GREAT LAKES INDIAN FISH AND WILDLIFE COMMISSION
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Via Electronic Mail

January 25, 2018

Technical Memorandum

To: Nancy Schuldt, Water Projects Coordinator, Fond du Lac Environmental Program

From: John Coleman, GLIFWC Environmental Section Leader

Re: Water Quality observations at Twin Lakes, US Steel site, June & August 2017

The purpose of this memorandum is to report on two site visits to the Twin Lakes (Sandy and Little Sandy Lake), adjacent to the U.S. Steel Minntac project tailings basins. This data report is preliminary and needs to be incorporated into the growing long-term record of constituent concentrations observed in the Sandy River watershed. This report appears to be the first near-simultaneous lakewide measurements of water quality in the Twin Lakes. This data suggests that future measurements must take into account the small-scale spatial variation in water quality that is present at the Twin Lakes. This type of spatially intensive data collection may help to focusing efforts in identifying and controlling the primary pollutant pathways to the lakes.

Methodology:

On June 6th and again on August 8th and 9th of 2017, Environmental Section staff traveled on foot and by canoe to the shore and inlets of the Twin Lakes in the headwaters of the Sandy River. These two lakes are less than 1/2 mile downstream of the U.S. Steel Minntac tailings basin. Field parameters were measured with a YSI ProDSS meter and water grab samples were collected. Prior to each site visit the YSI was calibrated to standards for specific conductance, pH, chloride, dissolved oxygen, temperature and depth. Time was synchronized with GPS satellites and sample locations were recorded with the YSI ProDSS internal GPS sensor and with a hand-held GPS receiver. Sample locations were identified either with existing IDs from 1854 Treaty Authority (1854 Treaty Authority, 2018) and Northern Technical Services (NTS, 2017) or were newly established during our field visits. GLIFWC-established sample locations are:

- SandL01 - The downstream side of the wooden snowmobile bridge across the inflow channel from Admiral Lake. Approximately 50 meters upstream of inflow mouth at Little Sandy Lake. (lat=47.616336 lon=-92.595335)
- SandL02 - Inflow channel on south-west side of Little Sand Lake, 170 meters upstream from lakeshore. (lat=47.616493 lon=-92.609530)
- SandL04 - The downstream side of the wooden snowmobile bridge across the Sandy River, between Little Sandy Lake and Admiral Lake. (lat=47.614551 lon=-92.594980)

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- SandL_Brdg - Upstream side of steel bridge over channel connecting Little Sandy and Sandy Lakes. (lat=47.620234 lon=-92.598146)

Grab Samples:

Surface water quality grab samples were collected at select locations (Figure 1) and samples submitted for analysis at the University of Wisconsin Stevens Point WEAL lab. A sample duplicate was collected at one sample site and submitted to the Northern Lake Service Lab in Crandon, Wisconsin.

Field measurements:

A YSI ProDSS water quality meter was used to collect spot measurements of 6 parameters, Specific Conductance (i.e. conductivity@25Deg.C), pH, Chloride[1], Dissolved Oxygen, Temperature and Depth. Sample sites are indicated in Figure 1. At two sites, field measurements were recorded once after parameter readings stabilized. At 5 sites, in-lake measurements were recorded from canoe at 10 second intervals for 1 to 5 minutes and the readings averaged.

Lake-wide transects:

Lakewide surveys, were conduced by canoe, primarily along the shoreline of Little Sandy and Sandy Lakes for the six parameters collected by the YSI ProDSS. The path of the transects is shown in Figure 1. The YSI ProDSS sensors were pulled behind the canoe at 0 to 2.5 miles per hour. Readings were recorded every 10 seconds and locations of the readings were recorded with the meter's internal GPS sensor. Depth of the readings were between 3 and 83 cm and averaged 29 cm. Depth was recorded by the meter's internal depth sensor. Speed of the canoe as it traversed the transects was calculated form the time and locational data collected by the YSI meter. Inlets to the Twin Lakes that had been previously identified from aerial photographs were investigated and field parameters measures at the mouth of the inlets.

Results:

Laboratory analysis of surface water grab samples:

In June, two samples were collected at site SandL02 and submitted to two different labs. In August only one sample was collected. Results are presented in Table 1. All samples exceeded the Minnesota Sulfate water quality standard for rice waters. The August 9th samples also exceed the Minnesota Class 3C standards for Hardness. On August 9th, at the SandL04 site, the sample came close to exceeding the state Class 2B standard for Aluminium. In Table 1, results that exceed both the Minnesota surface water quality standard and the EPA Secondary Drinking Water Standards (sMCL) are highlighted in orange. Results that exceed state water quality standards are highlighted in red. Those that exceed the EPA sMCL are highlighted in green. And those that are between half the MN standard and the MN standard are highlighted in yellow. Except for iron and manganese, constituent concentrations were generally equal to or higher at site SandL04 than at SandL02.

1 On June 6th the Cl^- probe failed calibration checks and chloride data were not recorded.

Table 1. Results from 3 surface water grab samples at two locations. Units mg/L.

	2017-06-06		2017-08-09
Site	SandL02	SandL02dup	SandL04
Lab. Grab-Sample Analysis			
Alkalinity	248	260	272
Aluminum	0.098	0.062	0.11
Arsenic	0.003	0.0025	ND
Barium	0.017	0.017	0.042
Beryllium	ND	ND	ND
Boron	0.088	0.11	0.112
Cadmium	0.0002	ND	ND
Calcium	56.903	57	91.954
Chloride (FIA)	25.1	22	77
Chromium	0.0046	ND	0.0021
Cobalt	ND	ND	ND
Copper	0.0014	ND	ND
Iron - Total	0.789	0.71	0.356
Lead	ND	ND	ND
Magnesium	74.692	80	142.379
Manganese	0.084	0.081	0.021
Nickel	ND	ND	ND
Phosphorus	0.02	0.022	0.015
Potassium	2.476	2.9	5.454
Selenium	ND	ND	ND
Silver	ND	ND	ND
Sodium	15.675	17	59.524
Sulfate (ICP)	191.89	190	516.59
Total Dissolved Solids	642	840[1]	1216
Total Hardness titrimetric	467		838
Total Suspended Solids	ND	ND	ND
Zinc	0.003	ND	0.004
Hardness from Ca & Mg	448	471	814

[1] TDS value >> TDS calculated from Specific Conductance

exceed both EPA sMCL and MN surface water standards

exceeds MN surface water standards

exceeds EPA sMCL

value between 1/2 the state standard and the state standard

Field Measurements:

Measurement of water quality parameters with the field YSI ProDSS meter (Table 2) showed low dissolved oxygen in waters flowing slowly through, or entering from, the cattail wetlands surrounding much of Little Sandy Lake (sites SandL02, Inflow_2 and Inflow_3. In tributaries to the lakes, i.e. SandL01, SandL02 and SandL04 and lake water near locations of flow into the lakes, i.e. Inflow_2, Inflow_3 and SL_S_Inflow, pH averaged approximately 7.5. The open water of the lakes appeared to have higher pH, with a reading of 8.2 at the bridge between the two lakes (site SandL_Brdg). Specific Conductance was highest in the inflow from the tailings basins by-way-of Admiral Lake i.e. SandL04 and SandL01, and lowest near an inlet on the south-east shore of Sandy Lake (SL_S_Inflow). Chloride

was highest in the inflow from the tailings basins by-way-of Admiral Lake i.e. SandL04 and SandL01. In Table 2, the highest reading of each parameter are highlighted in purple and the lowest reading of each parameter highlighted in blue.

Table 2. Results of field parameter measurements at 7 sites on two dates. Units mg/L unless noted otherwise.

	2017-06-06		2017-08-09					
Site	SandL02	SandL02 dup	SandL04	SandL01	Inflow_2	Inflow_3	SandL_Brdg	SL_S_Inflow
Field Parameters								
Dissolved O2	1.4	1.3	7.5	10.9	2	2.8	8.9	5.4
pH	7.2	7.2	7.4	7.7	7.7	7.3	8.2	7.5
Specific Conductance (uS/cm@25C)	845	850	1614	1598	836	787	829	446
Temp. deg.C Water	13.8	13.5	20.6	21.1	21.4	20.4	22.2	20.3
Chloride			55.3	58.6	33.9	35.6	35.2	33.4
TDS from calc. of 0.75 * SC[1]	634	638	1211	1199	627	590	622	335
n(repeat readings @ 10 sec)	1	1	1	11	25	35	21	6

[1] TDS:Specific Conductance ratio from average of 18 previous field and lab readings in Little Sandy Lake by the 1854 Treaty Authority

lowest value among sites

highest value among sites

Lake-wide transects:

Specific Conductance.- Specific Conductance (Figure 2), and by extrapolation total dissolved solids (TDS) was substantially higher in the upper lake (Little Sandy Lake) and substantially lower once one moved through the isthmus into Sandy Lake. It appears likely that unpolluted inputs from the watershed to Sandy Lake serve to dilute the high concentrations contributed by Little Sand Lake. Specific Conductance was approximately 2-fold higher near the Twin-1 inlet than elsewhere in Little Sandy Lake and approximately 3-fold higher than in Sandy Lake. Specific Conductance at Inflow_3 was substantially lower than observed elsewhere in Little Sandy Lake.

Chloride.- Chloride levels (Figure 3) in the lakes varied in a way similar to that observed in Specific Conductance. The highest values (> 70 mg/L Cl^-) were observed at the inlet to Little Sandy Lake marked as site Twin 1 by the 1854 Treaty Authority (1854 Treaty Authority, 2018). There were small isolated locations of chloride greater than 70 mg/L observed around the perimeter of Little Sandy lake. In general Sandy Lake had lower chloride readings.

pH.- pH levels (Figure 4) were generally high in both lakes, despite the lower pH's observed at the inflows to the lakes. Only at known inlets was pH less than 7.5. Exceptions were readings taken in a deeper water zone just to the west of the bridge between the lakes, where pH was below 7.5.

Dissolved Oxygen.- Dissolved Oxygen (Figure 5) varied in a way similar to pH, with levels above 5 mg/L in both lakes, except near the inlets from cattail marshes to the lakes and the deeper water zone west of the bridge.

Although the deeper water zone just to the west of the bridge showed low Dissolved Oxygen and pH, in general, Dissolved Oxygen, pH and the other constituents did not vary in a consistent way with depth. However, as noted under methods, the range of depth at which the readings were taken was limited (3 to 83 cm). Both Dissolved Oxygen and pH did vary with the speed of the transect. Both were low when the canoe was traveling at very low speeds. This may have been due to the sensor settling on

the bottom when stationary or traveling at low speeds. Other parameters (Specific Conductance and Chloride) did not vary in a consistent way with canoe speed.

Discussion:

The inflow measured at SandL04, SandL01 and at the mouth of the inlet at Twin 1, differed from other inflows in that the water had near neutral pH and high Dissolved Oxygen while other inlets had near neutral pH and low Dissolved Oxygen. The high volume and rapid movement of the water entering the lake at Twin 1, by way of SandL04 and SandL01, may create higher Dissolved Oxygen conditions.

The vast majority of water input to the Twin Lakes appears to come by-way-of Admiral Lake and enter on the southern shore of Little Sand Lake (site Inflow_1). Flow measured at Inflow_1 by Northeast Technical Services May - October of 2016 (NTS, 2016) ranged from 1,047 to 5,000 gpm and from 701 to 7,760 in 2017 (NTS, 2017) . As to the other inlets to Little Sandy Lake, Northern Technical Services concluded that: "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." While we did observe flow in the range of 10s of gpm at SandL02 in June, we did not measure flow during our June or August site visits. However, our visual observation corroborate the conclusion that the majority of water entering the Twin Lakes enters at Inflow_1 (Twin 1, SandL01).

The grab samples and lakewide transects illustrate the distribution of dissolved solids in the Twin Lakes and their tributaries. That distribution indicates that the majority of pollutants are entering the lake by way of the inlet at Inflow_1. The transects indicate that there is substantial spatial variation in most parameters in the lake downgradient of Inflow_1 (Twin 1, SandL01). During our August transects we noticed channelized flow through the aquatic vegetation in the lake near Inflow_1. Our sample taken August 9th at SandL04 and samples taken by the 1854 Treaty Authority (1854 Treaty Authority, 2018) and NTS (NTS, 2017) near Inflow_1 in the summer of 2017 indicate that there is also substantial temporal variation in most parameters at that location.

The high mineral content inputs to the Twin Lakes may be contributing to biological activity that drives pH higher in the open waters of the lake. pH levels were also found to be elevated, above 8.0, at multiple locations of the Twin Lakes and in multiple years by Northeast Technical Services (NTS, 2016). On the other hand, it seems possible that decomposition of organic matter in wetlands and in deeper zones of the lake may be depressing both pH and Dissolved Oxygen values. The low Dissolved Oxygen and pH readings during some of the the low speed portions of the transects and the possibility that the sensors settled on the bottom suggest that future transects surveys should set the sensors at a fixed depth so as to avoid the possible effects of sensors settling.

The dense aquatic vegetation observed near Inflow_1, the floating mats of decomposing cattail debris and the bubbling up of hydrogen sulfide observed near Inflow_2 and Inflow_3, suggests that biological activity stimulated by high mineral inputs may play a substantial role in lake water chemistry.

This series of grab samples and field measurements helps to identify the inlet at Twin 1 (Inflow_1, SandL01) as the primary source of pollutants to the Twin Lakes. Further investigation of temporal changes in pollutant loads due to season and changes in tailings basin activities is warranted. If you have any questions about this memo, please contact me at 608-263-2873 or jcoleman@glifwc.org.

cc: Jonathan Gilbert, Director, GLIFWC Biological Services Division
Ann McCammon Soltis, Director, GLIFWC Division of Intergovernmental Affairs

References

NTS, 2016. U. S. Steel Minntac Twin Lakes Wild Rice Restoration Opportunities Plan 2016 Annual Report,

1854 Treaty Authority, 2018. Sandy Lake and Little Sandy Lake Monitoring (2010-2017). 1854 Treaty Authority. Technical Report 18-05. January 2018.

Figures

Figure 1. Water quality sample locations and transects at Sandy and Little Sandy Lakes, St. Louis Co., MN, 2017.

Figure 2. Map of levels of Specific Conductance measured during canoe transects around the Twin Lakes, St. Louis County, MN, 2017.

Figure 3. Map of levels of Chloride measured during canoe transects around the Twin Lakes, St. Louis County, MN, 2017.

Figure 4. Map of levels of pH measured during canoe transects around the Twin Lakes, St. Louis County, MN, 2017.

Figure 5. Map of levels of Dissolved Oxygen measured during canoe transects around the Twin Lakes, St. Louis County, MN, 2017.

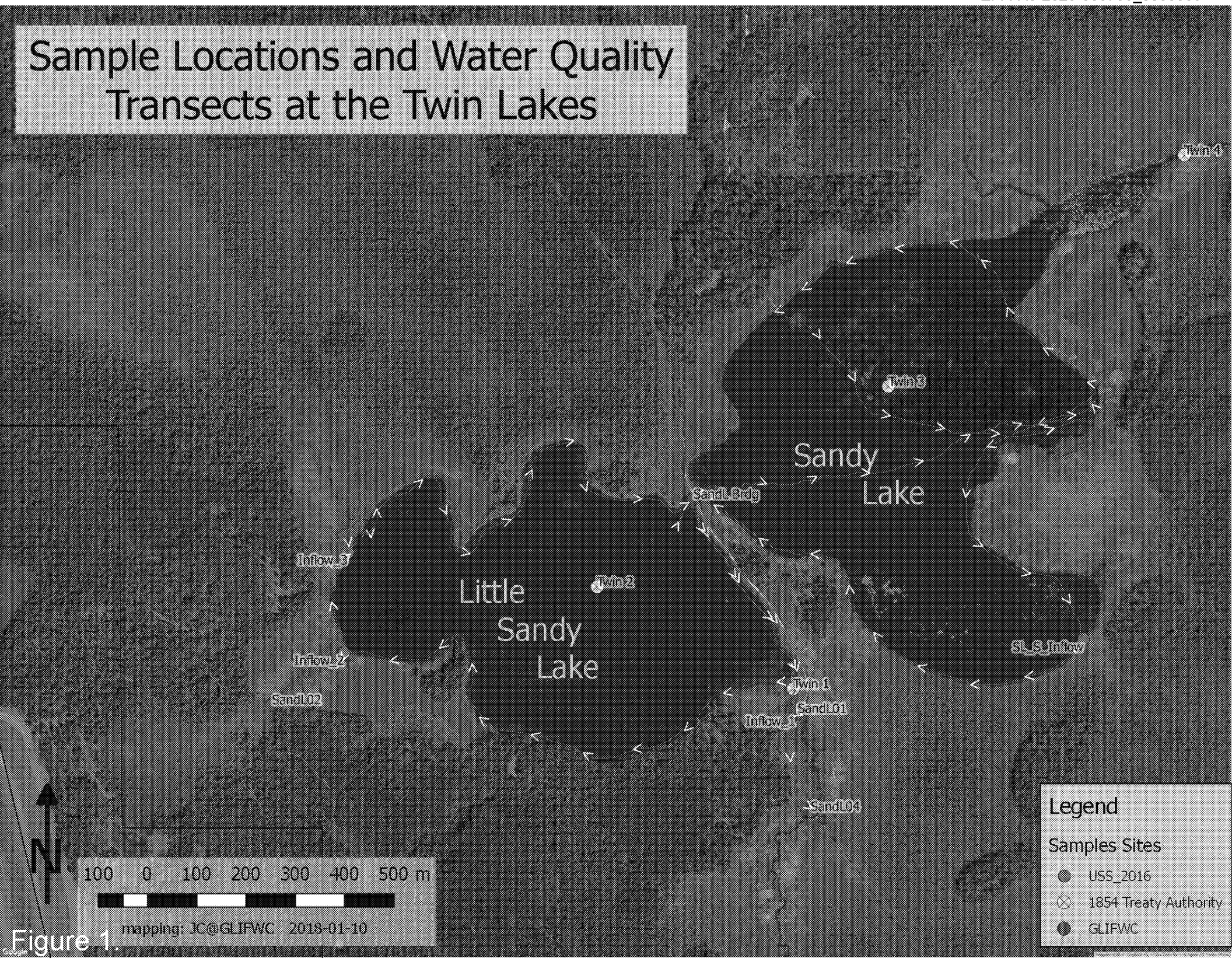
Sample Locations and Water Quality Transects at the Twin Lakes
Twin 4
Twin 3
Sandy Lake
SandLBrdg
Inflow_3
Twin 2
Little Sandy Lake
Inflow_2
SandL02
SL_S_Inflow
Twin 1
SandL01
Inflow_1
SandL04
N
100 0 100 200 300 400 500 m
mapping: IC@GLIFWC 2018-01-10
Legend
Samples Sites
USS_2016
1854 Treaty Authority
GLIFWC

Figure 1.

Specific Conductance Transects at the Twin Lakes

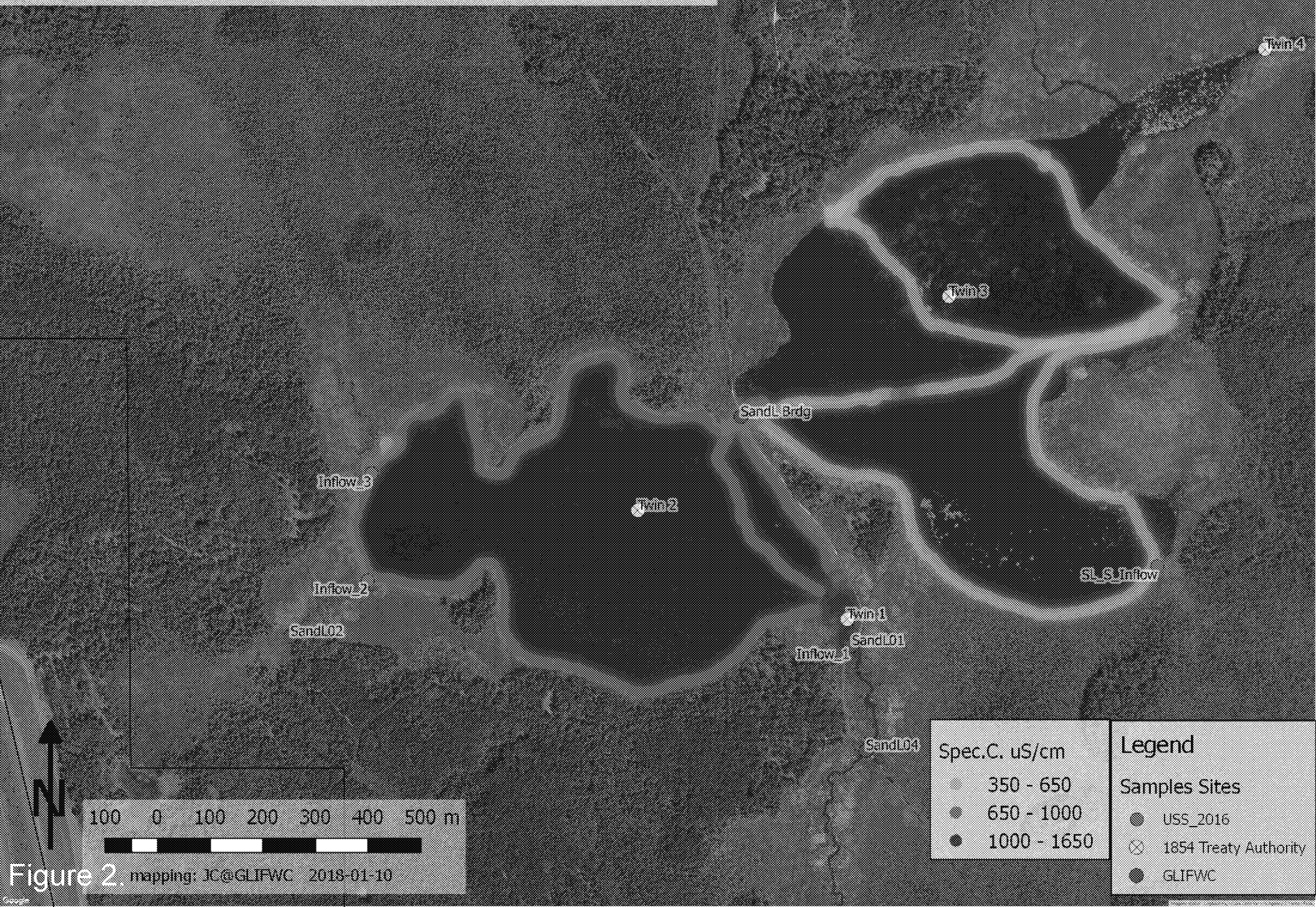

Figure 2.

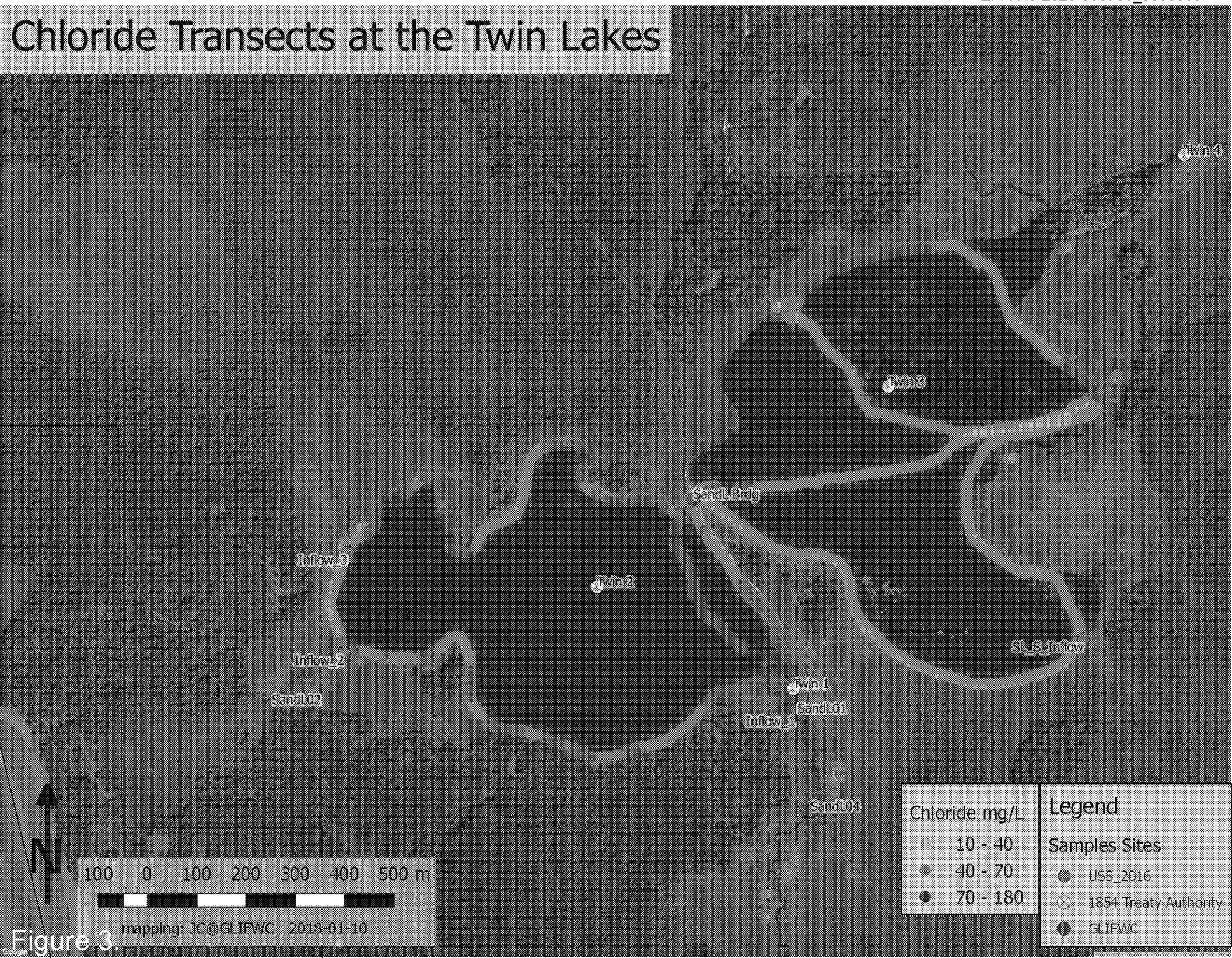
Chloride Transects at the Twin Lakes
Twin 4
Twin 3
SandL Brdg
Inflow_3
Twin 2
SL_S_Inflow
Inflow_2
Twin 1
SandL02
SandL01
Inflow_1
SandL04
N
100 0 100 200 300 400 500 m
mapping: IC@GLIFWC 2018-01-10
Chloride mg/L
10 - 40
40 - 70
70 - 180
Legend
Samples Sites
USS_2016
1854 Treaty Authority
GLIFWC

Figure 3.

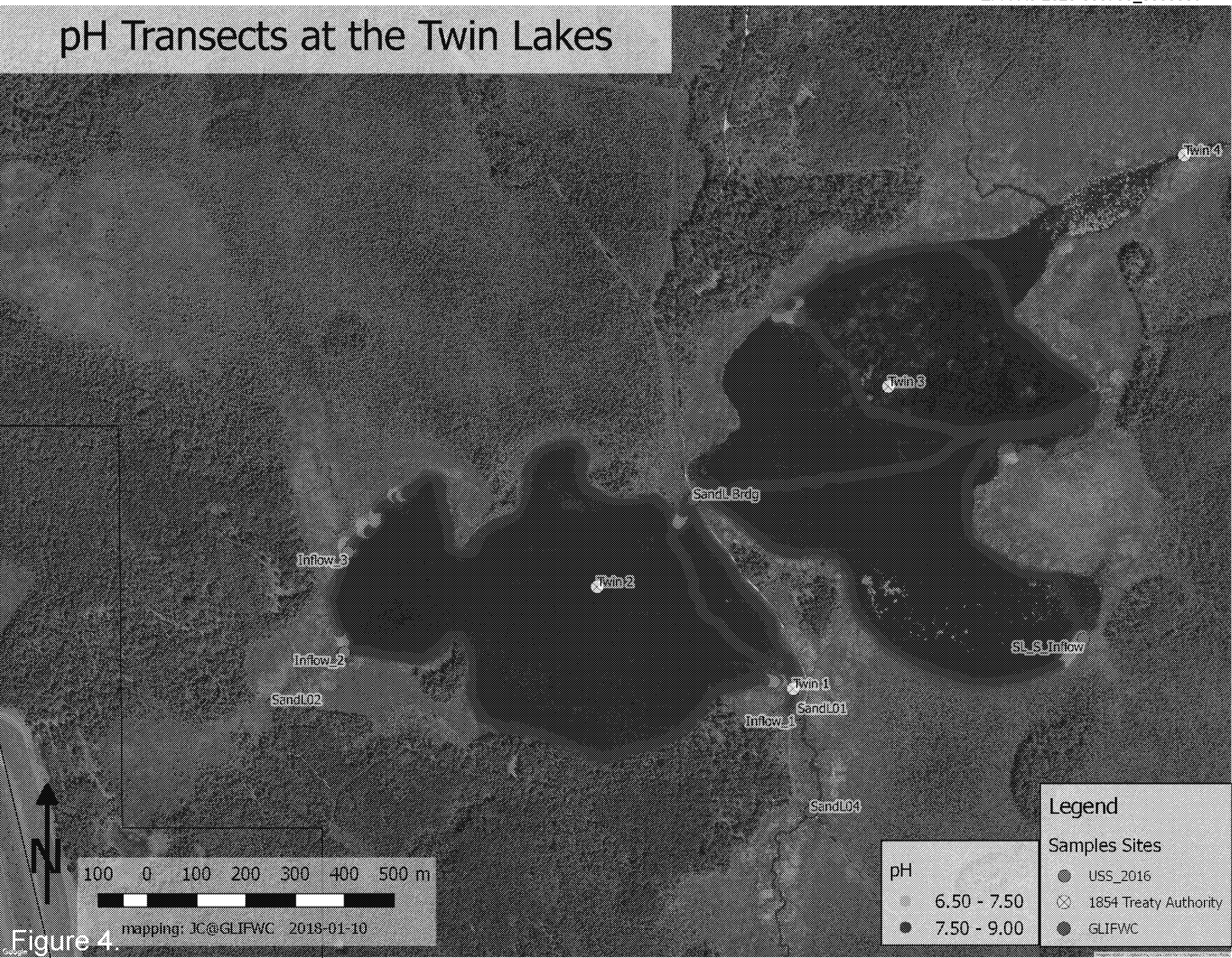
pH Transects at the Twin Lakes
Twin 4
Twin 3
SandL Brdg
Inflow_3
Twin 2
SL_S_Inflow
Inflow_2
Twin 1
SandL02
SandL01
Inflow_1
SandL04
N
100 0 100 200 300 400 500 m
mapping: IC@GLIFWC 2018-01-10
pH
6.50 - 7.50
7.50 - 9.00
Legend
Samples Sites
USS_2016
1854 Treaty Authority
GLIFWC

Figure 4.

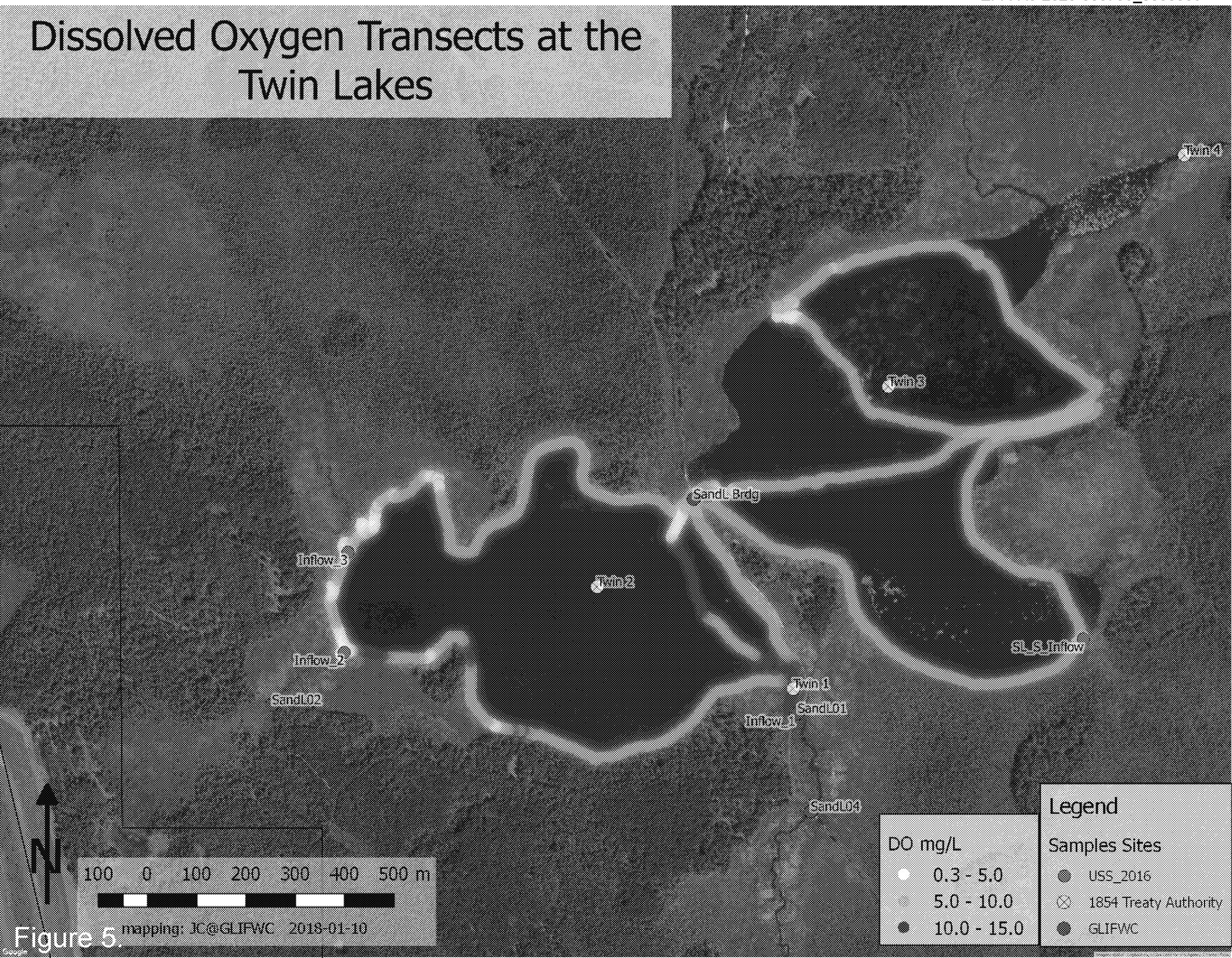
Dissolved Oxygen Transects at the Twin Lakes
Twin 4
Twin 3
SandL Brdg
Inflow_3
Twin 2
Inflow_2
SandL02
SL_S_Inflow
Twin 1
SandL01
Inflow_1
SandL04
N
100 0 100 200 300 400 500 m
mapping: IC@GLIFWC 2018-01-10
DO mg/L
0.3 - 5.0
5.0 - 10.0
10.0 - 15.0
Legend
Samples Sites
USS_2016
1854 Treaty Authority
GLIFWC

Figure 5.