087-00018




N

0 250 500 1,000

Feet

1 Inch = 500 Feet

## Legend

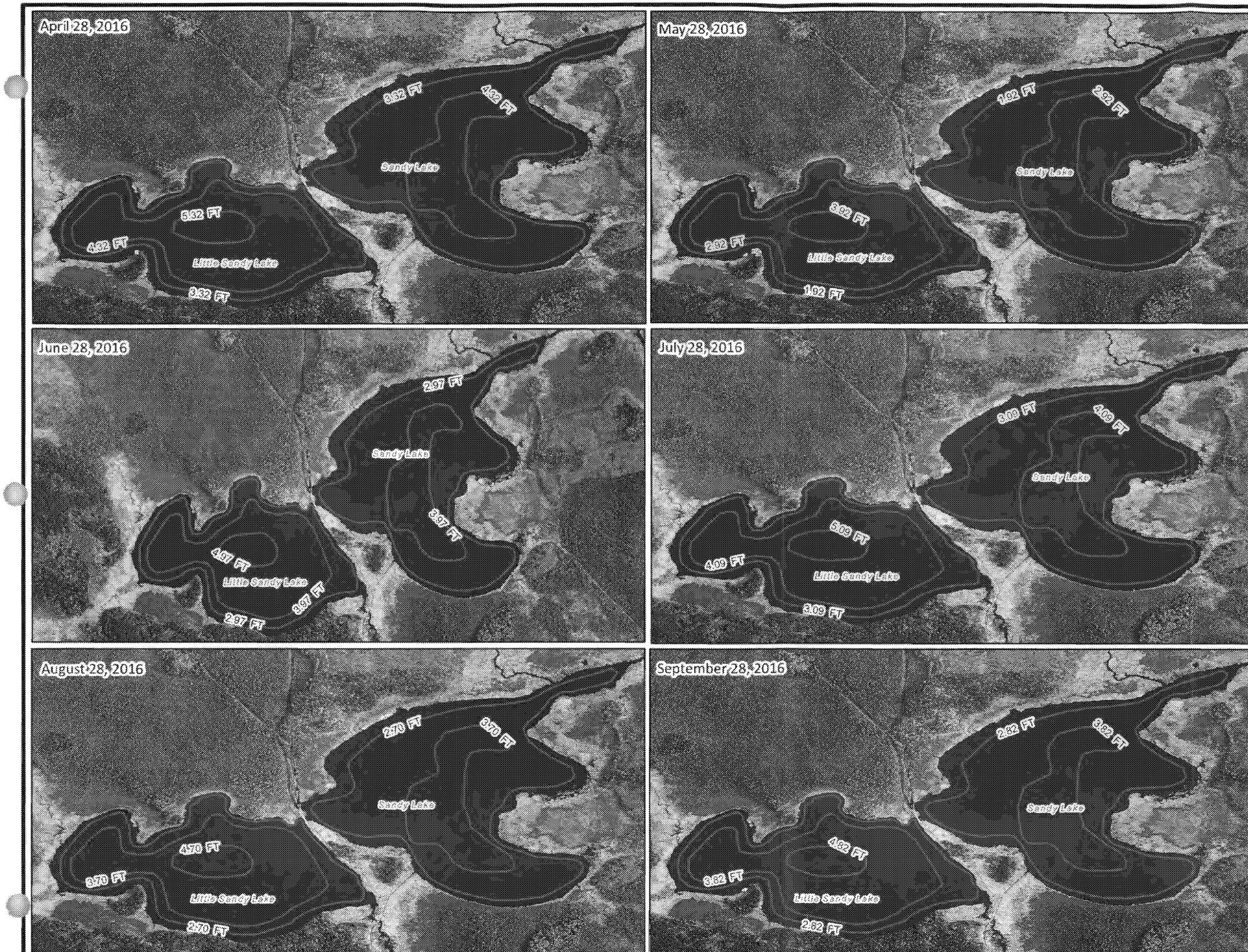
- Little Sandy Transect
- Sandy Lake Transect
- 2016 Vegetation Survey Transect

**Figure 4**
**Twin Lakes 2016 Aquatic Plant Survey Transect Locations**

Twin Lakes Survey
US Steel Corporation-
Minnesota Ore Operations
Mt. Iron, Minnesota (St. Louis County)

www.netechnical.com

| | |
|---|---|
| Date Drawn : November 14, 2016 | |
| Drawn By : Evan Johnson | 4 |
| NTS Project #: 10170E | |




N

0 600 1,200 2,400

Feet

1 Inch = 1,228 Feet

## Legend

Twin Lakes Bathymetry

Notes:

-Bathymetry lines were created by interpreting depths collected during monthly vegetation surveys. True bathymetry may differ from drawn contours.
-The water depth was corrected to match the 2015 water depth using bridge transducer data.
-The water depth according to the Bridge Transducer on August 18, 2015 was 2.40 feet.

# Figure 5
# 2016 Twin Lakes Bathymetry

**Twin Lakes Survey**
**US Steel Corporation-**
**Minnesota Ore Operations**
**Mt. Iron, Minnesota (St. Louis County)**

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| | |
|---|---|
| Date Drawn: November 30, 2016 | 5 |
| Drawn By: Evan Johnson | |
| NTS Project #: 10170E | |

## 2.8 Sand River (and Twin Lakes) Beaver and Dam Removal Activities

During the first full year of Plan implementation (2014), a private animal control contractor was hired to remove beaver and open dams downstream of the Twin Lakes. The effort resulted in measurable, albeit limited, success. As described in the 2014 Annual Report, dams downstream of the Twin Lakes were opened on three separate occasions (May, late June and late September) and there were indications of positive (downward) water level responses each time, as reflected in water depth measurements at the steel bridge. However, in each case beaver returned and rebuilt the dams, resulting in increased lake levels.

Since water depth has been identified as a critical factor in wild rice success, U. S. Steel contracted with a U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) crew based in Grand Rapids, MN, to conduct an intensive beaver and dam removal program in 2015. This effort resulted in the removal of an estimated 60 beavers by either the APHIS crew or by private trappers. The APHIS crew noted the presence of up to 30 dams along the Sand River downstream of Sandy Lake and removed an unspecified number of dams, both via explosives and by hand.

In 2016, the APHIS Crew evaluated the beaver presence two separate times (once in May and the other in August). Their conclusion was that beaver had not returned and were not a threat for the moment. However, in aggregate, the old beaver dams and associated channel debris are causing water levels to be held up in the system, especially after significant rainfall events, as evidenced by the pressure transducer data from the steel bridge. It will be difficult to maintain water levels in the Twin Lakes at optimum depths for consistent wild rice growth given the large number of relic dams and pinch points currently present in the Sand River channel between Sandy Lake and U.S. Hwy 53. This is especially critical during wetter years, as was the case for 2016.

## 2.9 Results of 2015 Wild Rice Pilot Seeding Efforts

As described in the 2015 Annual Report, seeding of three separate areas in each of the two lakes was undertaken in late October 2015 to determine the potential for wild rice growth. The areas were identified for seeding based on previous known wild rice areas, and appropriate existing water depths and sediment type (i.e., organic substrate). A couple of the seed plots were subsequently moved from the original plan based on input from area locals familiar with the lakes. Figure 6 shows locations of the wild rice seeding plot locations within the Twin Lakes.

Four of the six seed plots produced variable amounts of emergent wild rice, with two of the six demonstrating fairly good growth (see Appendix E for photos of the wild rice seed plots and Appendix G for estimates of wild rice densities). The two seed plots on the north side of Little Sandy Lake either showed zero or very sparse growth. Interestingly, the seed plot on the south side of Little Sandy Lake, close to the main inflow (Inflow 1 location) to the lake system, showed fairly strong wild rice growth. In general, there is much more aquatic plant growth in Sandy Lake than in Little Sandy, and there are portions of Little Sandy that demonstrate much more aquatic plant growth than in other areas, possibly



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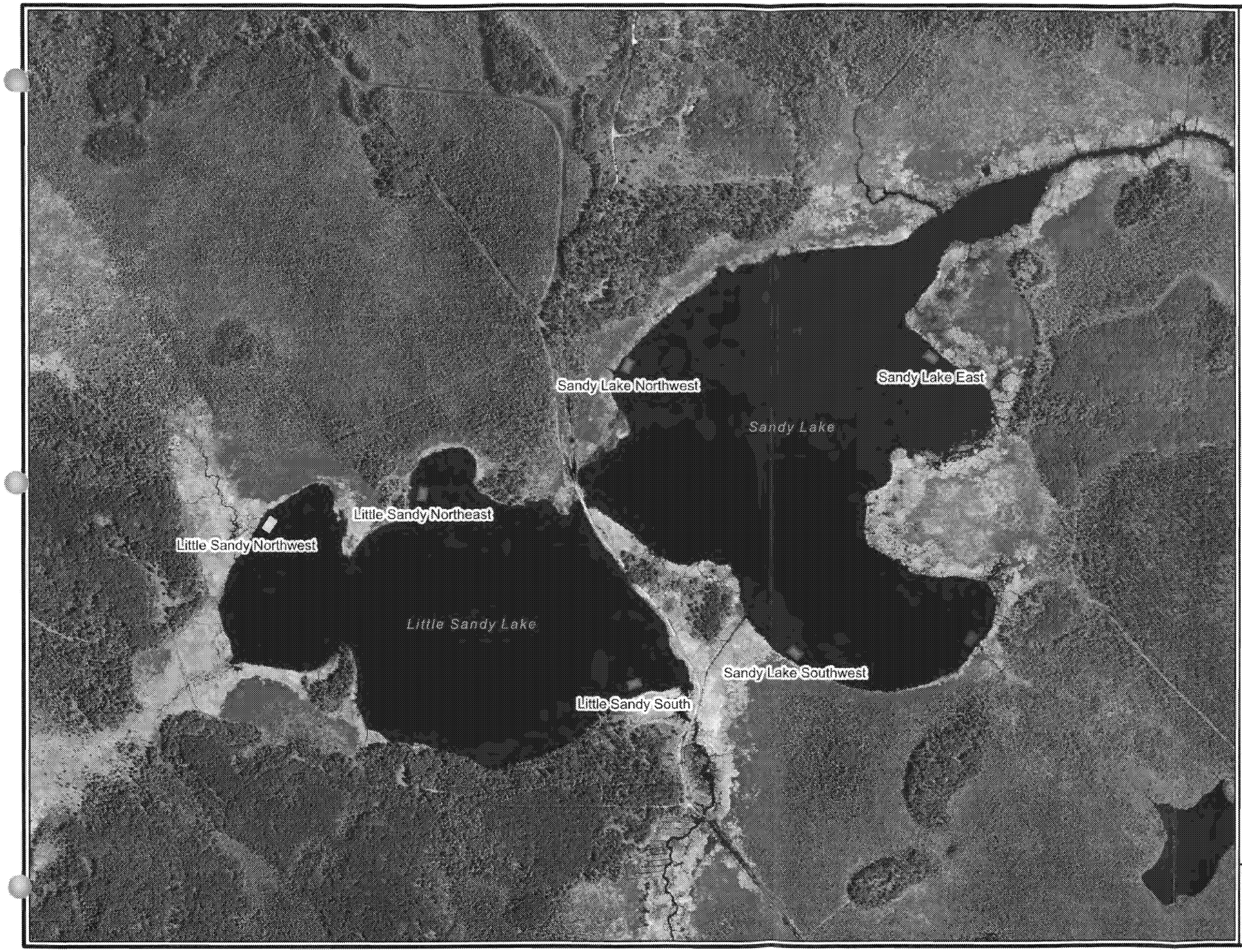


N

0 295 590 1,180

Feet

1 Inch = 602 Feet

## Legend

- Natural Wild Rice Growth
- Planted Wild Rice Growth
- Planted Wild Rice - No Growth

# Figure 6
# Twin Lakes 2016 Wild Rice Growth Areas

Twin Lakes Survey
US Steel Corporation-
Minnesota Ore Operations
Mt. Iron, Minnesota (St. Louis County)

NTS Environmental Science & Engineering
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| | |
|---|---|
| Date Drawn: November 16, 2016 | 6 |
| Drawn By: Evan Johnson | |
| NTS Project #: 10170E | |

due to the characteristics of the lakebed. There is documentation indicating that historically portions of the Twin Lakes consistently produced good stands of wild rice, while other portions of the lakes produced poorly or not at all. Therefore, it is possible, if not probable, that portions of the Twin Lakes are not suited to the production of wild rice and will not support wild rice growth due to site specific conditions unrelated to water quality or water depth.

During the 2016 field season, wild rice test seeding plots were inspected for growth of WR plants. Floating leaf stage WR plants were observed during July 2016; and were confirmed during August 2016. WR plants in at least the floating leaf stage were observed in all three test seeding plots in Sandy Lake. Mature, aerial, seed-producing WR plants were observed in the Sandy Lake East (SLE) and Sandy Lake Southwest (SLSW) locations with ≥ 200 plants per plot area. WR plants in the floating leaf stage were observed in the Sandy Lake Northwest location, but with only about 30 – 40 plants in the entire plot. WR plants in the SLE and SLSW locations produced a sufficient number of seeds to have the capability of limited 'self-seeding' in those areas. Observance of WR plants in these two areas during future years could indicate limited self-seeding events, or germination of legacy seed in the sediment from the 2015 seeding efforts. Also within Sandy Lake a natural group of WR plants was observed near the Sandy Lake Inflow South tributary location. These plants were not part of the WR seeding effort, and were classified as a natural WR stand. These plants were also mature, seed producing plants capable of a limited self-seeding event in the area. It was estimated that a total of 15 – 20 natural wild rice plants emerged into aerial phase near the mouth of the Sandy Lake Inflow South tributary.

Three plots were also seeded with WR in Little Sandy Lake. The test plot near 'Inflow 1' contained ≥ 100 mature, seed producing WR plants. Similar to seed producing plants in two plots in Sandy Lake, seed producing plants in Little Sandy Lake had the capability for a limited self-seeding event in that area / plot. Sparse floating leaf WR plants were observed in the Little Sandy Northeast test seeding plot, with 7 – 10 plants observed in the entire area. No WR plants were observed in the Little Sandy Lake test seeding plot near 'Inflow 3' (Little Sandy Northwest).

Regardless of the lake in which they were observed, mature seed-producing WR plants appeared healthy. No indications of nutrient deficiencies such as chlorosis associated with potential nitrogen deficiency, or discoloration associated with potential phosphorus deficiency were observed; and no evidence of diseased plants was observed (e.g., fungal brown spot disease).

However, based on historical observations of WR in the Twin Lakes system, water and sediment pore water chemistry may not have been the only influence on WR growth and density. Minnesota DNR studies from 1966 indicate that only isolated areas of Little Sandy Lake contained areas of WR growth. Sandy Lake is documented to have had WR throughout the entire lake, with some areas of denser WR growth than others. One criterion of these lakes that has measurably changed since these whole-lake studies were completed is water depth throughout the entirety of each lake. During the completion of these studies, water depth throughout the Twin Lakes system did not appear to extend past three feet. Over the course of the current Twin Lakes WR Restoration Opportunities Plan study, water depths within each lake routinely exceed four feet throughout the more central areas, and surpass five feet in the most central areas in each lake. During the time period from the 1966 studies to current, WR density has decreased to the point of absence from both lakes in some years; to current very sparse 'natural' growth areas. It is possible that as water depths throughout the Twin Lakes system increased, the ability of WR to compete for light during the seedling phenological stage has been adversely influenced

resulting in a nearly total lack of germination potential. However, the 2015 test plot seeding study would suggest this possibility does not entirely explain the lack of WR in other areas with similar water depths and sediment characteristics as the successful test seeding plots. Another possibility is that although WR seeds historically may have germinated, increasing water depths in early Spring resulted in decreasing success of adult plant development; this could have ultimately resulted in depletion of the sediment-associated WR seed bank throughout much of the Twin Lakes system. Overall, current physical conditions, such as water depth increases and fluctuations, within the Twin Lakes system may not be conducive to WR growth and development throughout the majority of the Twin Lakes system.

### 2.10 2016 Follow-on Seeding Efforts

Based on the success of the pilot seed plots that were observed throughout the 2016 growing season and described above, U. S. Steel developed plans to harvest additional wild rice from the Sand River upstream of MN Hwy 169, similar to what was completed in September 2015. However, the area experienced severe weather on the night of Labor Day, September 5, with heavy rain and strong winds. Subsequent efforts to harvest rice from that source were useless, as the wild rice plants were either uprooted, or the rice was stripped from the heads. Due to the vagaries associated with relying on this single source of seed for future planting activities, the possibility of using wild rice seed from other sources should be considered.

## 3.0 2017 Twin Lakes Work (Planned)

A general summary of the work proposed for 2017 in support of The Plan is shown in Appendix H. Details of the major components of the 2017 work plan are described separately below.

### 3.1 Rainfall, Water Level, and Temperature Monitoring

Continuous water depth measurements will again be recorded using the PT during the 2017 monitoring season (ice-out until freeze-up). The PT will be placed in the same location at the steel bridge between Little Sandy and Sandy lakes at ice-out in the Spring of 2017 as during previous deployments and will be retrieved prior to freeze-up during the Fall of 2017. Further, during each planned sampling / monitoring event, water level and temperature data will be downloaded to ensure that the data is being recorded as planned. Rainfall data will continue to be collected from the Minntac Tailings Basin weather station. This weather station was set up on the roof of the Tailings Basin Reclaim Pumphouse, which is located approximately 2 miles due south of the steel bridge. This new meteorological monitoring capability allows for more accurate measurement of local precipitation events, as well as local evaporation rate data.



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## 3.2 Sediment Pore Water Sampling and Analysis

In order to maintain consistency of measuring characteristics of Twin Lakes sediment pore water, peepers will again be deployed in specific locations within Little Sandy and Sandy lakes. Peepers (see Figure7) are fitted with sealed 50 mL centrifuge tubes so that when deployed the centrifuge tubes are located within the top 10 cm of sediment. Each 50-mL centrifuge tube is completely filled (no headspace) with analytical standards-grade deionized water obtained from Pace Analytical Laboratories (Pace; Virginia, MN). Each tube contains a 0.45 µM pore size filter in the cap to allow for deionized water / pore water equilibration via diffusion. Using peepers to collect pore water samples for characterization can better minimize, if not eliminate, the potential for the collected pore water to be exposed to air / oxygen.

For the 2017 field season, three peepers are planned for deployment in Little Sandy Lake and an additional three peepers are planned for deployment in Sandy Lake. Peepers are scheduled for six, 30-day deployments beginning immediately following ice out. One peeper is planned to be relocated from Inflow 3 to Sandy Lake Inflow South. Locations in Little Sandy Lake will be Inflow 1, Inflow 2, and the Little Sandy Lake middle location. Locations in Sandy Lake will be Sandy Lake Outflow, Sandy Lake Middle, and Sandy Lake Inflow South.

**Figure 7.** Peeper sediment pore water sampling device.

As mentioned in section 2.3, peeper samples collected at the Inflow 2 monitoring location show elevated sediment pore water hydrogen sulfide concentrations, with concurrent low extractable iron concentrations, which indicates that sulfide generation in this location likely exceeds the available iron



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for iron sulfide precipitation. One potential tactic to mitigate the elevated pore water sulfide may be to apply zero valent iron (ZVI) to the lake sediment in an area near / within the Inflow 2 monitoring location. This effort would be outside the scope of the original Work Plan, but appears to have merit as a potential wild rice restoration opportunity specifically focused on decreasing sediment pore water hydrogen sulfide.

Following the initial peeper deployment for sediment pore water hydrogen sulfide measurement, the appropriate amount of ZVI will be calculated to transform the measured concentration of hydrogen sulfide to iron sulfide. Application of 1.5x the calculated stoichiometric amount of ZVI will be added to the test plot area to provide excess available iron for sulfide precipitation. Tentatively, the suggested time period for this ZVI application is late-Spring / early-Summer 2017, with an estimated test-plot application area of 50' x 50'.

## 3.3 Continued Wild Rice / Aquatic Plants Survey within Twin Lakes System

Efforts to characterize the Twin Lakes in terms of wild rice presence, and density if present, will continue during each 2017 field visit. As alluded to in Section 2.7 above, an aquatic plant survey will be completed at the height of the 2017 growing season in both Little Sandy and Sandy Lakes, likely in mid-August. Repeated aquatic plant surveys are intended to inform future wild rice restoration efforts.

## 3.4 Continued Inflow / Outflow Flow Measurements, Water Quality Sampling, and Characterization Efforts

Water quality and quantity sampling and monitoring will continue on a monthly basis during the 2017 field monitoring season. The monthly sampling will follow the practice established in 2014 and continued in 2015 and 2016, with one exception – Inflow 3 sampling will be eliminated from the sampling mix since there does not appear to be a significant difference in the water quality at this location in comparison to other Little Sandy Lake water column samples collected previously. Monthly water quality samples will be collected at Inflow 1, Inflow 2, the Culvert, and Twin Lakes Outflow. In addition, samples from Sandy Lake South Inflow will be collected, as well as Station 701 and the middle of each lake. However, the Station 701 and mid-lake samples will be analyzed for an abbreviated list of parameters, consisting of the major cations and anions, as well as field data.

Flow monitoring will continue at Inflow 1, the Culvert, and Station 701, and the potential for gauging flow at Sandy Lake South Inflow will be evaluated. At a minimum, a visual estimate of flow at that location will be recorded each month. An additional flow monitoring site nearer the Twin Lakes Outflow sampling location was considered in 2016. Establishment of a flow monitoring site in that area would allow for a direct measurement of outflow from Sandy Lake and provide a better overall system water balance, without influence from other Sand River inflows between Sandy Lake and the 701 monitoring location. However, no alternative flow monitoring opportunities were identified during 2016. Due to the importance of this factor, additional efforts will be directed at establishing an outlet flow gauging site



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near the junction of Sandy Lake and the Sand River. Water quality and flow results will be compared to previous years' data so that characterization efforts may continue.

### 3.5 Continued Beaver Trapping and Water Level Control

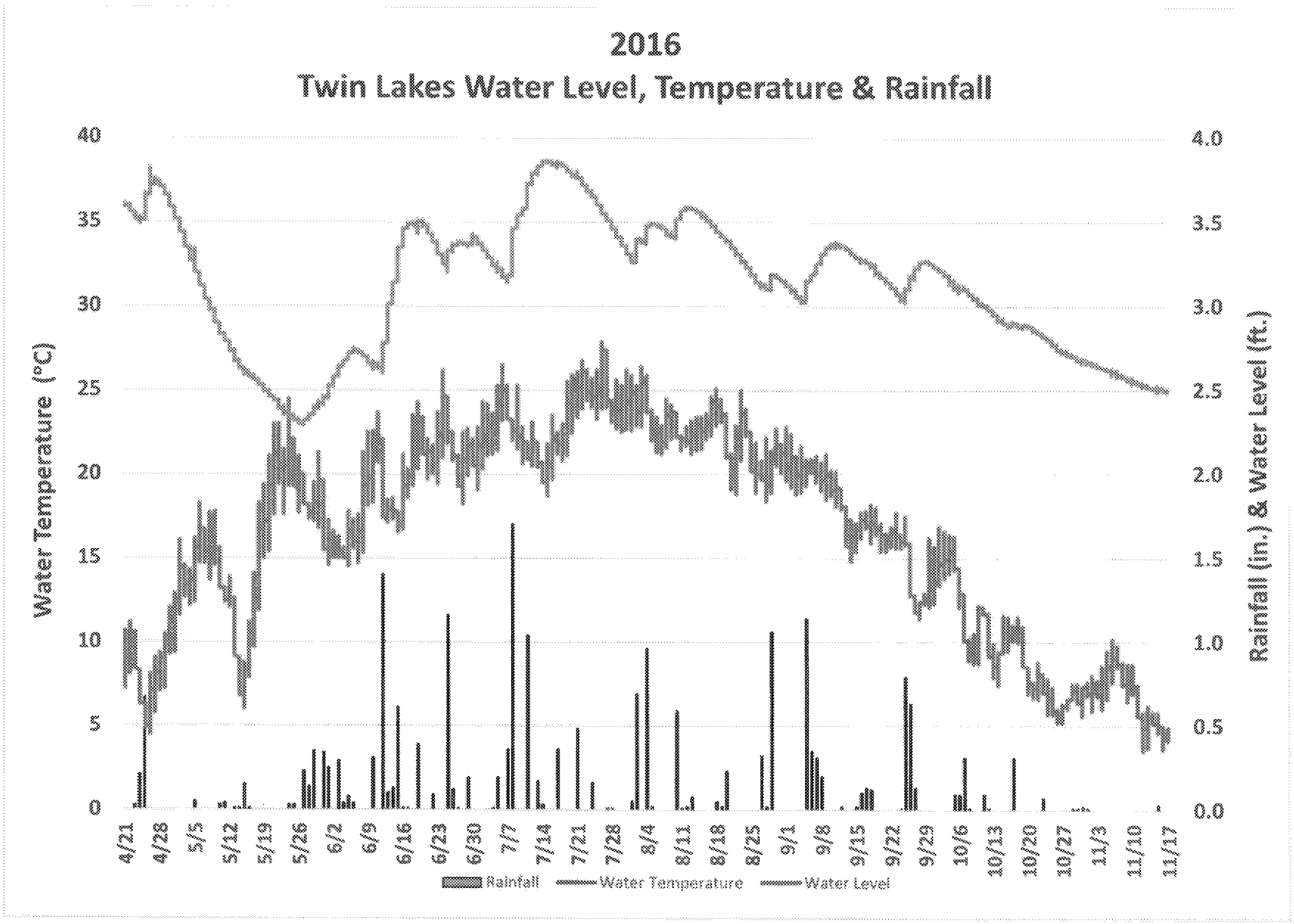
Continued management of lake water depths suitable for wild rice growth is critical to successful restoration of wild rice to the Twin Lakes system. To help ensure that flow through the lakes system is maintained, USDA APHIS will again be contracted for beaver and dam removal as needed. Specifically, the APHIS crew will be charged with removing any beaver that may have returned / moved in to the Sand River channel area, especially from the outlet of Sandy Lake downstream to approximately one mile east of U.S. Hwy 53. They will also be responsible for removing significant obstructions to flow along the Sand River mainstem soon after ice out and again during the early summer timeframe, following the period of above average rainfall typical to this area.

### 3.6 Consideration of Additional Wild Rice Seeding

Based on the results of the pilot-scale seeding efforts completed in October 2015 and discussed in Section 2.9 above, U. S. Steel may undertake similar seeding efforts in 2017. Although these are preliminary plans and subject to change depending upon circumstances encountered during the 2017 field season, it is envisioned that additional seeding will be pursued. However, as described in Section 2.10, efforts to collect additional seed from the Sand River on or about 9/9/16 were negated by severe weather. Serious consideration should be given to identifying alternative viable wild rice seed sources for planting activities, similar to what was undertaken in 2016 for seeding the St. Louis River estuary using wild rice from Leech Lake and White Earth sources.

# APPENDIX A

2016 Twin Lakes Rainfall, Water Level, and Temperature Measurements


2016
Twin Lakes Water Level, Temperature & Rainfall
Water Temperature (°C)
Rainfall (in.) & Water Level (ft.)
40
35
30
25
20
15
10
5
0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/21
4/28
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
9/8
9/15
9/22
9/29
10/6
10/13
10/20
10/27
11/3
11/10
11/17
Rainfall
Water Temperature
Water Level

# APPENDIX B

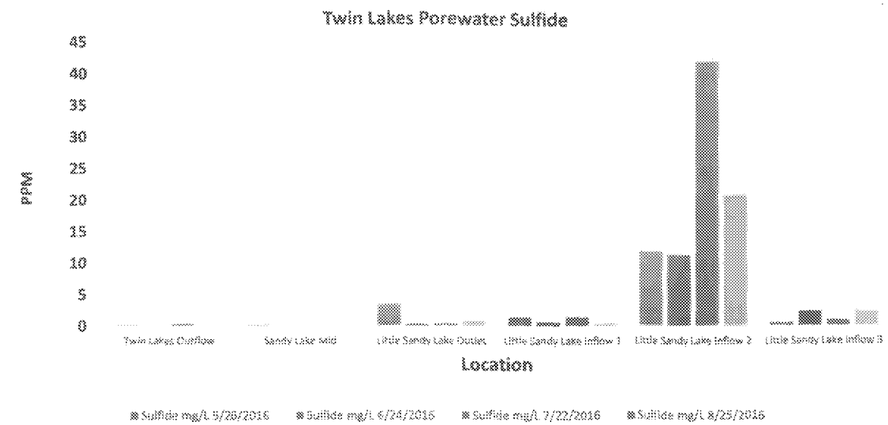
Twin Lakes 2016 Sediment Pore Water Results

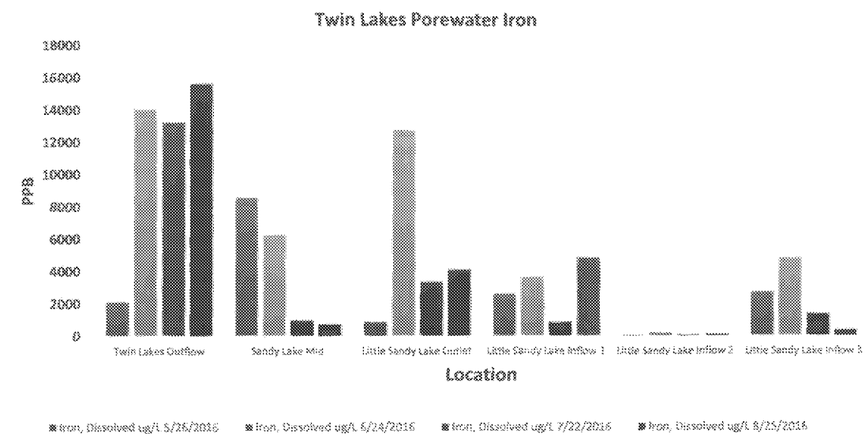
## TWIN LAKES PEEPER SEDIMENT POREWATER RESULTS
## 2016

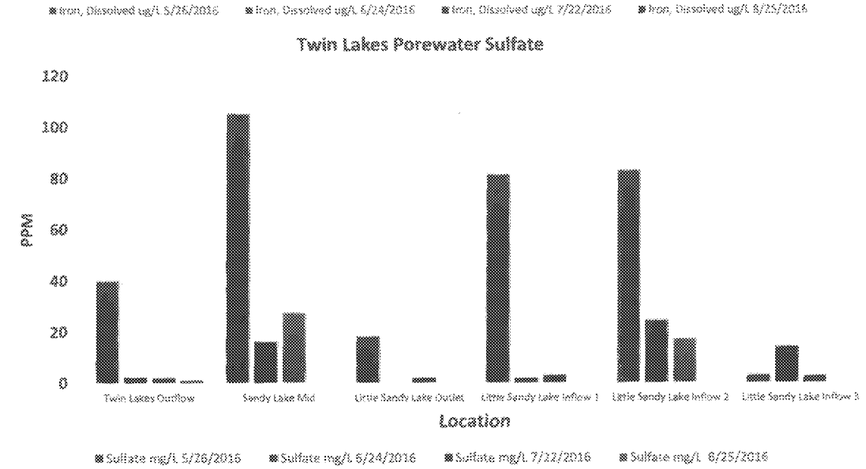
| PARAMETER | UNITS | DATE | Twin Lakes Outflow | Sandy Lake Mid | Little Sandy Lake Outlet | Little Sandy Lake Inflow 1 | Little Sandy Lake Inflow 2 | Little Sandy Lake Inflow 3 | MDL |
|---|---|---|---|---|---|---|---|---|---|
| Sulfide | mg/L | 5/26/2016 | 0.13 | 0.25 | 3.5 | 1.4 | 11.8 | 0.61 | Varies |
| | | 6/24/2016 | 0.11 | 0.13 | 0.28 | 0.63 | 11.3 | 2.4 | |
| | | 7/22/2016 | 0.34 | 0.18 | 0.37 | 1.5 | 41.9 | 0.97 | |
| | | 8/25/2016 | 0.18 | 0.17 | 0.77 | 0.37 | 20.8 | 2.3 | |
| Iron, Dissolved | ug/L | 5/26/2016 | 2100 | 8550 | 870 | 2600 | 57.9 | 2700 | 50.0 |
| | | 6/24/2016 | 14000 | 6240 | 12700 | 3620 | 376 | 4800 | |
| | | 7/22/2016 | 13200 | 989 | 3350 | 855 | 73.8 | 1360 | |
| | | 8/25/2016 | 15600 | 729 | 4110 | 4840 | 124 | 377 | |
| Sulfate | mg/L | 5/26/2016 | 39.7 | 105 | 18.2 | 81.3 | 82.8 | 3.0 | 2.0 |
| | | 6/24/2016 | 2.3 | 16.1 | <2.0 | 2.0 | 24.3 | 14.1 | |
| | | 7/22/2016 | 2.1 | 27.3 | 2.1 | 3.0 | 17.0 | 2.6 | |
| | | 8/25/2016 | <2.0 | <2.0 | <2.0 | <2.0 | 8.2 | <2.0 | |
| Chloride | mg/L | 5/26/2016 | 23.1 | 21.0 | 39.3 | 31.6 | 26.2 | 12.0 | 1.0 |
| | | 6/24/2016 | 32.6 | 29.0 | 37.3 | 40.6 | 52.9 | 18.6 | |
| | | 7/22/2016 | 33.0 | 31.3 | 40.7 | 43.7 | 40.4 | 15.3 | |
| | | 8/25/2016 | 19.1 | 24.4 | 41.5 | 44.7 | 47.4 | 20.7 | |
| Sodium, Dissolved | ug/L | 5/26/2016 | 13100 | 12600 | 20000 | 21400 | 15400 | 9010 | 1000 |
| | | 6/24/2016 | 20200 | 16800 | 18400 | 21800 | 29400 | 11400 | |
| | | 7/22/2016 | 18800 | 16500 | 19300 | 24000 | 24500 | 10600 | |
| | | 8/25/2016 | 13600 | 14400 | 24800 | 27600 | 34400 | 16700 | |
| Calcium, Dissolved | ug/L | 5/26/2016 | 28800 | 31800 | 34400 | 46900 | 49200 | 18400 | 500 |
| | | 6/24/2016 | 50600 | 25900 | 37500 | 33200 | 53700 | 22900 | |
| | | 7/22/2016 | 50400 | 30100 | 45200 | 37600 | 73700 | 25200 | |
| | | 8/25/2016 | 40100 | 26600 | 45500 | 40100 | 82700 | 36700 | |
| Potassium, Dissolved | ug/L | 5/26/2016 | 4530 | 4260 | 5770 | 7590 | 3460 | 3190 | 2500 |
| | | 6/24/2016 | 7130 | 5290 | 5550 | 7150 | 5450 | 4080 | |
| | | 7/22/2016 | 6950 | 4920 | 5460 | 7530 | 6750 | 4010 | |
| | | 8/25/2016 | 8910 | 4720 | 7810 | 8800 | 8800 | 4970 | |
| Magnesium, Dissolved | ug/L | 5/26/2016 | 28700 | 35400 | 30400 | 53700 | 42300 | 19600 | 500 |
| | | 6/24/2016 | 49100 | 25200 | 23000 | 31900 | 63300 | 23200 | |
| | | 7/22/2016 | 46200 | 30100 | 29800 | 38700 | 69500 | 25600 | |
| | | 8/25/2016 | 34800 | 28000 | 39400 | 38400 | 93900 | 42700 | |
| Manganese, Dissolved | ug/L | 5/26/2016 | 604 | 720 | 302 | 633 | 63.9 | 231 | 5.0 |
| | | 6/24/2016 | 1270 | 1370 | 720 | 502 | 257 | 355 | |
| | | 7/22/2016 | 958 | 287 | 522 | 366 | 341 | 247 | |
| | | 8/25/2016 | 1260 | 376 | 604 | 664 | 121 | 281 | |

MDL - Minimum Detection Limit

Vaires - MDL changes based on result's concentration.



## APPENDIX C

Twin Lakes 2016 Inflow / Outflow Water Sampling Data

# TWIN LAKES
# INFLOW / OUTFLOW SAMPLING EVENT
## 5/26/2016

| Analytes - Cations | Little Sandy Inflow 1 | Little Sandy Inflow 2 | Little Sandy Inflow 3 | Little Sandy Middle | Sandy Middle | Twin Lakes Outflow | Culvert Inflow | Reporting Detection Limits | Reporting Units |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | **55.8** | <0.50 | <0.50 | NM | NM | <0.50 | <0.50 | **0.50** | ug / L |
| Arsenic | NM | NM | NM | NM | NM | NM | NM | **0.05** | ug / L |
| Barium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| Calcium | **64.7** | **30.7** | **34.5** | **28.2** | **38.3** | **24.3** | **11.3** | **0.50** | mg / L |
| Iron | **1270** | **531** | **381** | NM | NM | **502** | **1560** | **50.0** | ug / L |
| Magnesium | **86.4** | **41.9** | **47.5** | **38.3** | **51.3** | **31.2** | **4.1** | **0.50** | mg / L |
| Manganese | **183** | **51.9** | **77.2** | NM | NM | **46.8** | **62.9** | **10.0** | ug / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | NM | **0.10** | mg / L |
| Potassium | **9.5** | **4.6** | **4.3** | **4.0** | **5.2** | **3.5** | **1.6** | **0.50** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | NM | **1.0** | ug / L |
| Sodium | **34.8** | **14.3** | **14.8** | **13.5** | **17.5** | **11.5** | **4.1** | **0.50** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **51.8** | **20.5** | **21.7** | **19.8** | **26.4** | **16.4** | **9.4** | **1.0** | mg / l |
| Nitrogen, Kjeldahl, Total | **0.68** | **0.96** | **0.92** | **0.80** | **0.76** | **0.71** | <0.50 | **0.50** | mg / L |
| Ammonium as Nitrogen | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | **0.10** | mg / L |
| Sulfate | **338** | **216** | **156** | **129** | **183** | **92.7** | <2.0 | **2.0** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **761** | **407** | **417** | **363** | **438** | **295** | **141** | **10.0** | mg / L |
| Total Suspended Solids | **4.0** | **18.7** | **6.5** | **2.0** | **2.8** | **1.6** | **2.4** | **1.0** | mg / L |
| Alkalinity, Total as CaCO3 | **174** | **120** | **140** | **106** | **138** | **92.4** | **37.1** | **6.1** | mg / L |
| Dissolved Organic Carbon | **10.5** | **15.6** | **16.2** | NM | NM | **14.8** | **13.9** | **1.0** | mg / L |
| Total Hardness by 2340B | **517** | **249** | **282** | **228** | **307** | **189** | **45.1** | **3.3** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | NM | **0.009** | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | NM | **0.1** | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.3** | **7.3** | **7.2** | **8.2** | **8.1** | **7.6** | **7.0** | **± 0.2** | Units |
| Temperature | **15.0** | **16.6** | **15.3** | **18.2** | **17.6** | **16.2** | **14.2** | **± 0.1** | °C |
| Specific Conductance | **1109** | **574** | **560** | **682** | **517** | **359** | **112** | **± 1%** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | NM | **± 0.01** | mg / L |

**Bold Print indicates the sample is above the detection limit**
"<" indicates value below reporting limit
NM indicates that the analyte was not measured

# TWIN LAKES
# INFLOW / OUTFLOW SAMPLING EVENT
## 6/24/2016

| Analytes - Cations | Little Sandy Inflow 1 | Little Sandy Inflow 2 | Little Sandy Inflow 3 | Little Sandy Middle | Sandy Middle | Twin Lakes Outflow | Culvert Inflow | Reporting Detection Limits | Reporting Units |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | <50.0 | <200 | <200 | NM | NM | <200 | <200 | **200** | ug / L |
| Arsenic | NM | NM | NM | NM | NM | NM | NM | **0.05** | ug / L |
| Barium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| Calcium | **43.6** | **34.0** | **34.4** | **35.5** | **31.5** | **25.2** | **11.8** | **0.50** | mg / L |
| Iron | **2590** | **929** | **439** | NM | NM | **724** | **5360** | **50.0** | ug / L |
| Magnesium | **54.5** | **47.5** | **49.0** | **48.9** | **42.9** | **33.4** | **3.9** | **0.50** | mg / L |
| Manganese | **81.3** | **101** | **82.8** | NM | NM | **70.6** | **411** | **5.0** | ug / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | NM | **0.10** | mg / L |
| Potassium | **4.9** | **3.5** | **3.2** | **3.7** | **3.6** | **3.1** | <2.5 | **2.50** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | NM | **1.0** | ug / L |
| Sodium | **22.5** | **14.9** | **14.6** | **15.9** | **15.2** | **12.4** | **3.1** | **1.0** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **31.8** | 21.0 | **20.6** | **23.0** | **22.0** | **19.5** | **7.1** | **2.0** | mg / L |
| Nitrogen, Kjeldahl, Total | **0.73** | 0.70 | **0.60** | <0.50 | <0.50 | <0.50 | **0.67** | **0.50** | mg / L |
| Ammonium as Nitrogen | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | **0.10** | mg / L |
| Sulfate | **212** | 160 | **163** | **170** | **147** | **114** | <2.0 | **4.0** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **530** | **447** | **447** | **465** | **389** | **316** | **145** | **10.0** | mg / L |
| Total Suspended Solids | **1.5** | **3.5** | **2.8** | **3.2** | **1.2** | **2.0** | **10** | **1.0** | mg / L |
| Alkalinity, Total as CaCO3 | **149** | **152** | **163** | **149** | **127** | **105** | **40.8** | **6.1** | mg / L |
| Dissolved Organic Carbon | **23.4** | **26.1** | **21.5** | NM | NM | **18.3** | **25.7** | **1.0** | mg / L |
| Total Hardness by 2340B | **333** | **281** | **287** | **290** | **255** | 201 | **45.6** | **3.3** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | NM | **0.009** | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | NM | **0.1** | L / mg*m |
| **YSI Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.0** | **7.1** | **7.2** | **7.7** | **7.7** | **7.4** | **6.5** | **± 0.2** | Units |
| Temperature | **19.1** | **22.5** | **20.3** | **22.8** | **22.3** | **21.3** | **19.8** | **± 0.1** | °C |
| Specific Conductance | **743** | **606** | **644** | **637** | **540** | **445** | **102** | **± 1%** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | NM | **± 0.01** | mg / L |

***Bold Print indicates the sample is above the detection limit***
"<" indicates value below reporting limit
NM indicates that the analyte was not measured

# TWIN LAKES
# INFLOW / OUTFLOW SAMPLING EVENT
**7/22/2016**

| Analytes - Cations | Little Sandy Inflow 1 | Little Sandy Inflow 2 | Little Sandy Inflow 3 | Little Sandy Middle | Sandy Middle | Twin Lakes Outflow | Culvert Inflow | Detection Limits | Reporting Units |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | **284** | **55.0** | **69.1** | NM | NM | **51.0** | **107** | **50.0** | ug / L |
| Arsenic | NM | NM | NM | NM | NM | NM | NM | **0.50** | ug / L |
| Barium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| Calcium | **39.4** | **36.1** | **36.6** | **30.1** | **36.5** | **27.4** | **14.1** | **0.50** | mg / L |
| Iron | **20700** | **2320** | **3270** | NM | NM | **2510** | **10400** | **50.0** | ug / L |
| Magnesium | **45.6** | **48.7** | **49.2** | **39.7** | **49.1** | **35.3** | **4.7** | **0.50** | mg / L |
| Manganese | **429** | **179** | **197** | NM | NM | **138** | **419** | **10.0** | ug / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | NM | **0.10** | mg / L |
| Potassium | **2.6** | **2.9** | **2.9** | **2.9** | **3.0** | **2.8** | **0.94** | **0.50** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | NM | **1.0** | ug / L |
| Sodium | **17.1** | **15.1** | **15.1** | **13.8** | **15.6** | **12.6** | **3.4** | **0.50** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **20.9** | **17.9** | **17.6** | **17.8** | **18.4** | **16.8** | **7.5** | **1.0/2.0** | mg / L |
| Nitrogen, Kjeldahl, Total | **2.6** | **1.5** | **1.6** | **1.4** | **1.3** | **1.3** | **1.3** | **0.50** | mg / L |
| Ammonium as Nitrogen | **0.36** | **0.15** | **0.12** | **0.15** | **0.11** | **0.13** | **0.12** | **0.10** | mg / L |
| Sulfate | **120** | **121** | **121** | **104** | **125** | **92.1** | **2.3** | **2.0/8.0** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **431** | **409** | **372** | **378** | **398** | **276** | **126** | **10.0** | mg / L |
| Total Suspended Solids | **14.0** | <2.5 | <2.5 | **2.0** | <1.0 | **3.6** | **5.0** | **1.0/2.5** | mg / L |
| Alkalinity, Total as CaCO3 | **153** | **175** | **179** | **114** | **160** | **125** | **40.2** | **6.1/5.0** | mg / L |
| Dissolved Organic Carbon | **63.7** | **36.1** | **38.2** | NM | NM | **31.6** | **35.4** | **1.0** | mg / L |
| Total Hardness by 2340B | **286** | **291** | **294** | **239** | **293** | **214** | **54.5** | **3.3** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | NM | **0.009** | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | NM | **0.1** | L / mg*m |
| **YSI Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **6.7** | **6.9** | **7.3** | **7.3** | **7.3** | **7.3** | **6.5** | **± 0.2** | Units |
| Temperature | **21.4** | **24.2** | **23.6** | **25.1** | **24.8** | **25.0** | **19.2** | **± 0.1** | °C |
| Specific Conductance | **547** | **572** | **585** | **567** | **459** | **422** | **107** | **± 1%** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | NM | **± 0.01** | mg / L |

**Bold Print indicates the sample is above the detection limit**
"<" indicates value below reporting limit
NM indicates that the analyte was not measured

# TWIN LAKES
# INFLOW / OUTFLOW SAMPLING EVENT
## 8/25/2016

| Analytes - Cations | Little Sandy Inflow 1 | Little Sandy Inflow 2 | Little Sandy Inflow 3 | Little Sandy Middle | Sandy Middle | Twin Lakes Outflow | Culvert Inflow | Reporting Detection Limits | Reporting Units |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | **70.5** | **111** | <50.0 | NM | NM | **57.3** | **132** | **50.0** | ug / L |
| Arsenic | NM | NM | NM | NM | NM | NM | NM | **0.50** | ug / L |
| Barium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| Calcium | **69.6** | **38.6** | **40.0** | NM | NM | **28.0** | **14.2** | **0.50** | mg / L |
| Iron | **2090** | **2250** | **1650** | NM | NM | **3280** | **10700** | **50.0** | ug / L |
| Magnesium | **99.3** | **53.5** | **56.0** | NM | NM | **33.4** | **4.9** | **0.50** | mg / L |
| Manganese | **138** | **214** | **220** | NM | NM | **136** | **304** | **10.0** | ug / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | NM | **0.10** | mg / L |
| Potassium | **5.5** | **2.3** | **2.5** | NM | NM | **2.2** | **1.1** | **0.50** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | NM | **1.0** | ug / L |
| Sodium | **39.0** | **15.4** | **16.8** | NM | NM | **11.7** | **4.1** | **0.50** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **56.5** | **18.6** | **20.2** | NM | NM | **15.4** | **9.5** | **1.0/2.0** | mg / l |
| Nitrogen, Kjeldahl, Total | **0.87** | **2.1** | **1.3** | NM | NM | **1.5** | **0.99** | **0.60** | mg / L |
| Ammonium as Nitrogen | <0.10 | **0.29** | **0.16** | NM | NM | **0.32** | <0.10 | **0.10** | mg / L |
| Sulfate | **314** | **96.7** | **108** | NM | NM | **64.3** | <2.0 | **2.0/4.0** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **836** | **434** | **473** | NM | NM | **356** | **155** | **10.0** | mg / L |
| Total Suspended Solids | **2.8** | **22.0** | **5.2** | NM | NM | <1.0 | **26.0** | **1.0/1.7** | mg / L |
| Alkalinity, Total as CaCO3 | **278** | **240** | **237** | NM | NM | **152** | **48.4** | **6.1** | mg / L |
| Dissolved Organic Carbon | **22.1** | **38.9** | **37.1** | NM | NM | **39.1** | **26.9** | **1.0/2.0** | mg / L |
| Total Hardness by 2340B | **582** | **317** | **330** | NM | NM | **207** | **55.5** | **3.3** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | NM | **0.009** | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | NM | **0.1** | L / mg*m |
| **YSI Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.1** | **7.4** | **7.2** | NM | NM | **7.3** | **6.7** | **± 0.2** | Units |
| Temperature | **19.1** | **20.2** | **19.8** | NM | NM | **20.0** | **16.1** | **± 0.1** | °C |
| Specific Conductance | **1141** | **600** | **576** | NM | NM | **417** | **119** | **± 1%** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | NM | **± 0.01** | mg / L |

**Bold Print indicates the sample is above the detection limit**
"<" indicates value below reporting limit
NM indicates that the analyte was not measured

# TWIN LAKES
# INFLOW / OUTFLOW SAMPLING EVENT
## 9/28/2016

| Analytes - Cations | Little Sandy Inflow 1 | Little Sandy Inflow 2 | Little Sandy Inflow 3 | Little Sandy Middle | Sandy Middle | Twin Lakes Outflow | Culvert Inflow | Reporting Detection Limits | Reporting Units |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | **84.6** | <50.0 | <50.0 | NM | NM | <50.0 | **54.5** | **50.0** | ug / L |
| Arsenic | NM | NM | NM | NM | NM | NM | NM | **0.50** | ug / L |
| Barium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| Calcium | **54.4** | **47.4** | **30.9** | NM | NM | **28.6** | **10.4** | **0.50** | mg / L |
| Iron | **1150** | **455** | **353** | NM | NM | **1420** | **2750** | **50.0** | ug / L |
| Magnesium | **72.6** | **65.9** | **49.4** | NM | NM | **36.0** | **3.7** | **0.50** | mg / L |
| Manganese | **84.7** | **84.0** | **90.6** | NM | NM | **54.1** | **101** | **10.0** | ug / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | NM | **0.10** | mg / L |
| Potassium | **5.8** | **3.3** | **1.5** | NM | NM | **2.6** | **1.5** | **0.50** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | NM | **1.0** | ug / L |
| Sodium | **28.4** | **20.9** | **9.2** | NM | NM | **13.3** | **4.0** | **0.50** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **47.0** | **31.5** | **12.5** | NM | NM | **21.1** | **10.4** | **1.0/2.0** | mg / l |
| Nitrogen, Kjeldahl, Total | **0.71** | **0.88** | **0.85** | NM | NM | **0.94** | <0.60 | **0.60** | mg / L |
| Ammonium as Nitrogen | <0.10 | <0.10 | <0.10 | NM | NM | **0.11** | <0.10 | **0.10** | mg / L |
| Sulfate | **229** | **165** | **39.6** | NM | NM | **81.9** | <2.0 | **2.0/4.0** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **661** | **561** | **367** | NM | NM | **346** | **120** | **10.0** | mg / L |
| Total Suspended Solids | **3.2** | **3.6** | **2.4** | NM | NM | **2.4** | **3.5** | **1.0** | mg / L |
| Alkalinity, Total as CaCO3 | **207** | **251** | **255** | NM | NM | **145** | **34.8** | **6.1** | mg / L |
| Dissolved Organic Carbon | **19.5** | **27.7** | **32.2** | NM | NM | **27.9** | **16.9** | **1.0/5.0** | mg / L |
| Total Hardness by 2340B | **435** | **390** | **280** | NM | NM | **220** | **41.2** | **3.3** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | NM | **0.009** | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | NM | **0.1** | L / mg*m |
| **YSI Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.3** | **7.8** | **7.4** | NM | NM | **7.6** | **6.8** | **± 0.2** | Units |
| Temperature | **10.9** | **11.7** | **11.8** | NM | NM | **11.0** | **11.2** | **± 0.1** | °C |
| Specific Conductance | **895** | **781** | **517** | NM | NM | **462** | **102.6** | **± 1%** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | NM | **± 0.01** | mg / L |

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# TWIN LAKES
# INFLOW / OUTFLOW SAMPLING EVENT

**10/20/2016**

| Analytes - Cations | Little Sandy Inflow 1 | Little Sandy Inflow 2 | Little Sandy Inflow 3 | Little Sandy Middle | Sandy Middle | Twin Lakes Outflow | Culvert Inflow | Reporting Detection Limits | Reporting Units |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | **83.1** | <50.0 | <50.0 | <50.0 | <50.0 | <50.0 | <50.0 | **50.0** | ug / L |
| Arsenic | NM | NM | NM | NM | NM | NM | NM | **0.50** | ug / L |
| Barium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| Calcium | **63.7** | **47.2** | **30.1** | **46.0** | **38.7** | **33.4** | **10.0** | **0.50** | mg / L |
| Iron | **1250** | **442** | **268** | **388** | **650** | **880** | **2220** | **50.0** | ug / L |
| Magnesium | **92.4** | **69.1** | **54.2** | **67.2** | **55.6** | **46.5** | **3.8** | **0.50** | mg / L |
| Manganese | **143** | **96.1** | **94.1** | **63.3** | **38.4** | **68.1** | **98.7** | **10.0** | ug / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | NM | **0.10** | mg / L |
| Potassium | **7.7** | **3.9** | **1.5** | **4.1** | **3.6** | **3.1** | **1.6** | **0.50** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | NM | **1.0** | ug / L |
| Sodium | **35.7** | **23.0** | **10.6** | **23.0** | **20.1** | **17.1** | **4.2** | **0.50** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | NM | **10.0** | ug / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **53.6** | **33.7** | **15.1** | **34.7** | **30.2** | **26.1** | **10.6** | **1.0/5.0** | mg / l |
| Nitrogen, Kjeldahl, Total | <0.60 | **0.80** | **0.66** | **0.75** | **0.79** | **0.79** | <0.60 | **0.60** | mg / L |
| Ammonium as Nitrogen | <0.10 | <0.10 | <0.10 | <0.10 | <.010 | <0.10 | <0.10 | **0.10** | mg / L |
| Sulfate | **294** | **172** | **84.3** | **176** | **135** | **109** | <2.0 | **2.0/10.0** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **739** | **532** | **375** | **548** | **460** | **392** | **113** | **10.0** | mg / L |
| Total Suspended Solids | **2.4** | **4.4** | **2.0** | **2.4** | **1.6** | **2.0** | **3.2** | **1.0** | mg / L |
| Alkalinity, Total as CaCO3 | **215** | **216** | **213** | **222** | **179** | **147** | **36.6** | **6.1** | mg / L |
| Dissolved Organic Carbon | **15.0** | **22.3** | **24.0** | **21.6** | **25.1** | **23.8** | **11.7** | **1.0** | mg / L |
| Total Hardness by 2340B | **540** | **402** | **298** | **392** | **326** | **275** | **40.4** | **3.3** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | NM | **0.009** | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | NM | **0.1** | L / mg*m |
| **YSI Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.1** | **6.9** | **7.2** | **8.0** | **8.0** | **7.6** | **7.0** | **± 0.2** | Units |
| Temperature | **5.8** | **6.0** | **5.4** | **7.6** | **7.3** | **6.5** | **5.8** | **± 0.1** | °C |
| Specific Conductance | **1057** | **632** | **526** | **732** | **619** | **527** | **105** | **± 1%** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | NM | **± 0.01** | mg / L |

**Bold Print indicates the sample is above the detection limit**
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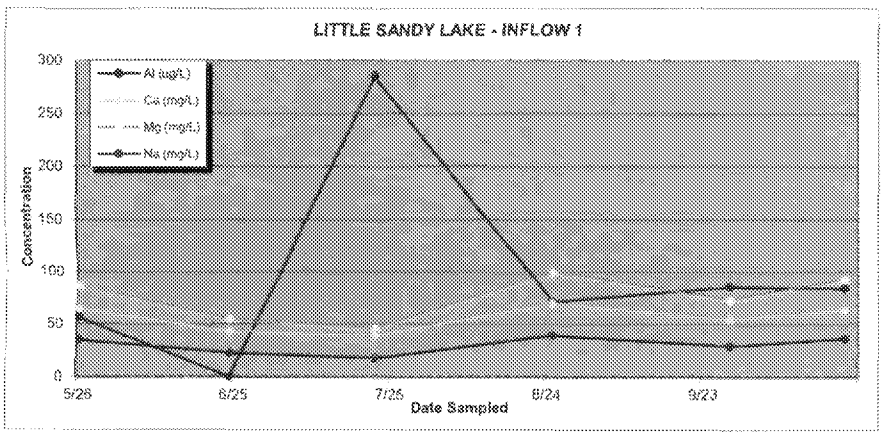
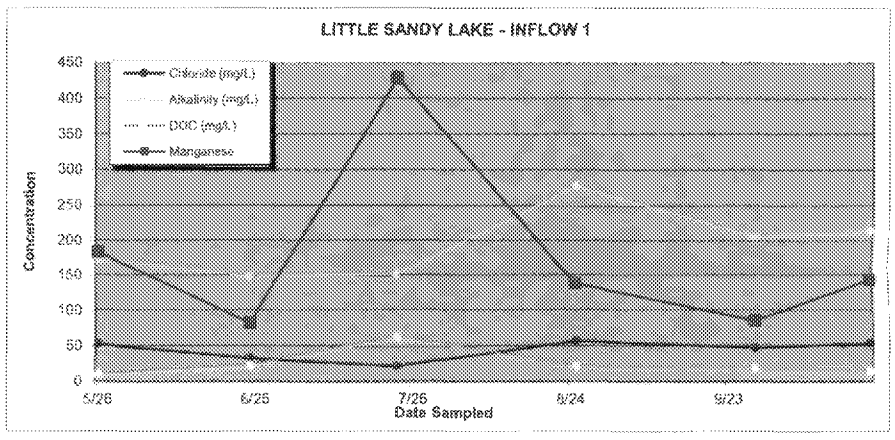
NM indicates that the analyte was not measured

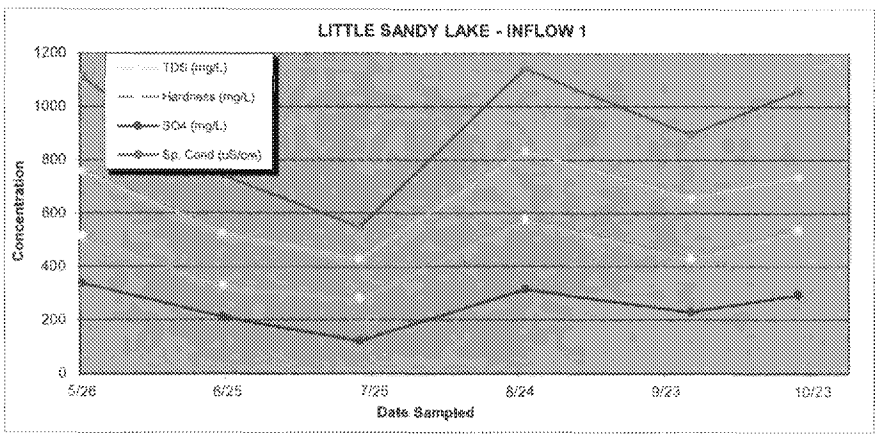
# LITTLE SANDY LAKE - INFLOW 1

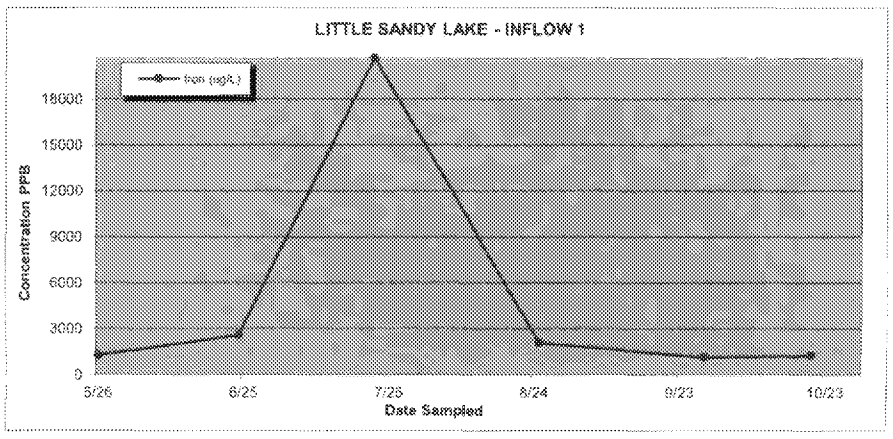
| Analytes - Cations | 5/26/2016 Little Sandy Inflow 1 | 6/24/2016 Little Sandy Inflow 1 | 7/22/2016 Little Sandy Inflow 1 | 8/25/2016 Little Sandy Inflow 1 | 9/28/2016 Little Sandy Inflow 1 | 10/20/2016 Little Sandy Inflow 1 | Reporting Units |
|---|---|---|---|---|---|---|---|
| Aluminum | **55.8** | <50.0 | **284** | **70.5** | **84.6** | **83.1** | µg / L |
| Arsenic | NM | NM | NM | NM | NM | NM | µg / L |
| Barium | NM | NM | NM | NM | NM | NM | µg / L |
| Calcium | **64.7** | **43.6** | **39.4** | **69.6** | **54.4** | **63.7** | mg / L |
| Iron | **1270** | **2590** | **20700** | **2090** | **1150** | **1250** | µg / L |
| Magnesium | **86.4** | **54.5** | **45.6** | **99.3** | **72.6** | **92.4** | mg / L |
| Manganese | **183** | **81.3** | **429** | **138** | **84.7** | **143** | µg / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | mg / L |
| Potassium | **9.5** | **4.9** | **2.6** | **5.5** | **5.8** | **7.7** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | µg / L |
| Sodium | **34.8** | **22.5** | **17.1** | **39** | **28.4** | **35.7** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | µg / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **51.8** | **31.8** | **20.9** | **56.5** | **47** | **53.6** | mg / L |
| Nitrogen, Kjeldahl, Total | **0.68** | **0.73** | **2.6** | **0.87** | **0.71** | <0.60 | mg / L |
| Ammonium as Nitrogen | NM | <0.10 | **0.36** | <0.10 | <0.10 | <0.10 | mg / L |
| Sulfate | **338** | **212** | **120** | **314** | **229** | **294** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **761** | **530** | **431** | **836** | **661** | **739** | mg / L |
| Total Suspended Solids | **4.0** | **1.5** | **14** | 2.8 | **3.2** | **2.4** | mg / L |
| Alkalinity, Total as CaCO3 | **174** | **149** | **153** | **278** | **207** | **215** | mg / L |
| Dissolved Organic Carbon | **10.5** | **23.4** | **63.7** | **22.1** | **19.5** | **15** | mg / L |
| Total Hardness by 2340B | **517** | **333** | **286** | **582** | **435** | **540** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.3** | **6.99** | **6.7** | **7.13** | **7.25** | **7.13** | Units |
| Temperature | **15.0** | **19.1** | **21.4** | **19.1** | **10.9** | **5.8** | °C |
| Specific Conductance | **1109** | **743** | **547.0** | **1141** | **895** | **1057** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | mg / L |

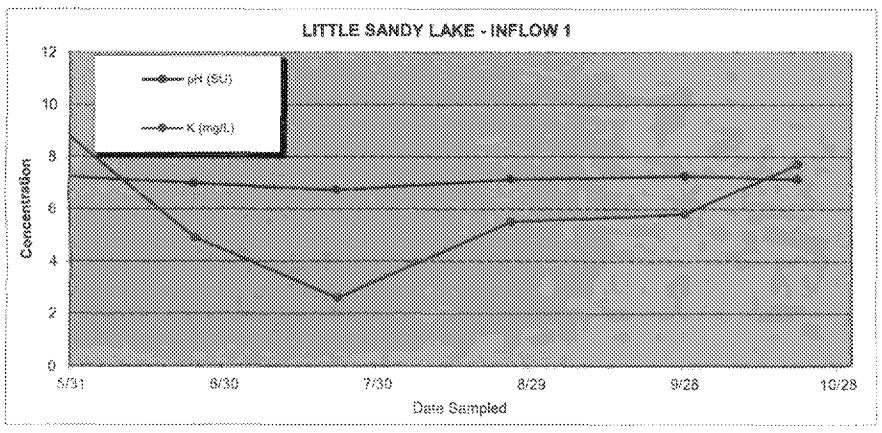
**Bold Print indicates the sample is above the detection limit**
NM indicates that the analyte was not measured
"<" indicates value below reporting limit
For a list of reporting detection limits, see data tables organized by sample date



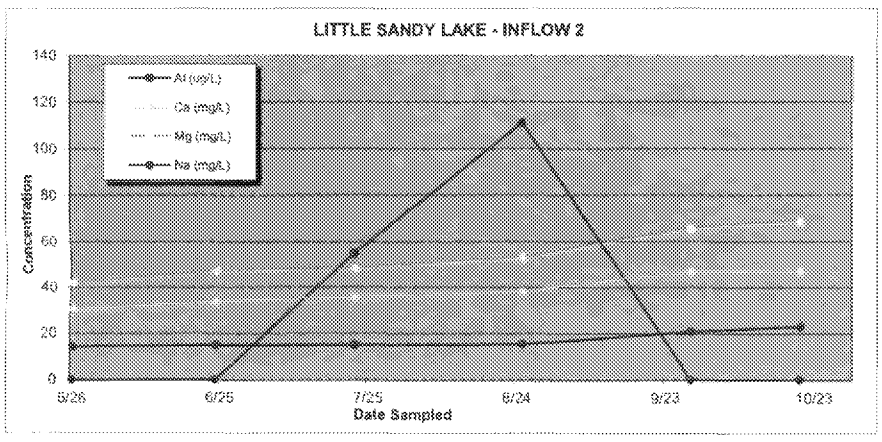



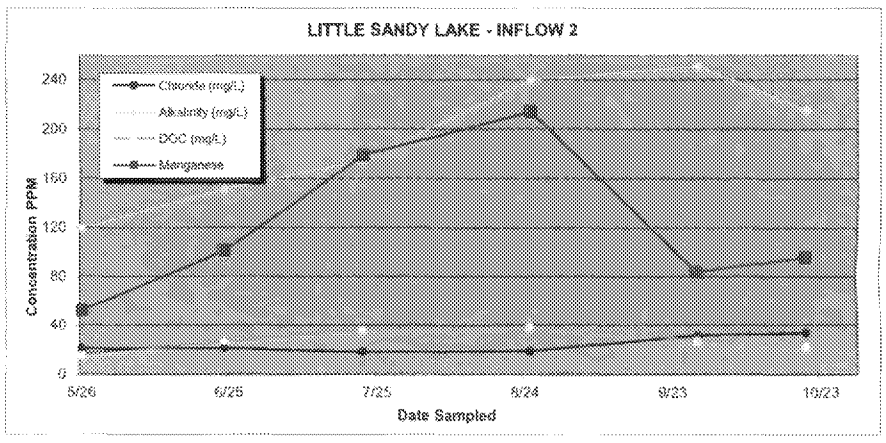



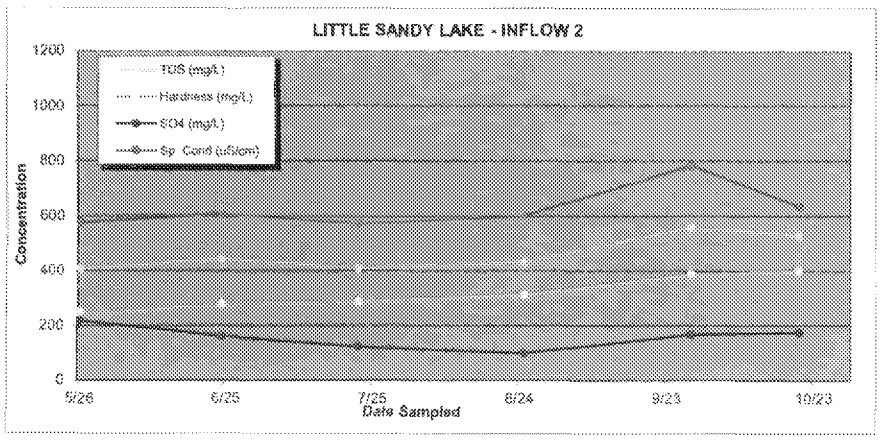
# LITTLE SANDY LAKE - INFLOW 2

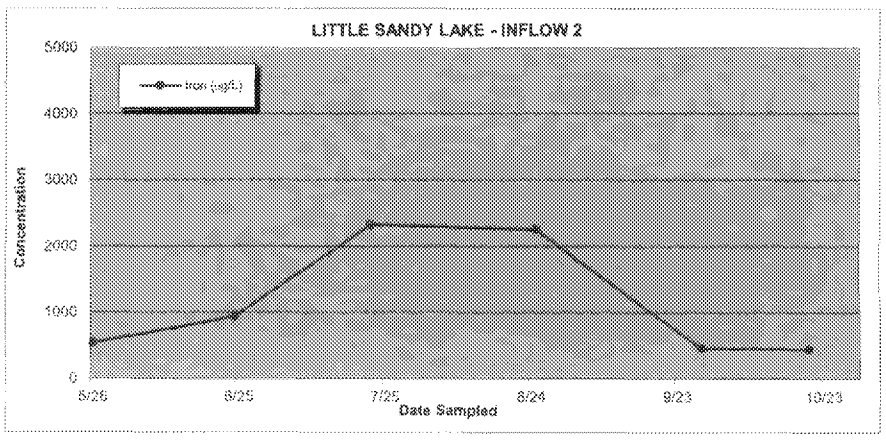
| Analytes - Cations | 5/26/2016 Little Sandy Inflow 2 | 6/24/2016 Little Sandy Inflow 2 | 7/22/2016 Little Sandy Inflow 2 | 8/25/2016 Little Sandy Inflow 2 | 9/28/2016 Little Sandy Inflow 2 | 10/20/2016 Little Sandy Inflow 2 | Reporting Units |
|---|---|---|---|---|---|---|---|
| Aluminum | <0.50 | <200 | **55** | **111** | <50.0 | <50.0 | µg / L |
| Arsenic | NM | NM | NM | NM | NM | NM | µg / L |
| Barium | NM | NM | NM | NM | NM | NM | µg / L |
| Calcium | **30.7** | **34.0** | **36.1** | **38.6** | **47.4** | **47.2** | mg / L |
| Iron | **531** | **929** | **2320** | **2250** | **455** | **442** | µg / L |
| Magnesium | **41.9** | **47.5** | **48.7** | **53.5** | **65.9** | **69.1** | mg / L |
| Manganese | **51.9** | **101** | **179** | **214** | **84.0** | **96.1** | µg / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | mg / L |
| Potassium | **4.6** | **3.5** | **2.9** | **2.3** | **3.3** | **3.91** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | µg / L |
| Sodium | **14.3** | **14.9** | **15.1** | **15.4** | **20.9** | **23.0** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | µg / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **20.5** | **21** | **17.9** | **18.6** | **31.5** | **33.7** | mg / L |
| Nitrogen, Kjeldahl, Total | **0.96** | **0.7** | **1.5** | **2.1** | **0.88** | **0.8** | mg / L |
| Ammonium as Nitrogen | NM | <0.10 | **0.15** | **0.29** | <0.10 | <0.10 | mg / L |
| Sulfate | **216** | **160** | **121** | **96.7** | **165** | **172** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **407** | **447** | **409** | **434** | **561** | **532** | mg / L |
| Total Suspended Solids | NM | NM | <2.5 | **22.0** | **3.6** | **4.4** | mg / L |
| Alkalinity, Total as CaCO3 | **120** | **152** | **175** | **240** | **251** | **216** | mg / L |
| Dissolved Organic Carbon | **15.6** | **26.1** | **36.1** | **38.9** | **27.7** | **22.3** | mg / L |
| Total Hardness by 2340B | **249** | **281** | **291** | **317** | **390** | **402** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.3** | **7.1** | **6.9** | **7.4** | **7.8** | **6.9** | Units |
| Temperature | **16.6** | **22.5** | **24.2** | **20.2** | **11.7** | **6** | °C |
| Specific Conductance | **574** | **606** | **572** | **600** | **781** | **632** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | mg / L |

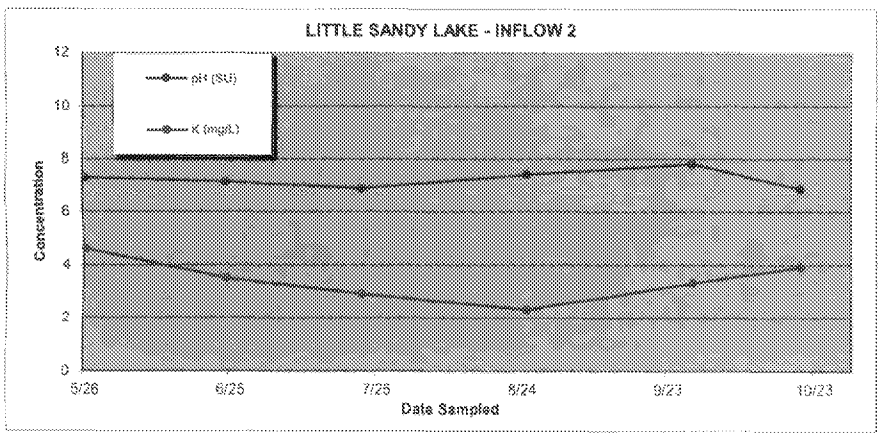
**Bold Print indicates the sample is above the detection limit**
NM indicates that the analyte was not measured
"<" indicates value below reporting limit
For a list of reporting detection limits, see data tables organized by sample date

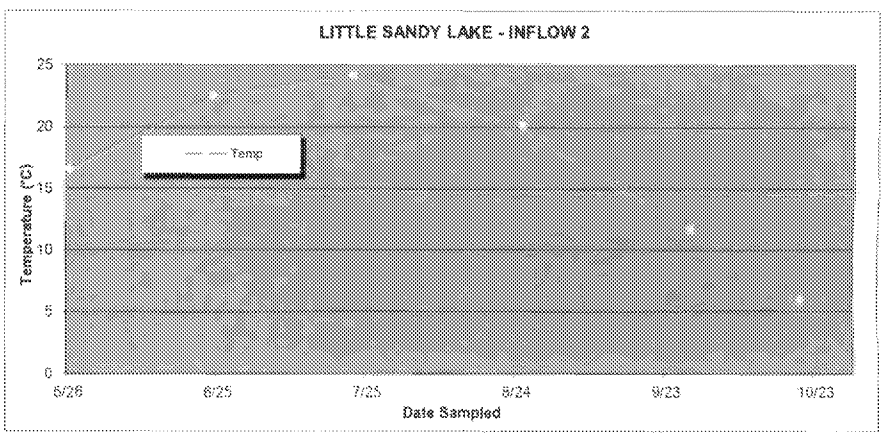


# LITTLE SANDY LAKE - INFLOW 3

| Analytes - Cations | 5/26/2016 Little Sandy Inflow 3 | 6/24/2016 Little Sandy Inflow 3 | 7/22/2016 Little Sandy Inflow 3 | 8/25/2016 Little Sandy Inflow 3 | 9/28/2016 Little Sandy Inflow 3 | 10/20/2016 Little Sandy Inflow 3 | Reporting Units |
|---|---|---|---|---|---|---|---|
| Aluminum | <0.50 | <200 | **69.1** | <50.0 | <50.0 | <50.0 | µg / L |
| Arsenic | NM | NM | NM | NM | NM | NM | µg / L |
| Barium | NM | NM | NM | NM | NM | NM | µg / L |
| Calcium | **34.5** | **34.4** | **36.6** | **40.0** | **30.9** | **30.1** | mg / L |
| Iron | **381** | **439** | **3270** | **1650** | **353** | **268** | µg / L |
| Magnesium | **47.5** | **49.0** | **49.2** | **56.0** | **49.4** | **54.2** | mg / L |
| Manganese | **77.2** | **82.8** | **197** | **220** | **90.6** | **94.1** | µg / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | mg / L |
| Potassium | **4.3** | **3.2** | **2.9** | **2.5** | **1.5** | **1.5** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | µg / L |
| Sodium | **14.8** | **14.6** | **15.1** | **16.8** | **9.2** | **10.6** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | µg / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **21.7** | **20.6** | **17.6** | **20.2** | **12.5** | **15.1** | mg / L |
| Nitrogen, Kjeldahl, Total | **0.92** | **0.60** | **1.6** | **1.3** | **0.85** | **0.66** | mg / L |
| *Ammonium as Nitrogen* | NM | <0.10 | **0.12** | **0.16** | <0.10 | <0.10 | *mg / L* |
| Sulfate | **156** | **163** | **121** | **108** | **39.6** | **84.3** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **417** | **447** | **372** | **473** | **367** | **375** | mg / L |
| Total Suspended Solids | **6.5** | **2.8** | <2.5 | **5.2** | **2.4** | **2.0** | mg / L |
| Alkalinity, Total as CaCO3 | **140** | **163** | **179** | **237** | **255** | **213** | mg / L |
| Dissolved Organic Carbon | **16.2** | **21.5** | **38.2** | **37.1** | **32.2** | **24.0** | mg / L |
| Total Hardness by 2340B | **282** | **287** | **294** | **330** | **280** | **298** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.2** | **7.2** | **7.3** | **7.2** | **7.4** | **7.2** | Units |
| Temperature | **15.3** | **20.3** | **23.6** | **19.8** | **11.8** | **5.4** | °C |
| Specific Conductance | **560** | **644** | **535** | **576** | **517** | **526** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | mg / L |

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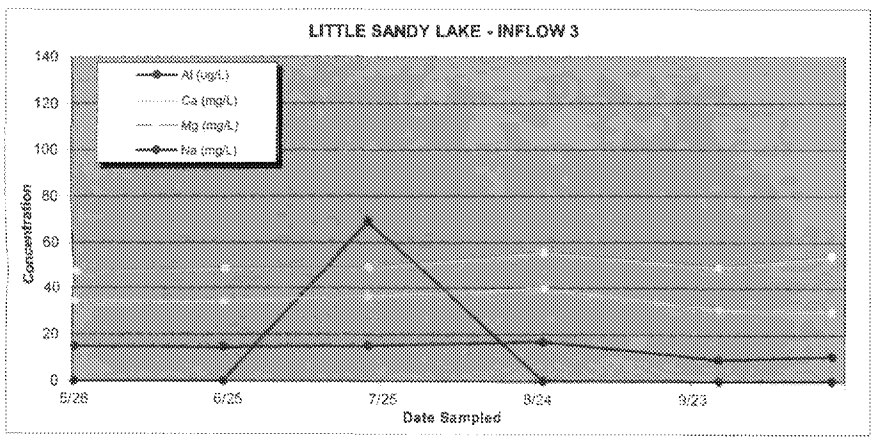
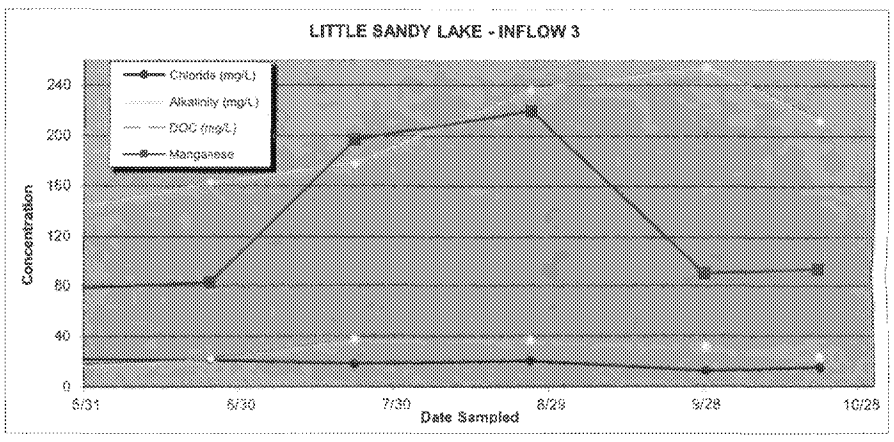
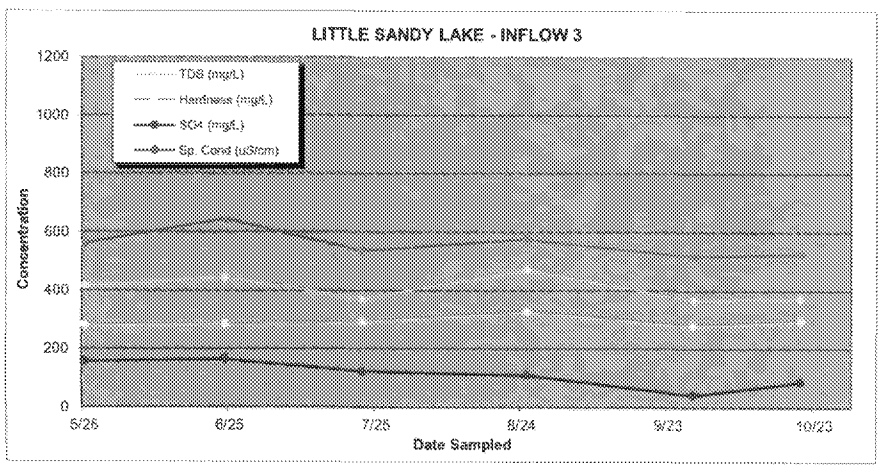
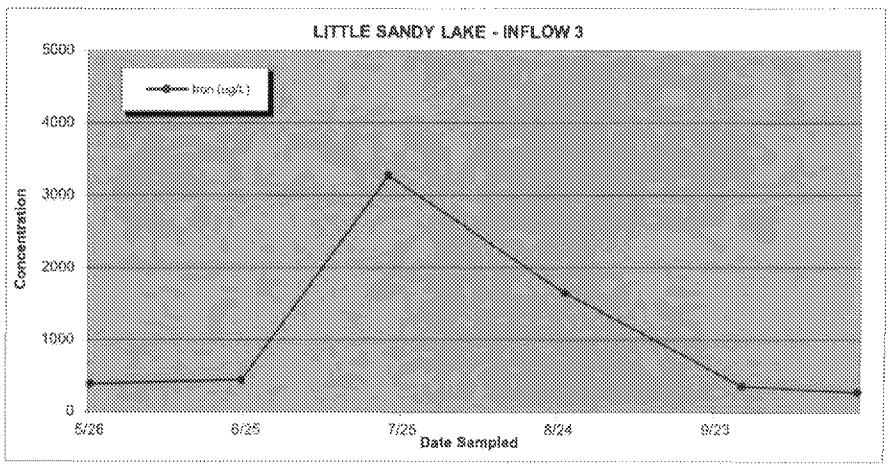
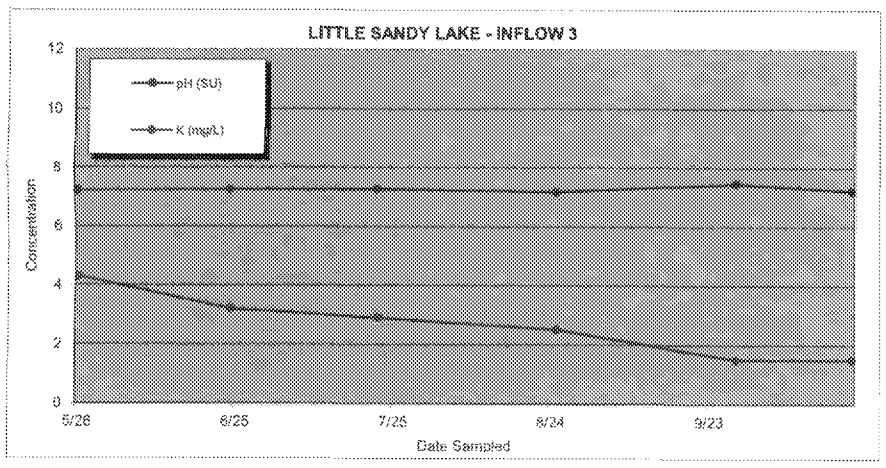
For a list of reporting detection limits, see data tables organized by sample date

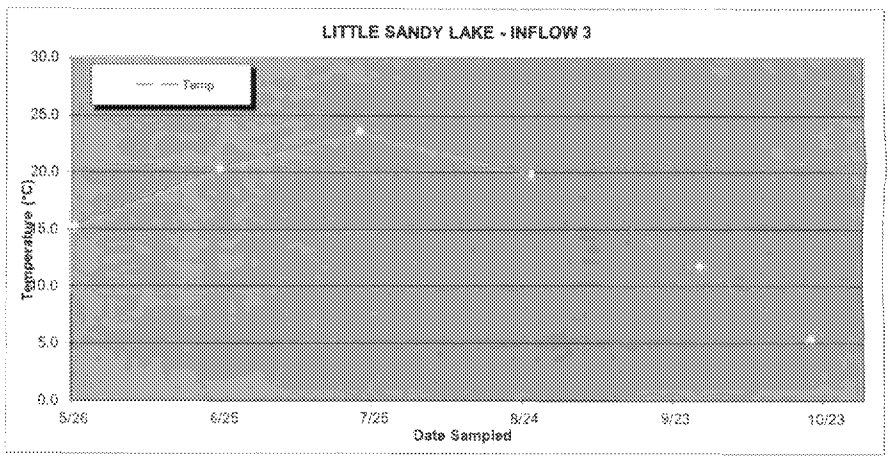


# LITTLE SANDY LAKE - MIDDLE

| Analytes - Cations | 5/26/2016 Little Sandy Middle | 6/24/2016 Little Sandy Middle | 7/22/2016 Little Sandy Middle | 8/25/2016 Little Sandy Middle | 9/28/2016 Little Sandy Middle | 10/20/2016 Little Sandy Middle | Reporting Units |
|---|---|---|---|---|---|---|---|
| Aluminum | NM | NM | NM | NM | NM | <50.0 | µg / L |
| Arsenic | NM | NM | NM | NM | NM | NM | µg / L |
| Barium | NM | NM | NM | NM | NM | NM | µg / L |
| Calcium | **28.2** | **35.5** | **30.1** | NM | NM | **46.0** | mg / L |
| Iron | NM | NM | NM | NM | NM | **388** | µg / L |
| Magnesium | **38.3** | **48.9** | **39.7** | NM | NM | **67.2** | mg / L |
| Manganese | NM | NM | NM | NM | NM | **63.3** | µg / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | mg / L |
| Potassium | NM | NM | NM | NM | NM | **4.1** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | µg / L |
| Sodium | **13.5** | **15.9** | **13.8** | NM | NM | **23.0** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | µg / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **19.8** | **23.0** | **17.8** | NM | NM | **34.7** | mg / L |
| Nitrogen, Kjeldahl, Total | NM | <0.50 | **1.4** | NM | NM | **0.75** | mg / L |
| Ammonium as Nitrogen | NM | <0.10 | 0.15 | NM | NM | <0.10 | mg / L |
| Sulfate | **129** | **170** | **104** | NM | NM | **176** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **363** | **465** | **378** | NM | NM | **548** | mg / L |
| Total Suspended Solids | NM | **3.2** | **2.0** | NM | NM | **2.4** | mg / L |
| Alkalinity, Total as CaCO3 | **106** | **149** | **114** | NM | NM | **222** | mg / L |
| Dissolved Organic Carbon | NM | NM | NM | NM | NM | **21.6** | mg / L |
| Total Hardness by 2340B | **228** | **290** | **239** | NM | NM | **392** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **8.2** | **7.7** | **7.3** | NM | NM | **8.0** | Units |
| Temperature | **18.2** | **22.8** | **25.1** | NM | NM | **7.6** | °C |
| Specific Conductance | **682** | **637** | **567** | NM | NM | **732** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | mg / L |

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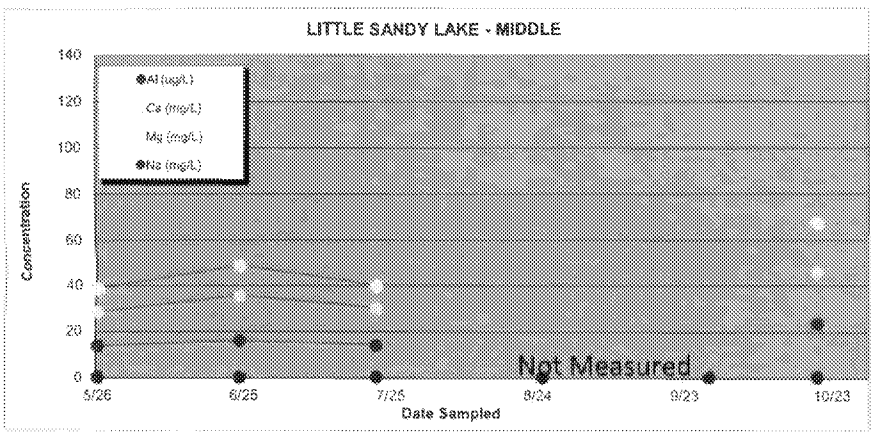
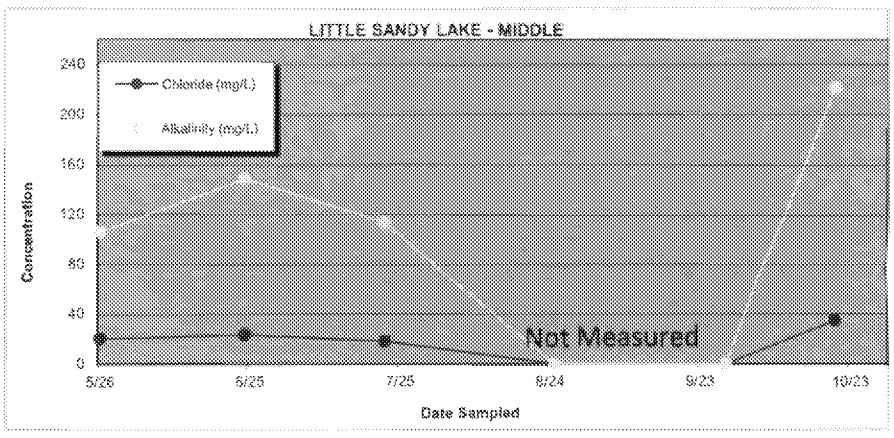
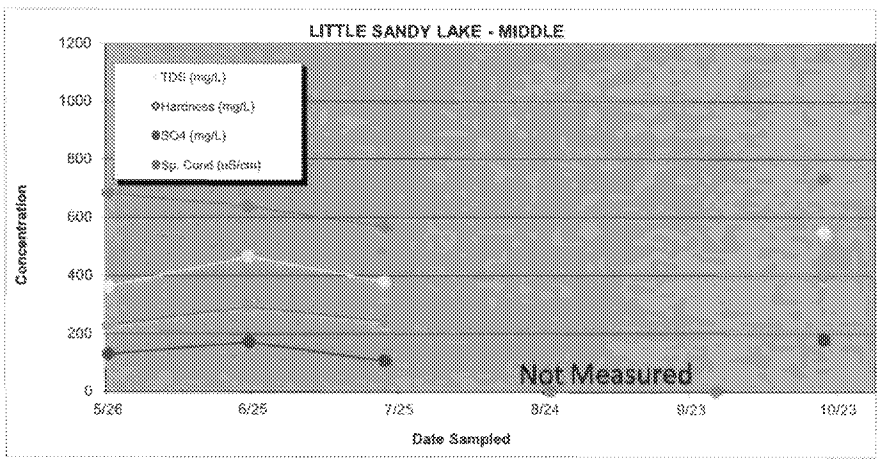
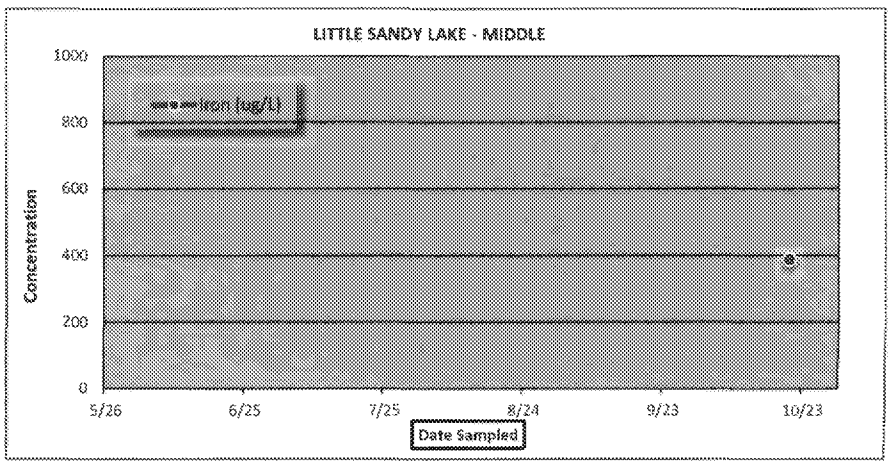
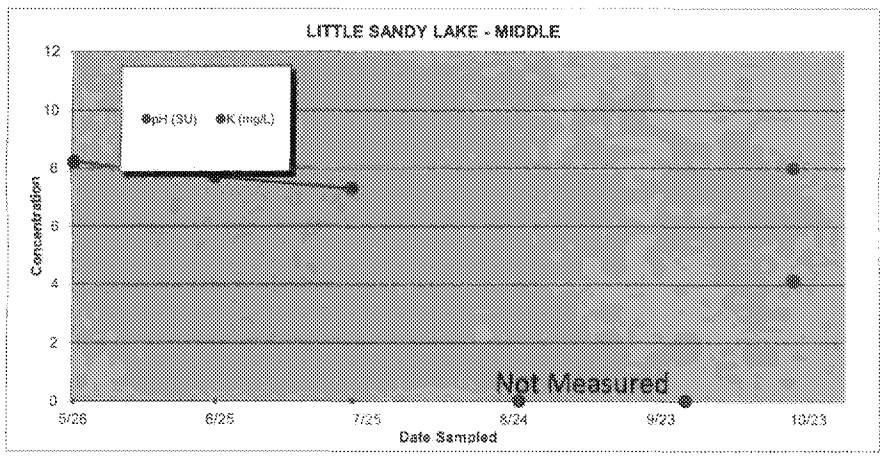
For a list of reporting detection limits, see data tables organized by sample date

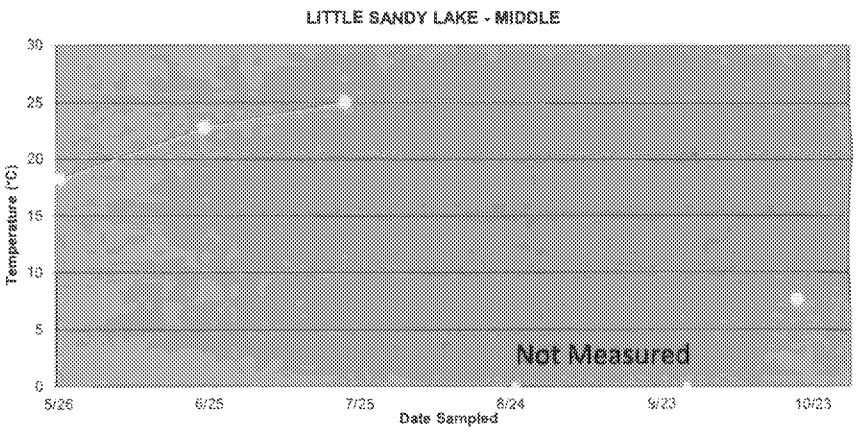


# SANDY LAKE - MIDDLE

| Analytes - Cations | 5/26/2016 Sandy Middle | 6/24/2016 Sandy Middle | 7/22/2016 Sandy Middle | 8/25/2016 Sandy Middle | 9/28/2016 Sandy Middle | 10/20/2016 Sandy Middle | Reporting Units |
|---|---|---|---|---|---|---|---|
| Aluminum | NM | NM | NM | NM | NM | <50.0 | µg / L |
| Arsenic | NM | NM | NM | NM | NM | NM | µg / L |
| Barium | NM | NM | NM | NM | NM | NM | µg / L |
| Calcium | **38.3** | **31.5** | **36.5** | NM | NM | **38.7** | mg / L |
| Iron | NM | NM | NM | NM | NM | **650** | µg / L |
| Magnesium | **51.3** | **42.9** | **49.1** | NM | NM | **55.6** | mg / L |
| Manganese | NM | NM | NM | NM | NM | **38.4** | µg / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | mg / L |
| Potassium | NM | NM | **3.0** | NM | NM | **3.6** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | µg / L |
| Sodium | **17.5** | **15.2** | **15.6** | NM | NM | **20.1** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | µg / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **26.4** | **22.0** | **18.4** | NM | NM | **30.2** | mg / L |
| Nitrogen, Kjeldahl, Total | NM | <0.50 | **1.3** | NM | NM | **0.79** | mg / L |
| Ammonium as Nitrogen | NM | <0.10 | **0.11** | NM | NM | <.010 | mg / L |
| Sulfate | **183** | **147** | **125** | NM | NM | **135** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **438** | **389** | **398** | NM | NM | **460** | mg / L |
| Total Suspended Solids | NM | **1.2** | <1.0 | NM | NM | **1.6** | mg / L |
| Alkalinity, Total as CaCO3 | **138** | **127** | **160** | NM | NM | **179** | mg / L |
| Dissolved Organic Carbon | NM | NM | NM | NM | NM | **25.1** | mg / L |
| Total Hardness by 2340B | **307** | **255** | **293** | NM | NM | **326** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **8.1** | **7.7** | **7.3** | NM | NM | **8.0** | Units |
| Temperature | **17.6** | **22.3** | **24.8** | NM | NM | **7.3** | °C |
| Specific Conductance | **517** | **540** | **459** | NM | NM | **619** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | mg / L |

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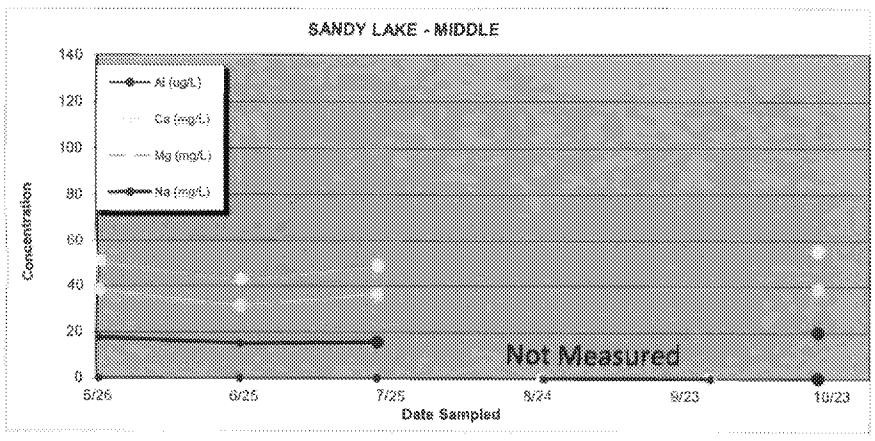
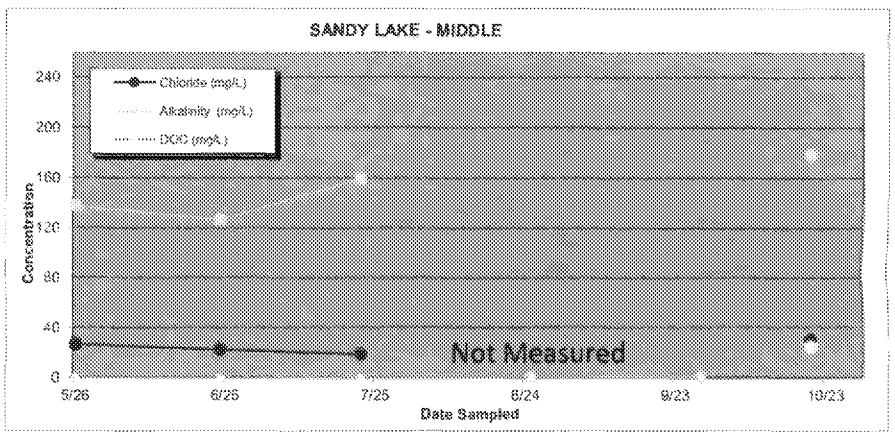
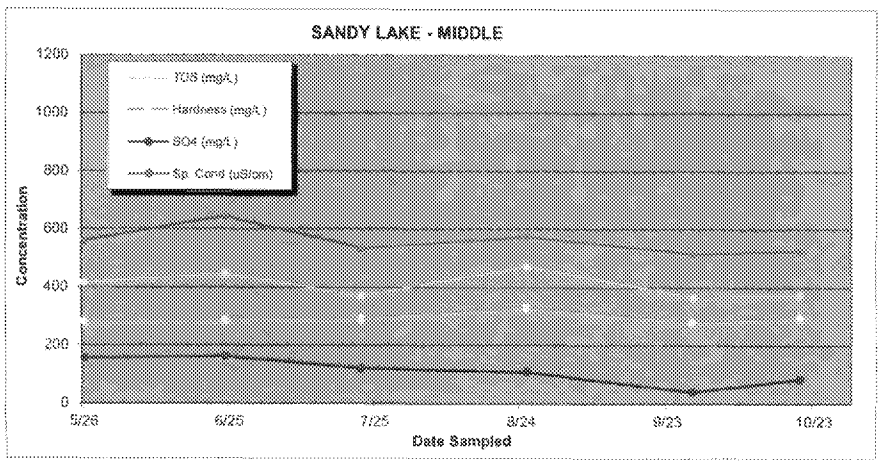
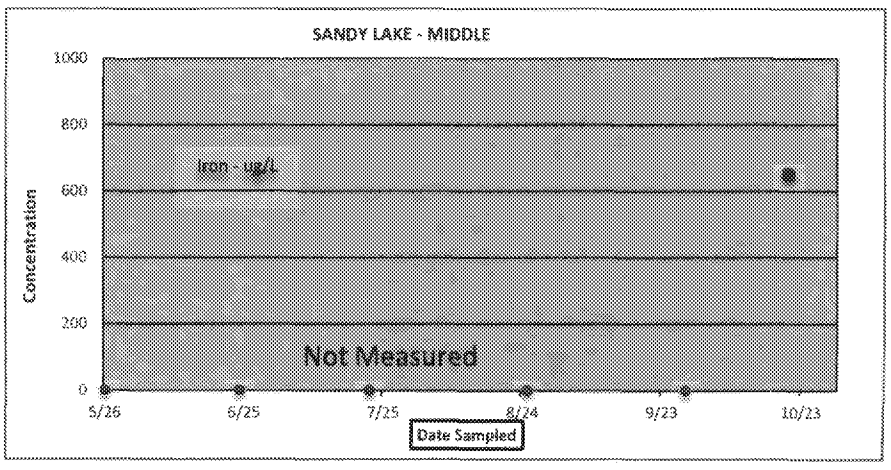
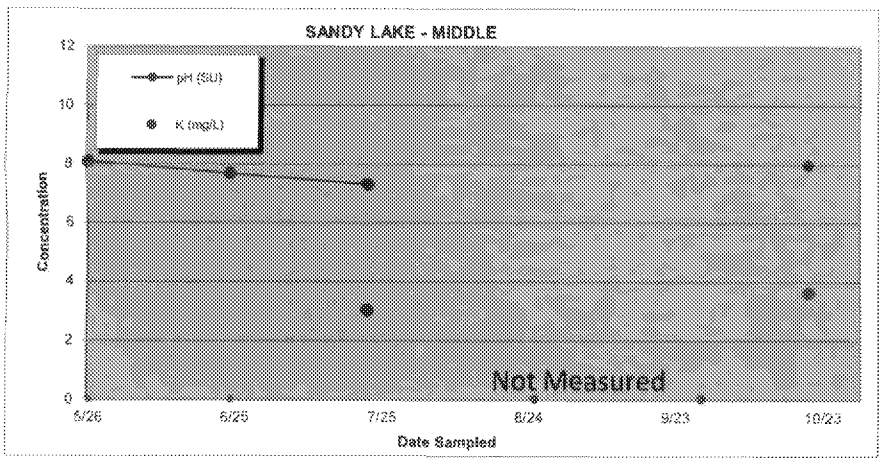
For a list of reporting detection limits, see data tables organized by sample date

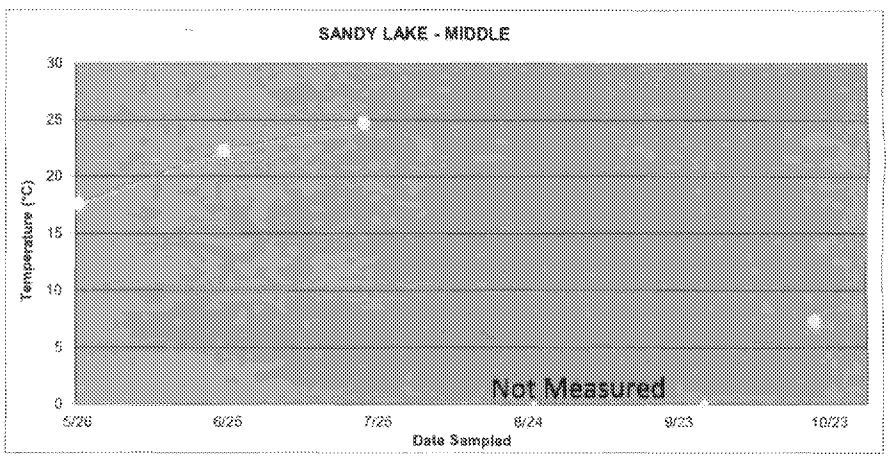


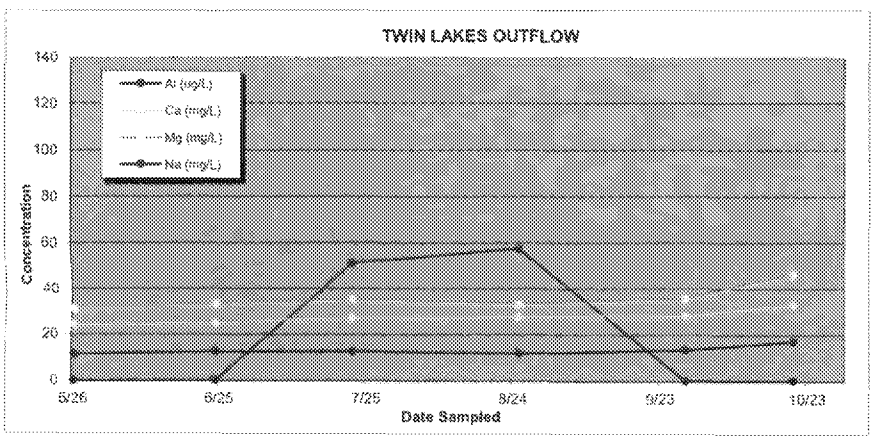



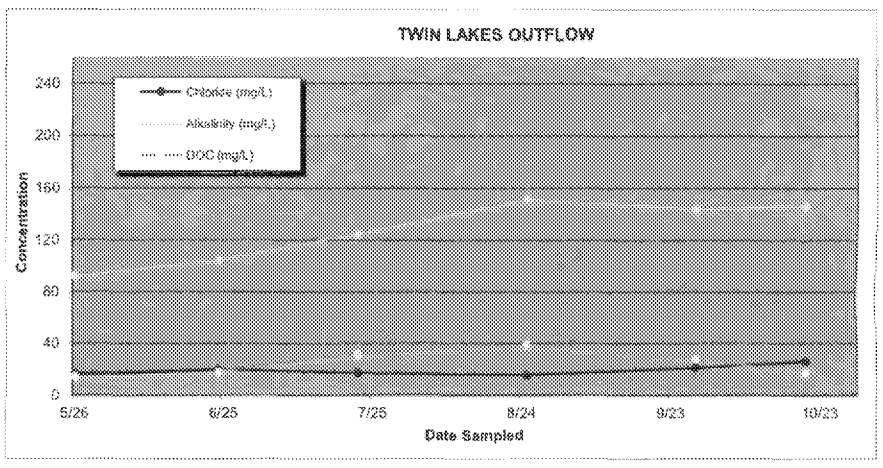



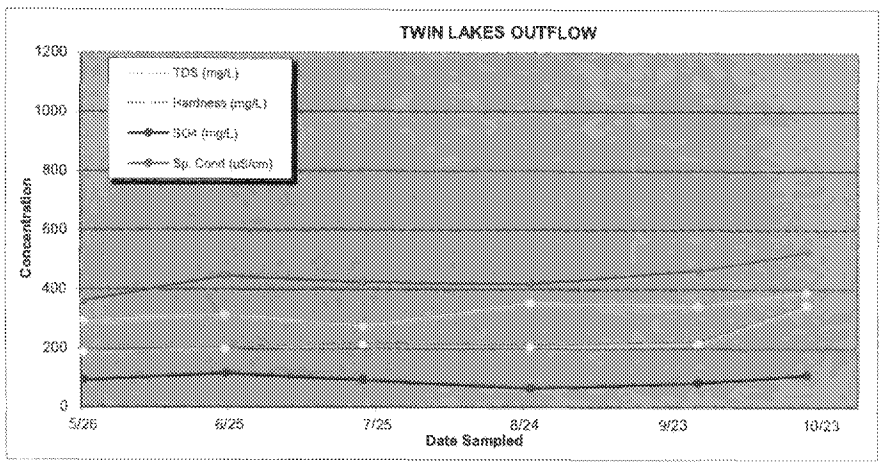
# TWIN LAKES OUTFLOW

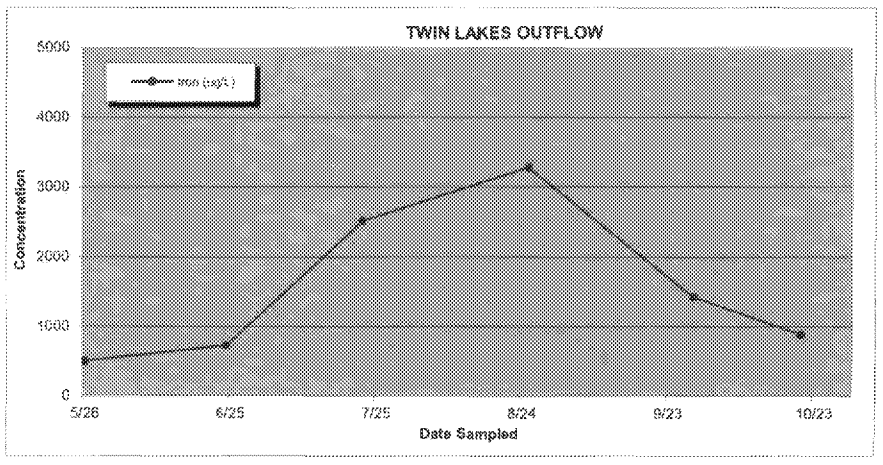
| Analytes - Cations | 5/26/2016 Twin Lakes Outflow | 6/24/2016 Twin Lakes Outflow | 7/22/2016 Twin Lakes Outflow | 8/25/2016 Twin Lakes Outflow | 9/28/2016 Twin Lakes Outflow | 10/20/2016 Twin Lakes Outflow | Reporting Units |
|---|---|---|---|---|---|---|---|
| Aluminum | <0.50 | <200 | **51** | **57.3** | <50.0 | <50.0 | µg / L |
| Arsenic | NM | NM | NM | NM | NM | NM | µg / L |
| Barium | NM | NM | NM | NM | NM | NM | µg / L |
| Calcium | **24.3** | **25.2** | **27.4** | **28.0** | **28.6** | **33.4** | mg / L |
| Iron | **502** | **724** | **2510** | **3280** | **1420** | **880** | µg / L |
| Magnesium | **31.2** | **33.4** | **35.3** | **33.4** | **36.0** | **46.5** | mg / L |
| Manganese | **46.8** | **70.6** | **138** | **136** | **54.1** | **68.1** | µg / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | mg / L |
| Potassium | **3.5** | **3.1** | **2.8** | **2.2** | **2.6** | **3.1** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | µg / L |
| Sodium | **11.5** | **12.4** | **12.6** | **11.7** | **13.3** | **17.1** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | µg / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **16.4** | **19.5** | **16.8** | **15.4** | **21.1** | **26.1** | mg / L |
| Nitrogen, Kjeldahl, Total | **0.71** | <0.50 | **1.3** | **1.5** | **0.94** | **0.79** | mg / L |
| Ammonium as Nitrogen | NM | <0.10 | **0.13** | **0.32** | **0.11** | <0.10 | mg / L |
| Sulfate | **92.7** | **114** | **92.1** | **64.3** | **81.9** | **109** | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **295** | **316** | **276** | **356** | **346** | **392** | mg / L |
| Total Suspended Solids | NM | **2.0** | **3.6** | <1.0 | **2.4** | **2.0** | mg / L |
| Alkalinity, Total as CaCO3 | **92.4** | **105** | **125** | **152** | **145** | **147** | mg / L |
| Dissolved Organic Carbon | **14.8** | **18.3** | **31.6** | **39.1** | **27.9** | **17.5** | mg / L |
| Total Hardness by 2340B | **189** | **201** | **214** | **207** | **220** | **349** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.6** | **7.4** | **7.3** | **7.3** | **7.6** | **7.6** | Units |
| Temperature | **16.2** | **21.3** | **25.0** | **20.0** | **11.0** | **6.5** | °C |
| Specific Conductance | **359** | **445** | **422** | **417** | **462** | **527** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | mg / L |

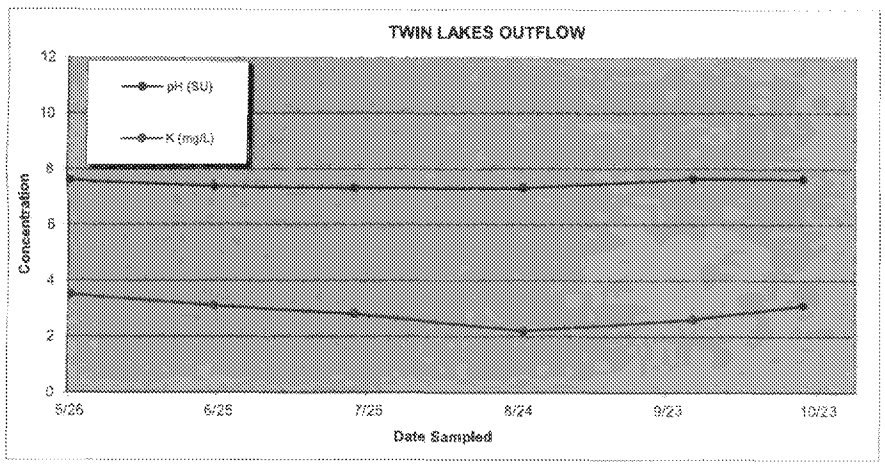
**Bold Print indicates the sample is above the detection limit**
NM indicates that the analyte was not measured
"<" indicates value below reporting limit
For a list of reporting detection limits, see data tables organized by sample date

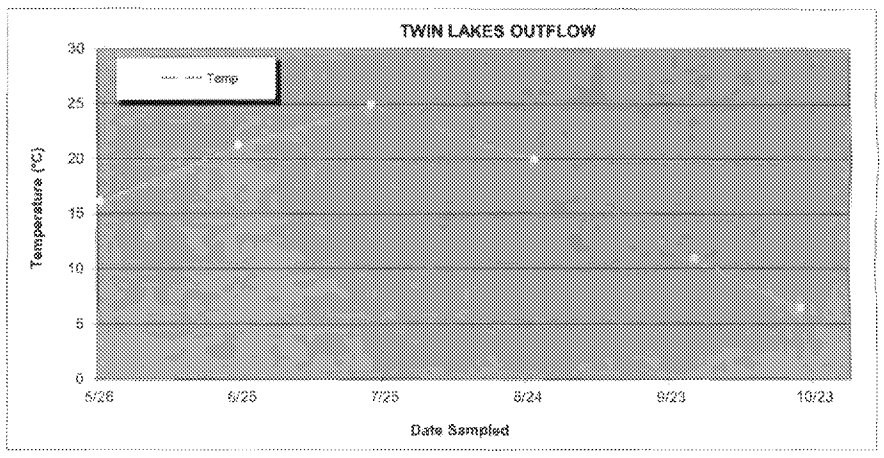


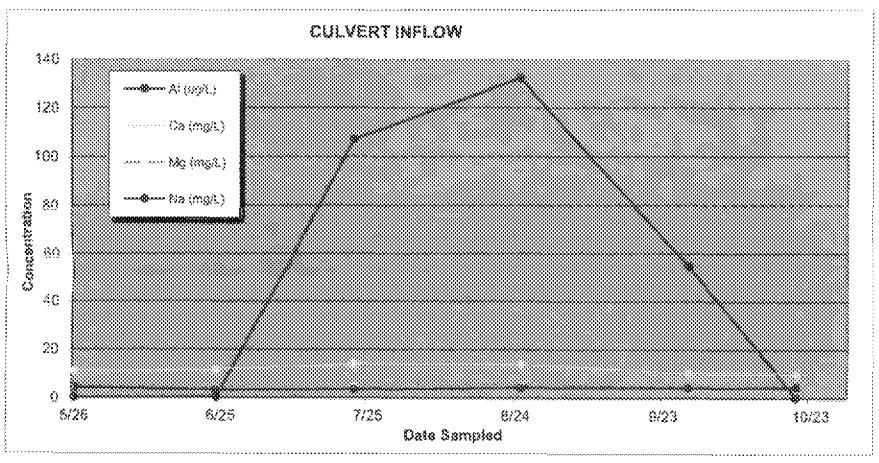



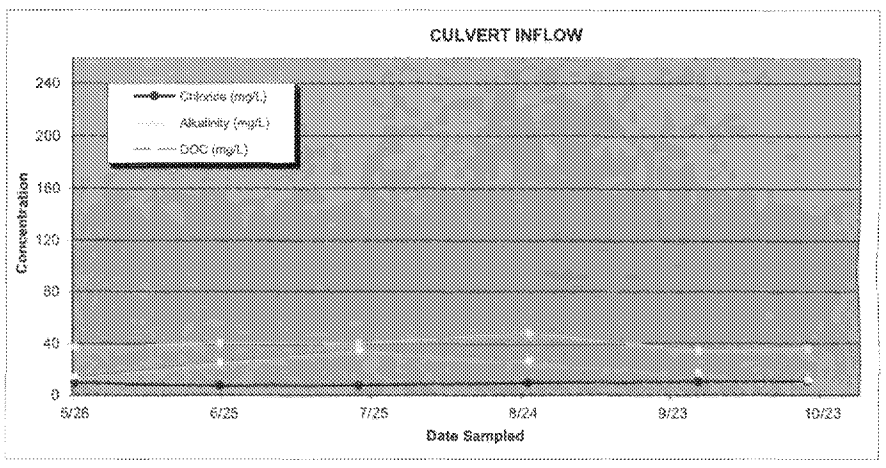



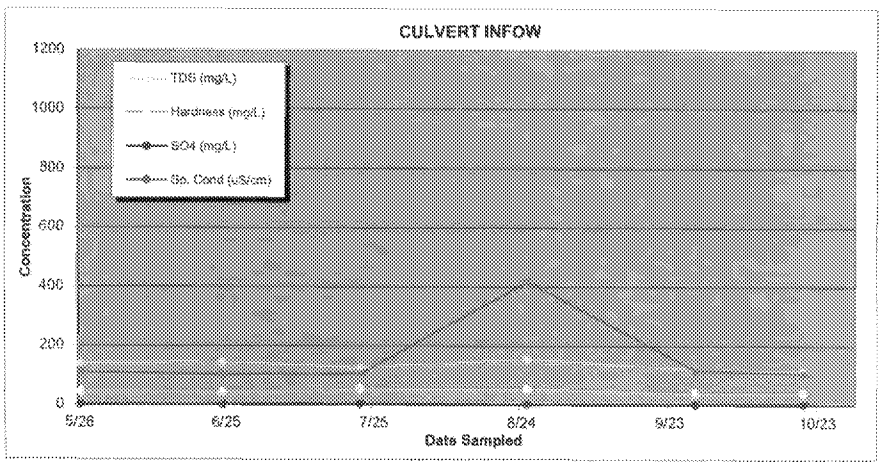
# CULVERT INFLOW

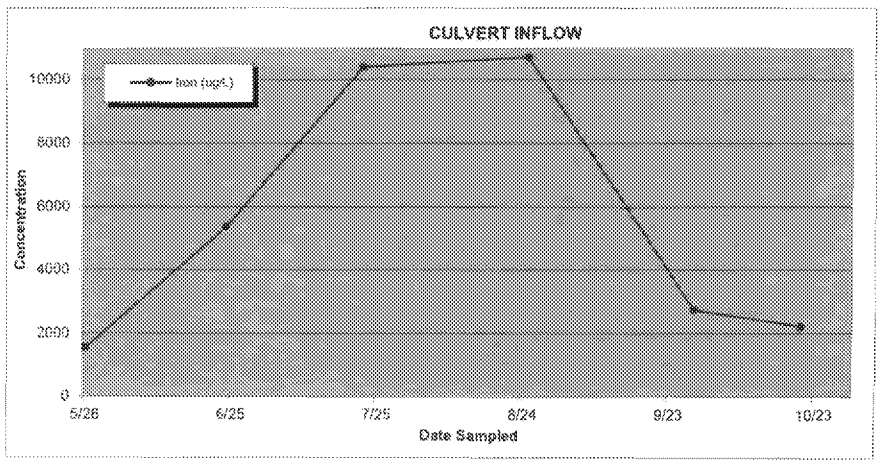
| Analytes - Cations | 5/26/2016 Culvert Inflow | 6/24/2016 Culvert Inflow | 7/22/2016 Culvert Inflow | 8/25/2016 Culvert Inflow | 9/28/2016 Culvert Inflow | 10/20/2016 Culvert Inflow | Reporting Units |
|---|---|---|---|---|---|---|---|
| Aluminum | <0.50 | <200 | **107** | **132** | **54.5** | <50.0 | µg / L |
| Arsenic | NM | NM | NM | NM | NM | NM | µg / L |
| Barium | NM | NM | NM | NM | NM | NM | µg / L |
| Calcium | **11.3** | **11.8** | **14.1** | **14.2** | **10.4** | **10.0** | mg / L |
| Iron | **1560** | **5360** | **10400** | **10700** | **2750** | **2220** | µg / L |
| Magnesium | **4.1** | **3.9** | **4.7** | **4.9** | **3.7** | **3.8** | mg / L |
| Manganese | **62.9** | **411** | **419** | **304** | **101** | **98.7** | µg / L |
| Phosphorus | NM | NM | NM | NM | NM | NM | mg / L |
| Potassium | **1.6** | <2.5 | **0.94** | **1.1** | **1.76** | **1.6** | mg / L |
| Rubidium | NM | NM | NM | NM | NM | NM | µg / L |
| Sodium | **4.1** | **3.1** | **3.4** | **4.1** | **4.0** | **4.2** | mg / L |
| Strontium | NM | NM | NM | NM | NM | NM | µg / L |
| **Analytes - Anions** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Chloride | **9.4** | **7.1** | **7.5** | **9.5** | **10.4** | **10.6** | mg / L |
| Nitrogen, Kjeldahl, Total | <0.50 | **0.67** | **1.3** | **0.99** | <0.60 | <0.60 | mg / L |
| Ammonium as Nitrogen | NM | <0.10 | **0.12** | <0.10 | <0.10 | <0.10 | mg / L |
| Sulfate | <2.0 | <2.0 | **2.3** | <2.0 | <2.0 | <2.0 | mg / L |
| **Analytes - Other** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| Total Dissolved Solids | **141** | **145** | **126** | **155** | **120** | **113** | mg / L |
| Total Suspended Solids | NM | NM | **5.0** | **26** | **3.5** | **3.2** | mg / L |
| Alkalinity, Total as CaCO3 | **37.1** | **40.8** | **40.2** | **48.4** | **34.8** | **36.6** | mg / L |
| Dissolved Organic Carbon | **13.9** | **25.7** | **35.4** | **26.9** | **16.9** | **11.7** | mg / L |
| Total Hardness by 2340B | **45.1** | **45.6** | **54.5** | **55.5** | **41.2** | **40.4** | mg / L |
| UV Absorbance @ 254 nm | NM | NM | NM | NM | NM | NM | $cm^{-1}$ |
| SUVA | NM | NM | NM | NM | NM | NM | L / mg*m |
| **YSI Probe Plus Data** | ========== | ========== | ========== | ========== | ========== | ========== | ========== |
| pH | **7.0** | **6.5** | **6.5** | **7.3** | **6.8** | **7.0** | Units |
| Temperature | **14.2** | **19.8** | **19.2** | **20.0** | **13.1** | **5.8** | °C |
| Specific Conductance | **112** | **102** | **107** | **417** | **118** | **105** | uS / cm |
| Dissolved Oxygen | NM | NM | NM | NM | NM | NM | mg / L |

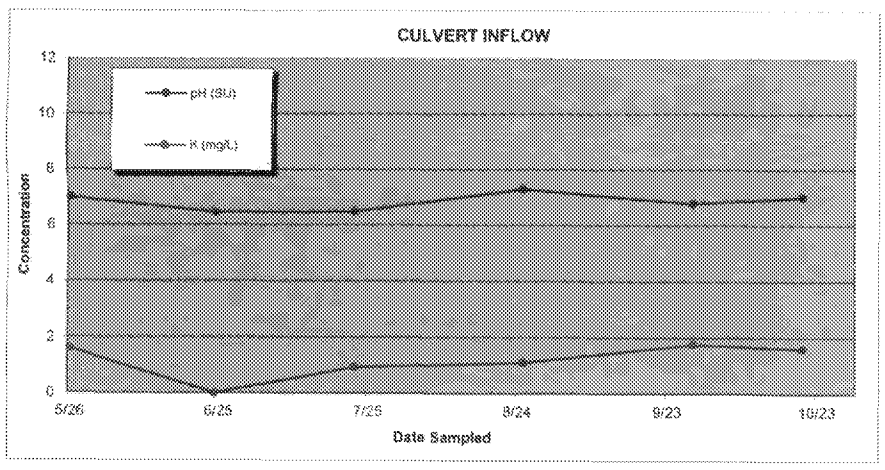
**Bold Print indicates the sample is above the detection limit**
NM indicates that the analyte was not measured
"<" indicates value below reporting limit
For a list of reporting detection limits, see data tables organized by sample date

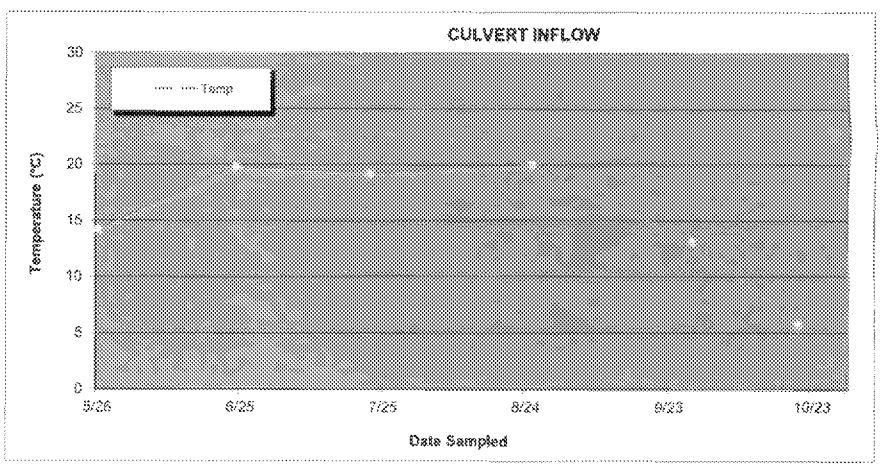


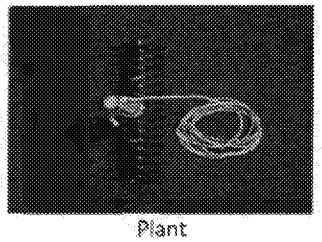



# APPENDIX D

Twin Lakes 2016 Aquatic Plant Survey

# 2016 Aquatic Plant Survey
## 22-Aug-16



**Double-headed Rake Method**

**Little Sandy Lake**

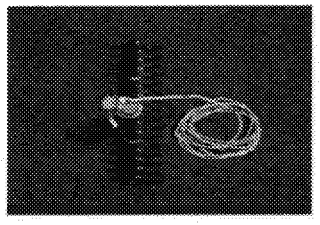
| Transect 1 | | Water Depth ft | % Coverage | Plant Name |
|---|---|---|---|---|
| | Station 1 | 2.0 | 30 | Northern Water Milfoil (1 - 2 plants) & Hard Stem 25% |
| | Station 2 | 3.75 | 0 | Decomposing plant material; No live plants |
| | Station 3 | 4.25 | 0 | Detritus only |
| | Station 4 | 4.25 | 0 | No identifiable Plant taxa |

| Transect 2 | | Water Depth ft | % Coverage | |
|---|---|---|---|---|
| | Station 1 | 2.25 | 75 | Wild Celery (one plant) & Coontail (70% |
| | Station 2 | 3.0 | 50 | Northern Water Milfoil |
| | Station 3 | 3.5 | 15 | Northern Water Milfoil & Wild Celery (1 plant) |
| | Station 4 | 3.5 | 2 | Wild Celery & Patch of Bur Reed |
| | Station 5 | 3.75 | 0 | None |
| | Station 6 | 3.75 | 0 | None |

| Transect 3 | | Water Depth ft | % Coverage | |
|---|---|---|---|---|
| | Station 1 | 3.0 | 1.5 | Slender Raiad |
| | Station 2 | 3.5 | 1.5 | Northern Water Milfoil & Slender Raiad (one plant each) |
| | Station 3 | 4.0 | 1 | Northern Water Milfoil (one plant) |
| | Station 4 | 4.5 | 2.5 | Northern Water Milfoil (one plant) |
| | Station 5 | 4.5 | 0 | None |
| | Station 6 | 4.75 | 0 | None |

| Transect 4 | | Water Depth ft | % Coverage | |
|---|---|---|---|---|
| | Station 1 | 2.0 | 0 | None |
| | Station 2 | 3.25 | 25 | Northern Water Milfoil |
| | Station 3 | 4.0 | 10 | Northern Water Milfoil |
| | Station 4 | 4.25 | 0 | None |

# 2016 Aquatic Plant Survey
## 22-Aug-16



**Double-headed Rake Method**

**Sandy Lake**

| Transect 1 | | Water Depth ft | % Coverage | Plant Name |
|---|---|---|---|---|
| | Station 1 | 2.25 | 100 | Coontail |
| | Station 2 | 2.75 | 20 | White Pond Lilly - 2 large leaves |
| | Station 3 | 3.0 | 20 | Wild Celery |
| | Station 4 | 3.0 | 100 | Coontail |
| | Station 5 | 2.75 | 100 | Coontail |
| | Station 6 | 2.0 | 100 | Coontail - some Detritus |

| Transect 2 | | Water Depth ft | % Coverage | |
|---|---|---|---|---|
| | Station 1 | 3.25 | 20 | Northern Bladderwort (living plant - 50%) & Detritus (50%) |
| | Station 2 | 3.5 | 50 | Mushgrass (48%) & Northern Water Milfoil (2%) |
| | Station 3 | 4.0 | 100 | Northern Water Milfoil (5%) & Mushgrass (95%) |
| | Station 4 | 4.5 | 25 | Northern Badderwort (2%), Pondweed (5%) & Northern Water Milfoil |
| | Station 5 | 4.0 | 10 | Northern Water Milfoil |
| | Station 6 | 4.0 | 5 | Northern Water Milfoil |

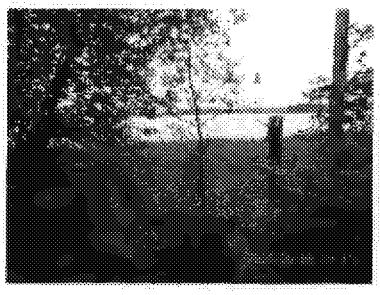
| Transect 3 | | Water Depth ft | % Coverage | |
|---|---|---|---|---|
| | Station 1 | 1.75 | 20 | Wild Rice |
| | Station 2 | 3.25 | 2 | Slender Raiad (1 plant) |
| | Station 3 | 3.25 | 0 | None |
| | Station 4 | 3.5 | 20 | N. Bladderwort (2%) and Spatterdock (18%) |
| | Station 5 | 3.75 | 3 | Spatterdock (1%), Detritus (1%) & Spatterdock (18%) |
| | Station 6 | 4.0 | 60 | N. Bladderwort (25%), Bur Reed (30%, with Small pondweed & White Stemmed Pondweed |

| Transect 4 | | Water Depth ft | % Coverage | |
|---|---|---|---|---|
| | Station 1 | 2.5 | 15 | Bur Reed |
| | Station 2 | 3.5 | 0 | None |
| | Station 3 | 4.5 | 5 | Pondweed (none identifiable pondweed) |
| | Station 4 | 4.25 | 1 | Chara sp. |
| | Station 5 | 4.25 | 1 | Detritus - possible Chara sp. |
| | Station 6 | 4.5 | 1 | Northern Water Milfoil |

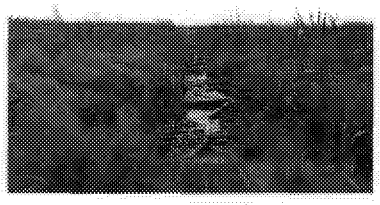
# APPENDIX E

Twin Lakes 2016 Field Pictures

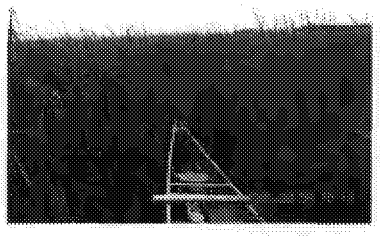
# Twin Lakes Pictures in 2016



Twin Lake's Landing Area

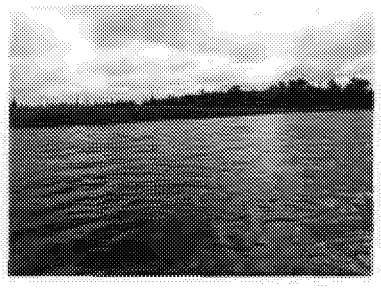


Canoe Landing North



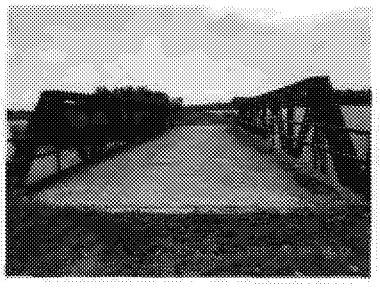
Typical shoreline of Twin Lakes

Sandy Lake Outflow



Sandy Lake East

Sandy Lake Looking Northwest



Twin Lakes Bridge

By Bridge Looking North

View of old Road under water

Looking South – PT visable

# Twin Lakes Pictures in 2016

Location of Staff Gauge

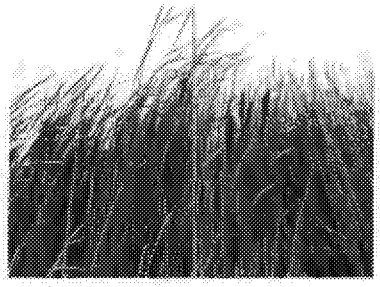
Little Sandy Lake – South

Inflow 1 Location

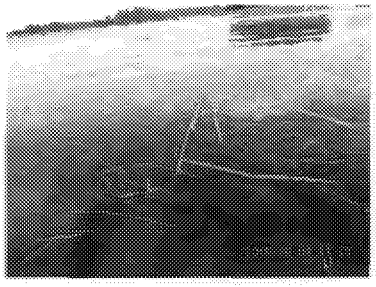
Old Bridge at Inflow 1

Sandy Lake Looking North

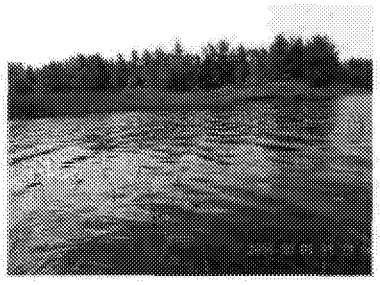
Sandy Lake Rice Bed



Typical Lake Edge

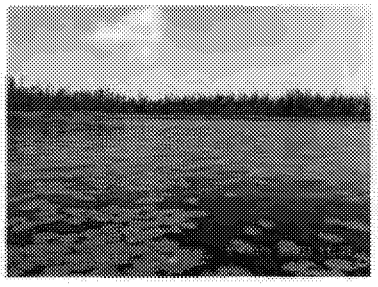


Aquatic Plant Life



Rice Bed

Sandy Lake looking NW



Little Sandy Lake

Sandy Lake

# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 1

Little Sandy Lake Inflow 1

# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 2

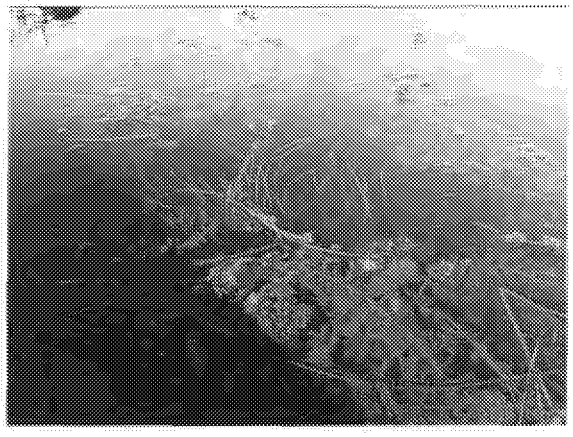
Little Sandy Lake Transect T2 - 1

Little Sandy Lake Transect T2 Wild Celery

Little Sandy Lake Transect T2 Coontail

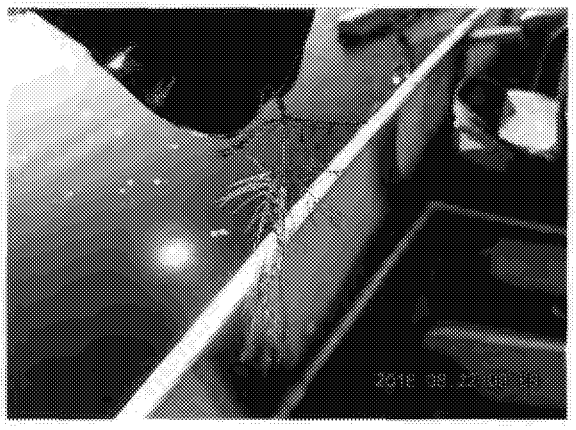
# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 3

Little Sandy Lake Transect 2 - 2



Northern Water Milfoil

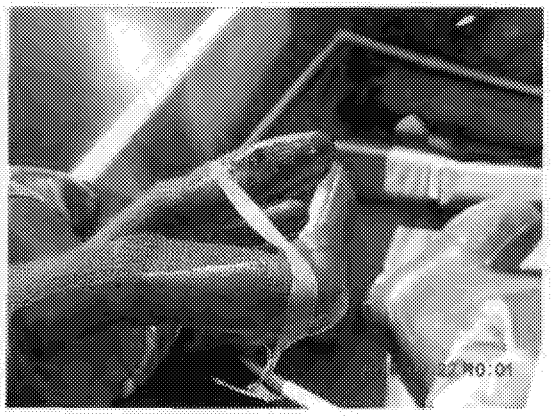
Little Sandy Lake Transect 2-3



# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 4

Little Sandy Lake Transect T - 2

Little Sandy Lake Transect T2 - 4

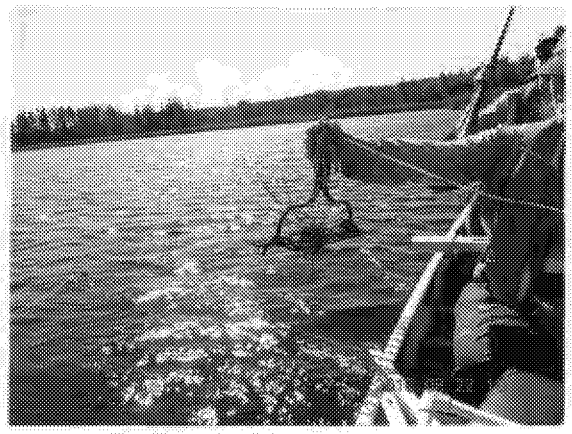


Little Sandy Lake South

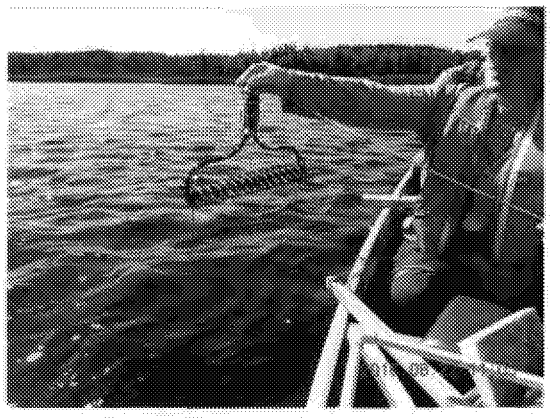
# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 5

Little Sandy Lake Inflow 2

Little Sandy Lake Transect 3 - 1

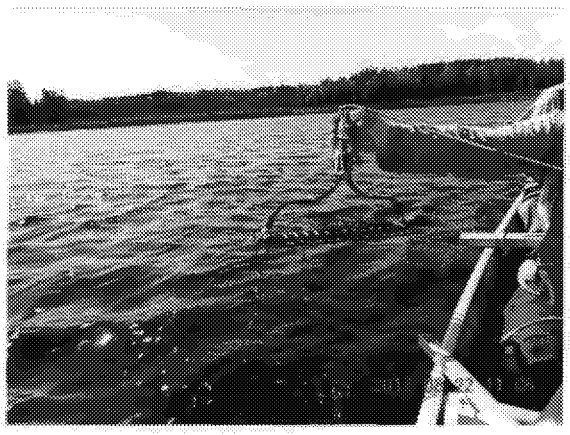


Little Sandy Lake Transect T3 – 2 Slender raiad

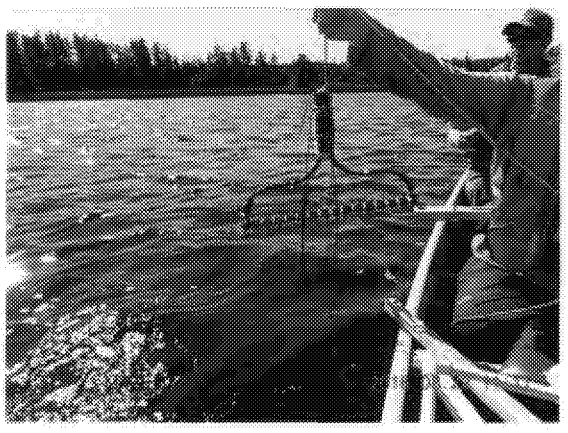


# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 6

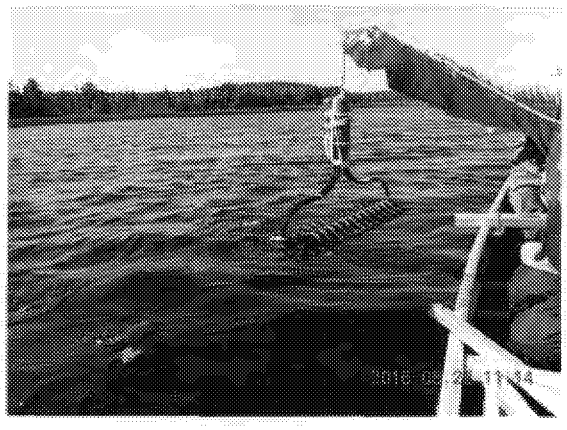
Little Sandy Lake Transect T3 - 3



Little Sandy Lake Transect T3 – 4

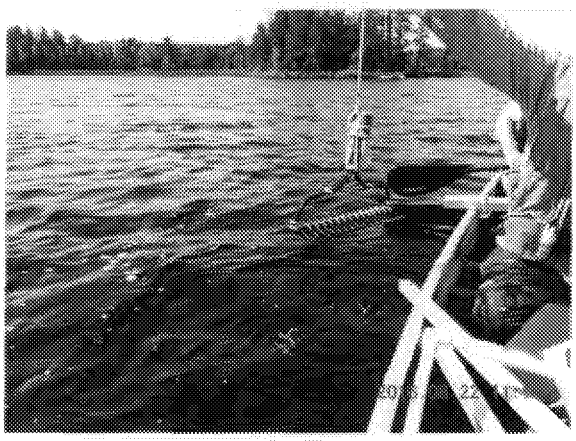


Little Sandy Lake Transect T3 - 5

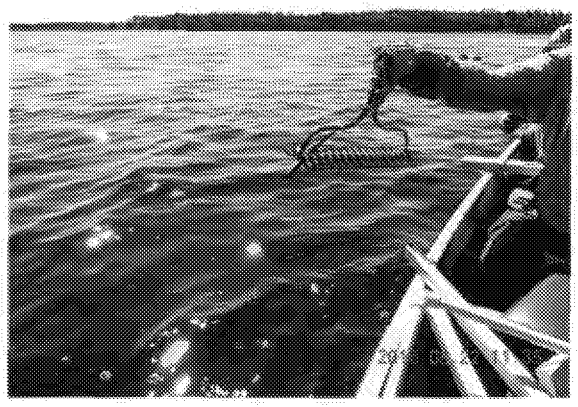


# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 7

Little Sandy Lake T3 - 6



Little Sandy Lake T4 - 1



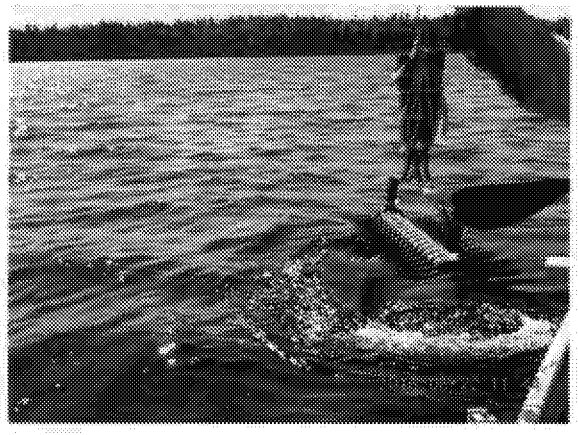
Little Sandy Lake T4 - 2

# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 8

Little Sandy Lake Transect T4 - 3

Little Sandy Lake Transect T4 - 4

Little Sandy Lake Transect T1 - 1



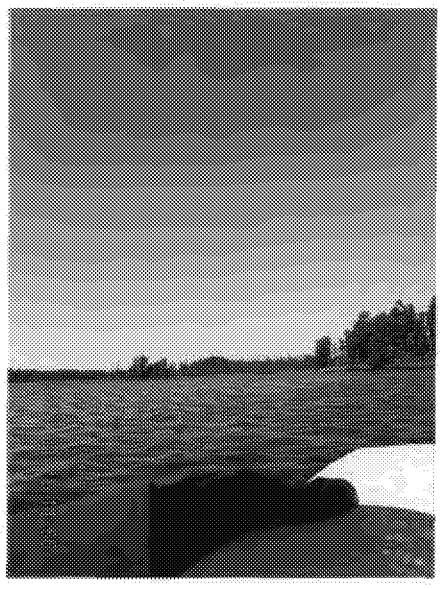
# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 9

Little Sandy Lake Transect T1 - 1

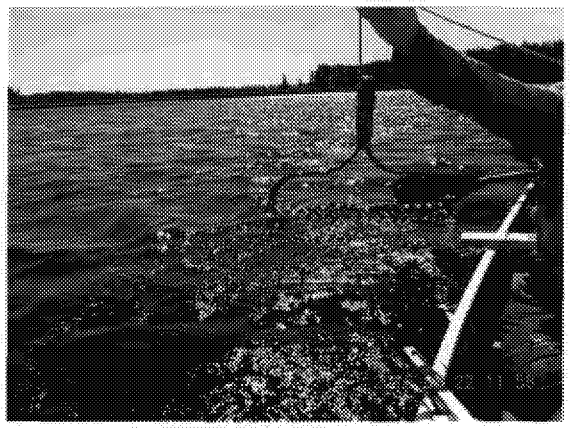
Little Sandy Lake Transect T1 - 2

# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 10

Little Sandy Lake T1 - 3

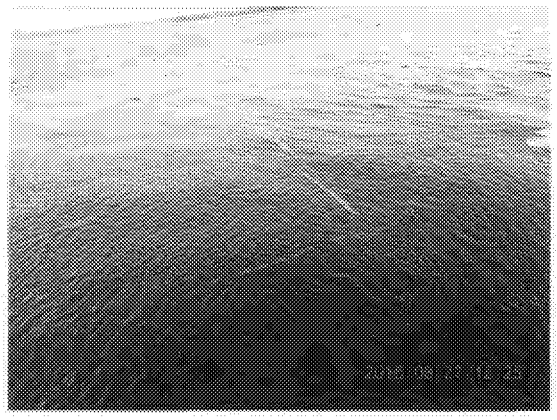


Little Sandy Lake Transect T1 - 4



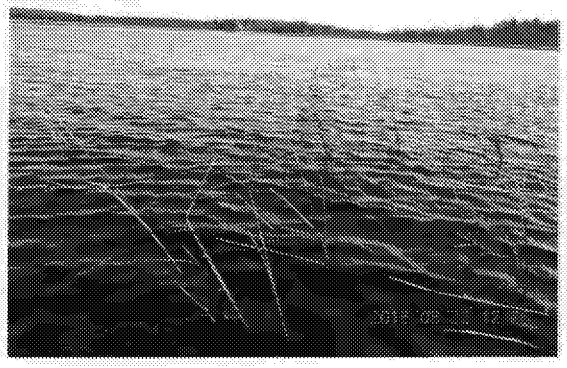
# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 11

Sandy Lake Southwest Wild Rice Plot



# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 12

Sandy Lake Southwest Wild Rice Plot

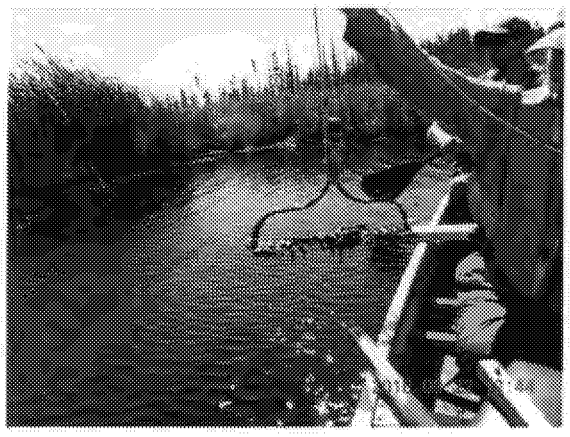


# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 13

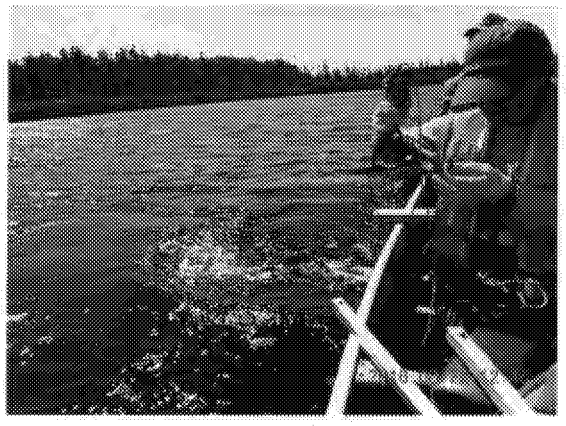
Sandy Lake Transect T3 - 1

# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 14

Sandy Lake Transect 3 - 1



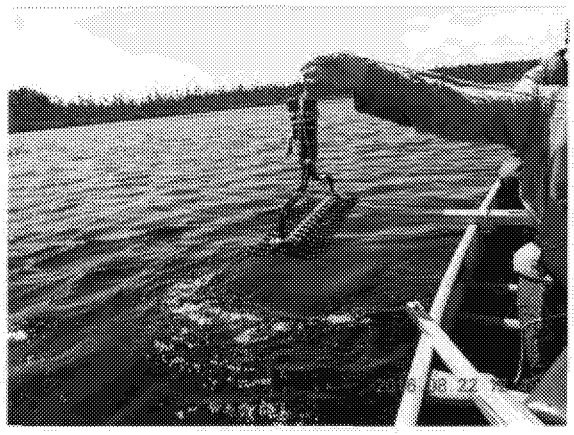
Sandy Lake Transect T3 - 2



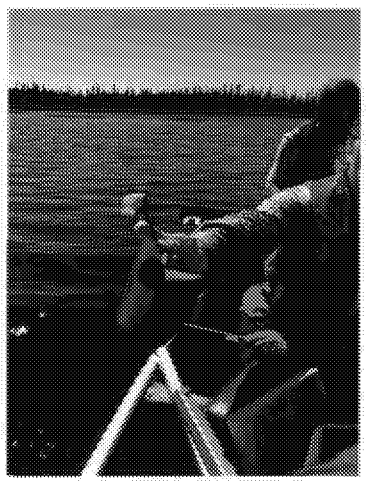
# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 15

Sandy Lake Transect T3 – 2 Spatterdock

Sandy Lake Transect T3 - 3



Sandy Lake Transect 3 – 4 Spatterdock



# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 16

Sandy Lake Transect T3 - 5

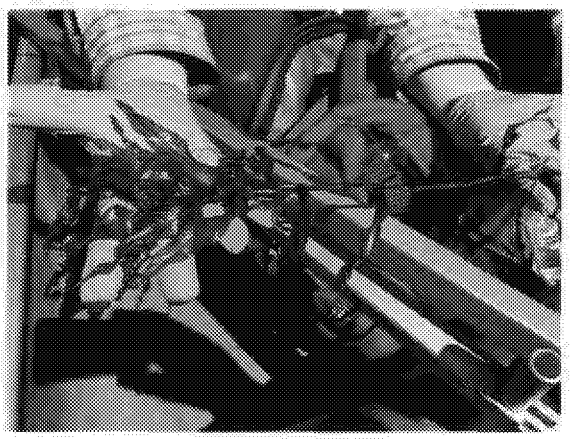
Sandy Lake Transect T3 - 6

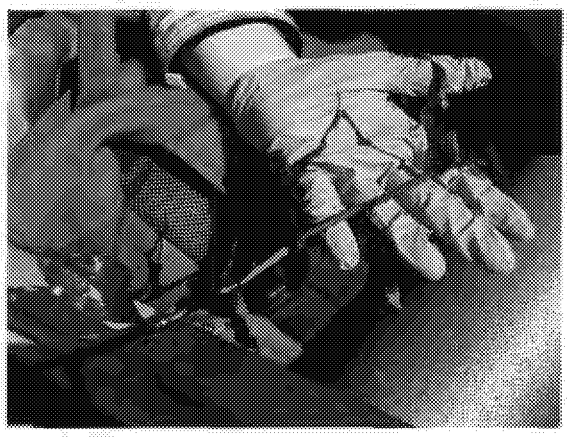
Sandy Lake Transect T3 – 6 Bur Reed

# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 17

Sandy Lake Transect T3-6 Small Pondweed

Sandy Lake Transect T3- 6 White Stemmed Pondweed



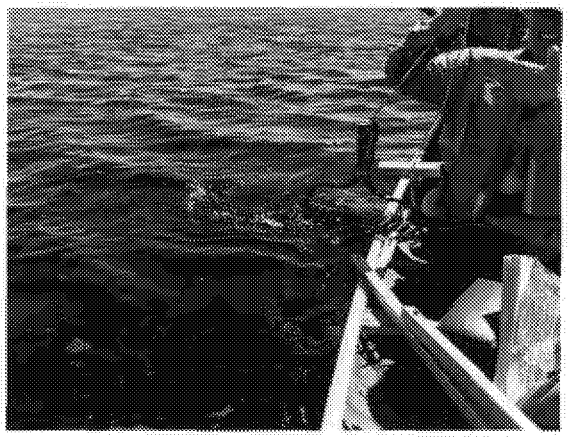


Sandy Lake Transect 4 - 1

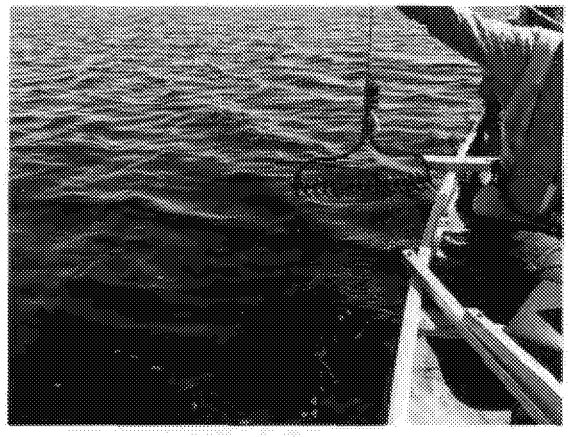
# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 18

Sandy Lake Transect 4 - 3

Sandy Lake Transect 4 - 4



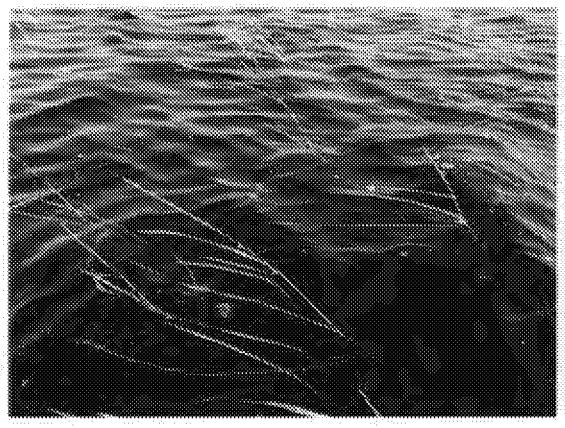
Sandy Lake Transect 4 - 5

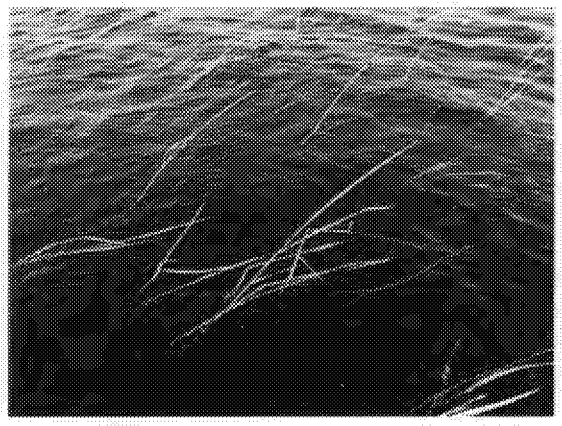


# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 19

Sandy Lake Transect T4 - 6

Sandy Lake East Wild Rice Plot





# Twin Lakes Aquatic Plant Survey Pictures
## August 22, 2016 Page 20

Sandy Lake Transect 1 - 1

# Observation of Twin Lakes Planted Wild Rice Growth
## August 12, 2016

**Sandy Lake Southwest (Close View)**

**Sandy Lake Southwest (Wide Angle)**

**Sandy Lake East (Wide Angle)**

**Sandy Lake East (Close View)**

# APPENDIX F

2016 Beaver Management Activities

**[External]-Twin Lakes Beaver work**
Sahr, Duane P \Pete\- APHIS - APHIS 12/14/2016 10:50 AM
To: Tom A Moe

History: This message has been forwarded.

Hi Tom,

We did do some beaver trapping on the Twin Lakes (Sand River) project this spring.

We started trapping May 24 and ended June 8. In that time we caught 8 beaver on the upper stretch (from the Lake to Hwy 53) and 14 beaver on the lower stretch (from Hwy 53 to the Rice River Road (CR 303)). We hand pulled 7 dams (some old, but some new also. Those were fresh stick dams with very little mud).

We went back on August 25 and floated the entire project and pulled 4 older dams that were exposed by lower water levels. No new beaver sign.

We purchased a mud motor this summer, which was the only way we were able to motor on the river in August because the system was pretty weed choked. Would have really been tough otherwise.

Let me know if you need anything else.

Thanks


Duane P. Sahr
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Duane.P.Sahr@aphis.usda.gov
(218) 327-3350 phone
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# APPENDIX G

2016 Observations of Wild Rice Pilot Seeding Plots

# Observation of Twin Lakes Planted Wild Rice Growth
## August 9 & 22, 2016



**Sandy Lake; Northwest**

- Counted 31 wild rice plants with ½ in Aerial Phase
- One wild rice plant has flower/seed pods
- Observed wild rice stalks that have been bitten off
- Water depth in rice bed: Between 2.7' and 3.9'
- Most plants observed in 2.7' to 2.9' of water depth
- Flowers observed between 12" and 18" above water surface

**Sandy Lake; East**

- Over 200 wild rice plants with ½ in Aerial Phase
- Patchy growth with 5.5 wild rice plants per square meter
- Many plants observed flowering
- Observed wild rice stalks that have been bitten off
- Water depth in rice bed: 3.8' to 4.0'
- Flowers observed between 12" and 18" above water surface

**Sandy Lake; Southwest**

- Over 200 wild rice plants with ½ in Aerial Phase
- Very patchy growth with 11 wild rice plants per square meter
- About half of the Aerial Phase plants flowering
- Observed wild rice stalks that have been bitten off
- Water depth in rice bed: 3.5'
- Little to no competitive vegetation in wild rice plot area
- Wild rice is taller, more stout/rigid than Northwest & East plants

**Little Sandy; Lake South**

- Over 200 wild rice plants with ½ I Aerial Phase
- Patchy growth with 30 wild rice plants per square meter
- A lot of Bur Reed competition in planted wild rice plot
- Some of the plants flowering, all between 12" and 18" above water surface
- Water depth in rice bed: 3.75' to 4.0'
- Little to no competitive vegetation in wild rice plot area

**Little Sandy Lake; Northwest**

- No evidence of wild rice growing in this plot

**Little Sandy Lake; Northeast**

- Approximately 10 wild rice plants found in plot
- Plants were only in floating leaf stage
- Water depth in rice bed: 3.2' to 3.9'

## Peeper Porewater Analysis in Twin Lakes Rice Beds

**August 25 to September 28, 2016**

| | Units | Reportable Detection Limit | Sandy Lake East | Sandy Lake NW | Sandy Lake SW | Sandy Lake South (Natural)* | Little Sandy South |
|---|---|---|---|---|---|---|---|
| **Sulfide** | mg/L | 0.10 | <0.10 | <0.10 | <0.10 | **0.15** | <0.10 |
| **Iron** | ug/l | 50.0 | **505** | **1150** | **1210** | **37700** | **15400** |
| **Sulfate** | mg/L | 10.0 | **370** | **358** | **107** | **284** | **423** |
| **NO2 as N** | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| **NO3 as N** | mg/L | 0.20 | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| **N, NH3** | mg/L | 0.10 | <0.10 | <0.11 | <0.12 | <0.13 | <0.14 |
| **N. Kjeldahl** | mg/L | 2.5 | **3.7** | **3.9** | <2.5 | **14.2** | <2.5 |
| **Phos (Tot)** | mg/L | 0.50/0.10 | <0.50 | **0.12** | <0.10 | **1.8** | <0.10 |

* This location was not planted rice but was found coming up "naturally."

## Water Column Analysis in Twin Lakes Rice Beds

| | | | 25-Aug-16 | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Units | Reportable Detection Limit | Sandy Lake East | Sandy Lake NW | Sandy Lake SW | Sandy Lake South (Natural)* | Little Sandy South | Little Sandy NE |
| **N, NH3** | mg/L | 0.10 | **0.35** | **0.36** | **0.39** | **0.48** | <0.10 | **0.13** |
| **N, Kjeldahl** | mg/L | 0.60 | **1.7** | **1.6** | **1.8** | **2.1** | **1.3** | **1.3** |
| **Aluminum** | mg/L | 50.0 | **64.0** | **58.7** | **99.5** | **196** | <50.0 | <50.0 |
| **Calcium** | mg/L | 0.50 | **30.8** | **33.4** | **27.6** | **22.5** | **44.5** | **39.7** |
| **Iron** | ug/L | 50.0 | **2850** | **2760** | **4720** | **10800** | **1580** | **1630** |
| **Magnesium** | mg/L | 0.50 | **39.6** | **43.7** | **35.7** | **27.3** | **62.8** | **55.4** |
| **Manganese** | ug/L | 10.0 | **88.9** | **126** | **178** | **243** | **97.8** | **132** |
| **Potassium** | mg/L | 0.50 | **2.5** | **2.7** | **2.4** | **2.1** | **3.1** | **2.7** |
| **Sodium** | mg/L | 0.50 | **13.5** | **14.6** | **12.7** | **11.4** | **21.1** | **17.4** |
| **Total Hardness** | mg/L | 3.3 | **240** | **263** | **216** | **168** | **370** | **327** |
| **Alkalinity, (Tot)** | mg/L | 6.1 | **168** | **178** | **156** | **118** | **229** | **223** |
| **Total Dis. Solids** | mg/L | 10.0 | **380** | **393** | **389** | **339** | **472** | **535** |
| **Total Susp. Solids** | mg/L | 1.0 | **2.8** | **2.0** | **2.0** | **16.7** | **2.0** | **3.6** |
| **Chloride** | mg/L | 1.0 | **17.2** | **18.0** | **17.2** | **17.5** | **27.9** | **21.9** |
| **Sulfate** | mg/L | 2.0 | **77.0** | **87.2** | **70.2** | **43.5** | **152** | **121** |
| **Dis. Org. Carbon** | mg/L | 1.0 | **42.0** | **40.7** | **47.2** | **51.2** | **33.9** | **36.1** |
| **pH** | Units | ± 0.2 | **7.6** | **7.7** | **7.3** | **6.5** | **7.7** | **7.8** |
| **Sp. Conductance** | mv | ± 1% | **469** | **498** | **439** | **277** | **725** | **648** |
| **Temperature** | ° C | ± 0.1 | **20.6** | **21.0** | **20.6** | **18.1** | **20.4** | **21.2** |

* This location was not planted rice but was found coming up "naturally."

| | | | 28-Sep-16 | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Units | Reportable Detection Limit | Sandy Lake East | Sandy Lake NW | Sandy Lake SW | Sandy Lake South (Natural)* | Little Sandy South | Little Sandy NE |
| **N, NH3** | mg/L | 0.10 | **0.12** | **0.11** | **0.11** | **0.10** | <0.10 | <0.10 |
| **N, Kjeldahl** | mg/L | 0.60 | **1.2** | **1.0** | **1.0** | **0.87** | **0.81** | **0.80** |
| **Aluminum** | mg/L | 50.0 | **53.3** | **59.9** | **56.5** | NM | <50.0 | <50.0 |
| **Calcium** | mg/L | 0.50 | **34.3** | **38.0** | **35.3** | NM | **48.0** | **45.9** |
| **Iron** | ug/L | 50.0 | **1240** | **1110** | **1350** | NM | **565** | **569** |
| **Magnesium** | mg/L | 0.50 | **45.9** | **51.6** | **48.1** | NM | **65.9** | **63.8** |
| **Manganese** | ug/L | 10.0 | **42.3** | **56.8** | **55.9** | NM | **74.6** | **93.0** |
| **Potassium** | mg/L | 0.50 | **2.9** | **3.2** | **3.0** | NM | **4.2** | **3.7** |
| **Sodium** | mg/L | 0.50 | **16.4** | **18.2** | **17.1** | NM | **23.4** | **21.7** |
| **Total Hardness** | mg/L | 3.3 | **275** | **307** | **286** | NM | **391** | **377** |
| **Alkalinity, (Tot)** | mg/L | 6.1 | **188** | **189** | **172** | **52.7** | **221** | **221** |
| **Total Dis. Solids** | mg/L | 10.0 | **393** | **461** | **403** | **198** | **541** | **516** |
| **Total Susp. Solids** | mg/L | 1.0 | **2.0** | **3.6** | **3.6** | NM | **1.6** | <1.0 |
| **Chloride** | mg/L | 1.0 | **24.8** | **26.9** | **25.5** | **29.6** | **35.6** | **32.0** |
| **Sulfate** | mg/L | 2.0 | **100** | **123** | **108** | **12.9** | **176** | **159** |
| **Dis. Org. Carbon** | mg/L | 1.0 | **31.5** | **30.0** | **31.2** | NM | **24.8** | **25.7** |
| **pH** | Units | ± 0.2 | **8.0** | **8.0** | **7.9** | **7.1** | **8.0** | **8.1** |
| **Sp. Conductance** | mv | ± 1% | **559** | **619** | **572** | **295** | **786** | **741** |
| **Temperature** | ° C | ± 0.1 | **11.2** | **11.7** | **11.2** | **11.1** | **11.6** | **12.1** |

* This location was not planted rice but was found coming up "naturally."

## Water Column Analysis in Twin Lakes Rice Beds

| | | | 25-Aug-16 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Units | Reportable Detection Limit | Rice Bed Sandy Lake East | Water Col Sandy Lake Outflow | Rice Bed Sandy Lake NW | Rice Bed Sandy Lake SW | Rice Bed Sandy Lake South (Natural)* | Sandy Lake Inflow South | Rice Bed Little Sandy South | Water Col Little Sandy Inflow 1 | Rice Bed Little Sandy NE | Water Col Little Sandy Inflow 2 | Water Col Little Sandy Inflow 3 |
| N, NH3 | mg/L | 0.10 | 0.35 | 0.32 | 0.36 | 0.39 | 0.48 | 0.63 | <0.10 | <0.10 | 0.13 | 0.29 | 0.16 |
| N, Kjeldahl | mg/L | 0.60 | 1.7 | 1.5 | 1.6 | 1.8 | 2.1 | 2.1 | 1.3 | 0.87 | 1.3 | 2.1 | 1.3 |
| Aluminum | mg/L | 50.0 | 64.0 | 57.3 | 58.7 | 99.5 | 196 | 213 | <50.0 | 70.5 | <50.0 | 111 | <50.0 |
| Calcium | mg/L | 0.50 | 30.8 | 28.0 | 33.4 | 27.6 | 22.5 | 12.9 | 44.5 | 69.6 | 39.7 | 38.6 | 40.0 |
| Iron | ug/L | 50.0 | 2850 | 3280 | 2760 | 4720 | 10800 | 14900 | 1580 | 2060 | 1630 | 2250 | 1650 |
| Magnesium | mg/L | 0.50 | 39.6 | 33.4 | 43.7 | 35.7 | 27.3 | 12.1 | 62.8 | 99.3 | 55.4 | 53.5 | 56.0 |
| Manganese | ug/L | 10.0 | 88.9 | 136 | 126 | 178 | 243 | 267 | 97.8 | 138 | 132 | 214 | 220 |
| Potassium | mg/L | 0.50 | 2.5 | 2.2 | 2.7 | 2.4 | 2.1 | 1.5 | 3.1 | 5.5 | 2.7 | 2.3 | 2.5 |
| Sodium | mg/L | 0.50 | 13.5 | 11.7 | 14.6 | 12.7 | 11.4 | 8.5 | 21.1 | 39.0 | 17.4 | 15.4 | 16.8 |
| Total Hardness | mg/L | 3.3 | 240 | 207 | 263 | 216 | 168 | 82.2 | 370 | 582 | 327 | 317 | 330 |
| Alkalinity, (Tot) | mg/L | 6.1 | 168 | 152 | 178 | 156 | 118 | 59.7 | 229 | 278 | 223 | 240 | 237 |
| Total Dis. Solids | mg/L | 10.0 | 380 | 356 | 393 | 389 | 339 | 251 | 472 | 836 | 535 | 434 | 473 |
| Total Susp. Solids | mg/L | 1.0 | 2.8 | <1.0 | 2.0 | 2.0 | 16.7 | 8.0 | 2.0 | 2.8 | 3.6 | 22.0 | 5.2 |
| Chloride | mg/L | 1.0 | 17.2 | 15.4 | 18.0 | 17.2 | 17.5 | 18.7 | 27.9 | 56.5 | 21.9 | 18.6 | 20.2 |
| Sulfate | mg/L | 2.0 | 77.0 | 64.3 | 87.2 | 70.2 | 43.5 | <2.0 | 152 | 314 | 121 | 96.7 | 108 |
| Dis. Org. Carbon | mg/L | 1.0 | 42.0 | 39.1 | 40.7 | 47.2 | 51.2 | 55.3 | 33.9 | 22.1 | 36.1 | 38.9 | 37.1 |
| pH | Units | ± 0.2 | 7.6 | 7.3 | 7.7 | 7.3 | 6.5 | 6.4 | 7.7 | 7.1 | 7.8 | 7.4 | 7.2 |
| Sp. Conductance | mv | ± 1% | 469 | 417 | 498 | 439 | 277 | 209 | 725 | 1141 | 648 | 600 | 600 |
| Temperature | ° C | ± 0.1 | 20.6 | 20.0 | 21.0 | 20.6 | 18.1 | 17.2 | 20.4 | 19.1 | 21.2 | 20.2 | 19.8 |

* This location was not planted rice but was found coming up "naturally."

## Water Column Analysis in Twin Lakes Rice Beds

| | | | 28-Sep-16 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Units | Reportable Detection Limit | Rice Bed Sandy Lake East | Water Col Sandy Lake Outflow | Rice Bed Sandy Lake NW | Rice Bed Sandy Lake SW | Rice Bed Sandy Lake South (Natural)* | Sandy Lake Inflow South | Rice Bed Little Sandy South | Water Col Little Sandy Inflow 1 | Rice Bed Little Sandy NE | Water Col Little Sandy Inflow 2 | Water Col Little Sandy Inflow 3 |
| N, NH3 | mg/L | 0.10 | 0.12 | 0.11 | 0.11 | 0.11 | 0.10 | 0.11 | <0.10 | <10.0 | <0.10 | <0.10 | <10.0 |
| N, Kjeldahl | mg/L | 0.60 | 1.2 | 0.94 | 1.0 | 1.0 | 0.87 | 0.79 | 0.81 | 0.71 | 0.80 | 0.88 | 0.85 |
| Aluminum | mg/L | 50.0 | 53.3 | <50.0 | 59.9 | 56.5 | NM | 65.4 | <50.0 | 84.6 | <50.0 | <50.0 | <50.0 |
| Calcium | mg/L | 0.50 | 34.3 | 28.6 | 38.0 | 35.3 | NM | 7.2 | 48.0 | 54.4 | 45.9 | 47.4 | 30.9 |
| Iron | ug/L | 50.0 | 1240 | 1420 | 1110 | 1350 | NM | 3290 | 565 | 1150 | 569 | 455 | 353 |
| Magnesium | mg/L | 0.50 | 45.9 | 36.0 | 51.6 | 48.1 | NM | 7.8 | 65.9 | 72.6 | 63.8 | 65.9 | 49.4 |
| Manganese | ug/L | 10.0 | 42.3 | 54.1 | 56.8 | 55.9 | NM | 119 | 74.6 | 84.7 | 93.0 | 84.0 | 90.6 |
| Potassium | mg/L | 0.50 | 2.9 | 2.6 | 3.2 | 3.0 | NM | 2.8 | 4.2 | 5.8 | 3.7 | 3.3 | 1.5 |
| Sodium | mg/L | 0.50 | 16.4 | 13.3 | 18.2 | 17.1 | NM | 11.5 | 23.4 | 28.4 | 21.7 | 20.9 | 9.2 |
| Total Hardness | mg/L | 3.3 | 275 | 220 | 307 | 286 | NM | 50.2 | 391 | 435 | 377 | 390 | 280 |
| Alkalinity, (Tot) | mg/L | 6.1 | 188 | 145 | 189 | 172 | 52.7 | 34.7 | 221 | 207 | 221 | 251 | 255 |
| Total Dis. Solids | mg/L | 10.0 | 393 | 346 | 461 | 403 | 198 | 158 | 541 | 661 | 516 | 561 | 367 |
| Total Susp. Solids | mg/L | 1.0 | 2.0 | 2.4 | 3.6 | 3.6 | NM | 3.2 | 1.6 | 3.2 | <1.0 | 3.6 | 2.4 |
| Chloride | mg/L | 1.0 | 24.8 | 21.1 | 26.9 | 25.5 | 29.6 | 30.0 | 35.6 | 47.0 | 32.0 | 31.5 | 12.5 |
| Sulfate | mg/L | 2.0 | 100 | 81.9 | 123 | 108 | 12.9 | <2.0 | 176 | 229 | 159 | 165 | 39.6 |
| Dis. Org. Carbon | mg/L | 1.0 | 31.5 | 27.9 | 30.0 | 31.2 | NM | 22.6 | 24.8 | 19.5 | 25.7 | 27.7 | 32.2 |
| pH | Units | ± 0.2 | 8.0 | 7.6 | 8.0 | 7.9 | 7.1 | 6.5 | 8.0 | 7.3 | 8.1 | 7.8 | 7.4 |
| Sp. Conductance | mv | ± 1% | 559 | 462 | 619 | 572 | 295 | 172 | 786 | 895 | 741 | 781 | 517 |
| Temperature | ° C | ± 0.1 | 11.2 | 11.0 | 11.7 | 11.2 | 11.1 | 11.1 | 11.6 | 10.9 | 12.1 | 11.7 | 11.8 |

* This location was not planted rice but was found coming up "naturally."

## Peeper Pore water Analysis in Twin Lakes Rice Beds
## Compared to Seasonal Locations

| | Units | Reportable Detection Limit | Rice Bed Sandy Lake East | 2016 Twin Lakes Outflow | Rice Bed Sandy Lake NW | 2016 Sandy Lake Middle | Rice Bed Sandy Lake SW | Rice Bed SL South (Natural)* | 2016 LSL Outlet | Rice Bed Little Sandy South | 2016 LSL Inflow 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sulfide** | mg/L | 0.10 | <0.10 | **0.11-0.34** | <0.10 | **0.13-0.25** | <0.10 | **0.15** | **0.28-3.5** | <0.10 | **0.37-1.5** |
| **Iron** | mg/L | 50.0 | **0.5** | **2.1-15.6** | **1.2** | **0.7-8.6** | **1.2** | **37.7** | **0.9-12.7** | **15.4** | **0.9-4.8** |
| **Sulfate** | mg/L | 10.0 | **370** | **<2.0-39.7** | **358** | **<2.0-105** | **107** | **284** | **<2.0-18.2** | **423** | **<2.0-81.3** |

| | |
|---|---|
| * | This location was not planted rice but was found coming up "naturally." |
| Red | Data in Red are pore water monthly results taken from April through September. |
| Black | Data in Black are pore water results taken from August 25 - September 28 in Rice Beds. |

# APPENDIX H

Twin Lakes 2017 Activities Plan

# U. S. Steel Minntac

## Twin Lakes Wild Rice Restoration Opportunities Plan

**Proposed Implementation Plan - 2017 Plan Activities**

| April-17 | May-17 | June-17 | July-17 | August-17 | September-17 | October-17 | November-17 | December-17 |
|---|---|---|---|---|---|---|---|---|
| 1 Install PT at Bridge | 1 Monthly Water Quantity / Quality Monitoring | 1 Monthly Water Quantity / Quality Monitoring | 1 Monthly Water Quantity / Quality Monitoring | 1 Monthly Water Quantity / Quality Monitoring | 1 Monthly Water Quantity / Quality Monitoring | 1 Monthly Water Quantity / Quality Monitoring | 1 Collect water depth data and remove PT for Winter storage | 1 Prepare and Submit Annual Report 12/31/17 |
| 2 Deploy Peepers | 2 Collect water depth data | 2 Collect water depth data | 2 Collect water depth data | 2 Collect water depth data | 2 Collect water depth data | 2 Collect water depth data | | |
| | 3 Observe and document WR growth | 3 Observe and document WR growth | 3 Observe and document WR growth | 3 Observe and document WR growth | 3 Observe and document WR growth | 3 Recover Peepers | | |
| | 4 Recover Peepers and redeploy | 4 Recover Peepers and redeploy | 4 Recover Peepers and redeploy | 4 Recover Peepers and redeploy | 4 Recover Peepers and redeploy | | | |
| | 5 Assess beaver and dam removal situation. Remove as needed | 5 Assess pore water sulfide from Inflow 2 peeper. Complete pilot-scale ZVI application | 5 Reassess beaver and dam removal situation. Remove as needed | 5 Complete Aquatic Plant Survey | | | | |
| | | | 6 Consider 2017 seeding efforts and source of wild rice seed | | | | | |

Environmental Science & Engineering

# U.S Steel Minntac

# Twin Lakes Wild Rice Restoration

# Opportunities Plan

# 2016 Annual Report

December 30, 2016

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