



**U.S. Army Corps of Engineers
Omaha District**

Water Quality Sampling Report

Results of the 2017 Water Quality Monitoring of the Van Hook Arm of Lake Sakakawea in Response to Avian Mortality



September 2017

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1 BACKGROUND INFORMATION

1.1 Project Location

The Van Hook Arm of Lake Sakakawea extends approximately 12.5 miles NNW of the main channel of Lake Sakakawea near River Mile (RM) 1452. It has a surface area of roughly 61 square miles and is considerably shallower than the main channel area of Lake Sakakawea. The Van Hook Arm contains many small islands dispersed throughout its northern end which provide habitat for migratory and endemic bird species including terns, gulls, ducks, geese, pelicans, and cormorants. Due to oil production activity in western North Dakota significant population and industrial growth has occurred in the areas surrounding the Van Hook Arm. Considerable development has occurred in the vicinity of the city of New Town located 3 miles from the NW shore of the Van Hook Arm. Numerous hydraulic fracturing well pads have been constructed in the area, and many road improvement projects have been completed or are ongoing.

1.2 Project Description

Avian mortality events have occurred in the Van Hook Arm during the summers of 2016 and 2017. Both events were observed on Fox Island; however, it has been reported that events took place on other islands as well. The 2016 avian mortality event took an estimate of 700 birds and occurred during the mid-July to mid-August time frame. The 2017 avian mortality event has taken an estimate of 189 birds and occurred during the mid-May to late-June time frame. Two deceased bird specimens were collected by Garrison Project personnel on May 16, 2017 and sent to the USGS National Wildlife Health Center for necropsy analysis. Results of the analysis indicate that ingestion of toxic plants or heavy metals may be possible causes. Heavy metals analysis of the liver from one specimen indicated potentially toxic levels of zinc as well as elevated levels of cadmium, molybdenum, and manganese.



Figure 1. Location of the Van Hook Arm relative to Lake Sakakawea.

1.3 Water Quality Sampling

In order to better understand the potential water quality factors that may be involved in the observed avian mortality events the Garrison Project requested that the District Water Quality Team conduct reconnaissance water quality sampling. The developed Quality Control Plan (QCP) “2017 Water Quality Monitoring of the Van Hook Arm of Lake Sakakawea in Response to Avian Mortality” (USACE, 2017) identified sample collection to assess algal toxins and heavy metals concentrations at three of the islands in the Van Hook Arm of Lake Sakakawea where avian mortality events have occurred (Figure 2). The two objectives identified for the monitoring were:

- 1) Document concentrations of heavy metals present in the identified locations of the Van Hook Arm of Lake Sakakawea at the time of sampling.
- 2) Document concentrations of algal toxins and the dominant algal genera present in the identified locations of the Van Hook Arm of Lake Sakakawea at the time of sampling.



Figure 2. Location of Fox Island, Lonetree Island, and Gull Island and their respective sediment sample locations.

2 SAMPLING AND ANALYSIS METHODS

Water and sediment/soil samples representative of the areas where avian mortality has been observed were collected and analyzed. The results were used to assess the potential that water quality conditions may play a role in the observed avian mortality events.

2.1 Quality Control Plan

A QCP was developed in consultation with Garrison Project personnel and is included as Attachment 1. The parameters that were measured in the field and analyzed in the laboratory for the collected water and sediment/soil samples are listed in Table 1. Analytical methods are provided in the QCP (Attachment 1).

Table 1. Parameters measured and analyzed for the different media assessed as part of the water and sediment/soil sampling

Parameter	Soil/Sediment Samples	Water Samples
FIELD MEASUREMENTS		
Water Temperature (°C)		X
Dissolved Oxygen (mg/L and % Sat)		X
pH (S.U.)		X
Specific Conductance (µS/cm)		X
Turbidity		X
Algal Samples		
Phytoplankton (Taxa ID, Biovolume, Density)		X
Microcystin, Total (Immunoassay)		X
Cylindrospermopsin, Total (Test Strip)		X
METALS (Dissolved)		
Dissolved Metals Scan		X
METALS (Total)		
Total Metals Scan	X	X

2.2 Collection of Sediment/Soil Samples

Sediment/soil samples were collected at four sites at each of the three identified islands (Fox, Lonetree, and Gull Islands) on 9-August-2017 (Figure 2). The four locations on each island where the sediment/soil samples were collected are shown in Figure 2 and described in Tables 2 and 3. The sediment samples at each site were collected with a 2 in. diameter stainless steel sediment core sampler. Core samples were collected to a depth of 1 foot at each location and then all four samples from each individual island were composited. A 500 mL volume of the composited sediment/soil material was then collected and transported to the laboratory for analysis. Total metals analysis was then performed on each of the three composited 500 mL sediment/soil samples.

Table 2. Sediment/soil samples collected at the three Van Hook Arm islands for metals analysis.

Sample Type	Sample ID	Sample Date	Sampled Depth	Sampling Method
Sediment/Soil	FX1	09-August-2013	0 – 1 feet	Core
Sediment/Soil	FX2	09-August-2013	0 – 1 feet	Core
Sediment/Soil	FX3	09-August-2013	0 – 1 feet	Core
Sediment/Soil	FX4	09-August-2013	0 – 1 feet	Core
Sediment/Soil	GL1	09-August-2013	0 – 1 feet	Core
Sediment/Soil	GL2	09-August-2013	0 – 1 feet	Core
Sediment/Soil	GL3	09-August-2013	0 – 1 feet	Core
Sediment/Soil	GL4	09-August-2013	0 – 1 feet	Core
Sediment/Soil	LT1	09-August-2013	0 – 1 feet	Core
Sediment/Soil	LT2	09-August-2013	0 – 1 feet	Core
Sediment/Soil	LT3	09-August-2013	0 – 1 feet	Core
Sediment/Soil	LT4	09-August-2013	0 – 1 feet	Core

Table 3. GPS locations where sediment/soil samples were collected at the Van Hook Arm islands.

Site	Latitude	Longitude
FX1	47° 54' 16.1"	102° 23' 01.0"
FX2	47° 54' 12.0"	102° 23' 00.0"
FX3	47° 54' 11.9"	102° 23' 02.4"
FX4	47° 54' 08.9"	102° 22' 58.8"
GL1	47° 55' 49.8"	102° 21' 50.1"
GL2	47° 55' 43.8"	102° 21' 54.3"
GL3	47° 55' 48.3"	102° 21' 53.4"
GL4	47° 55' 45.5"	102° 21' 40.5"
LT1	47° 53' 55.1"	102° 23' 45.1"
LT2	47° 53' 54.7"	102° 23' 47.7"
LT3	47° 53' 55.2"	102° 23' 51.1"
LT4	47° 53' 56.5"	102° 23' 49.3"

Note: GPS device used for determining locations was Garmin Map 76.

2.3 Collection of Water Samples and Field Measurements

Surface water grab samples were collected near the shoreline at each of the three islands on 9-August-2017. Surface grab samples were collected at a depth of 0.1 m by placing individual sample containers below the surface, allowing them to fill, and administering the appropriate preservative following sample collection. Following collection all water samples were placed in iced coolers and transported to the laboratory for analysis. Field measurements were taken as noted in Table 1 and collected by lowering a Hydrolab Series 5 Datasonde 0.1 m below the surface and recording the measurements.

3 RESULTS

3.1 Sediment Sample Results

Sediment sample results for the three different islands are shown in Table 4. The values reported are similar to those reported in previous studies (USACE, 2012). The metals found in the highest concentrations were Calcium, Magnesium, Iron, and Aluminum. Concentrations of silver were below the detection limit for all samples. Analytical laboratory reports are also provided in Attachment 2.

Table 4. Laboratory results for sediment samples collected at the Van Hook Arm Islands.

Sediment Monitoring Results				
Parameter	Detection Limit	Sample Location		
		Lonetree Island	Gull Island	Fox Island
Aluminum, Total (mg/kg)	1.3	5469	1620	1967
Antimony, Total (mg/kg)	0.005	0.05	0.02	0.02
Arsenic, Total (mg/kg)	0.003	4.3	2.4	4.5
Barium, Total (mg/kg)	0.07	125.3	33.8	26.9
Beryllium, Total (mg/kg)	0.07	0.2	0.08	<0.05
Cadmium, Total (mg/kg)	0.001	0.19	0.07	0.11
Calcium, Total (mg/kg)	8.2	41460	33180	51100
Chromium, Total (mg/kg)	0.5	10.9	5.2	5.4
Copper, Total (mg/kg)	0.2	6.2	1.7	1.7
Iron, Total (mg/kg)	2.1	10870	5302	5414
Lead, Total (mg/kg)	0.005	3.2	1.6	2
Magnesium, Total (mg/kg)	2	12330	10140	18870
Manganese, Total (mg/kg)	0.2	619	299.4	247.6
Mercury, Total (mg/kg)	0.0007	0.01	0.006	0.002
Nickel, Total (mg/kg)	0.3	12.1	5.7	5.6
Selenium, Total (mg/kg)	0.01	1.5	0.6	0.5
Silver, Total (mg/kg)	0.2	<0.2	<0.2	<0.2
Sodium, Total (mg/L)	1.4	165.5	69.9	84.9
Thallium, Total (mg/kg)	0.0007	0.09	0.04	0.03
Zinc, Total (mg/kg)	0.8	37.3	13.8	12.7

< = Not detected. Lower than Detection Limit

3.2 Field Measurements and Water Sample Results

Field Measurements and water sample results are shown in Table 5 along with North Dakota state water quality standards. Results were similar to those seen in sediment samples with Calcium, Magnesium, and Sodium occurring in the highest concentrations.

Table 5. Field measurement and laboratory results for water samples collected at the Van Hook Arm Islands.

Parameter	Detection Limit	Monitoring Results					
		Sample Location			Water Quality Standards Attainment		
		Lonetree Island	Gull Island	Fox Island	ND WQS Criteria(C)	No. of WQS Exceedances	Percent WQS Exceedance
Water Temperature (°C)	0.1	21.6	22.2	21.4	29.4(1,2)	0	0%
Dissolved Oxygen (mg/L)	0.1	8.4	9.4	8.5	5(1,3)	0	0%
Dissolved Oxygen (% Sat.)	0.1	98.8	111.4	99.5	-----	-----	-----
pH (S.U.)	0.1	8.3	8.5	8.3	7.0(1,3), 9.0(1,2)	0	0%
Specific Conductance (uS/cm)	1	632	632	633	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	319	324	336	-----	-----	-----
Turbidity (NTU)	1	9.8	4.2	5.7	-----	-----	-----
Aluminum, Dissolved (ug/L)	40	<40	<40	<40	-----	-----	-----
Aluminum, Total (ug/L)	40	370	100	170	750(6)	0	0%
Antimony, Dissolved (ug/L)	0.03	0.7	0.5	0.6	-----	-----	-----
Antimony, Total (ug/L)	0.03	0.5	0.4	0.4	5.6(8)	0	0%
Arsenic, Dissolved (ug/L)	0.008	0.8	0.8	0.3	-----	-----	-----
Arsenic, Total (ug/L)	0.008	0.9	0.7	0.7	340(1), 150(2), 10(3)	0, 0, 0	0%, 0%, 0%
Barium, Dissolved (ug/L)	1	47	48	46	-----	-----	-----
Barium, Total (ug/L)	1	54	48	53	1,000(8)	0	0%
Beryllium, Dissolved (ug/L)	1	<1	<1	<1	-----	-----	-----
Beryllium, Total (ug/L)	1	<1	<1	<1	4(8)	0	0%
Cadmium, Dissolved (ug/L)	0.007	<0.007	0.1	<0.007	-----	-----	-----
Cadmium, Total (ug/L)	0.007	0.03	0.01	0.9	10(6), 4(7), 5(8)	0, 0, 0	0%, 0%, 0%
Calcium, Dissolved (mg/L)	0.05	51.63	50.34	49.83	-----	-----	-----
Calcium, Total (mg/L)	0.05	51.93	50.86	51.09	-----	-----	-----
Chromium, Dissolved (ug/L)	4	<4	<4	<4	-----	-----	-----
Chromium, Total (ug/L)	4	<4	<4	<4	3220(6), 154(7), 100(8)	0, 0, 0	0%, 0%, 0%
Copper, Dissolved (ug/L)	6	<6	<6	<6	-----	-----	-----
Copper, Total (ug/L)	6	<6	<6	<6	27(6), 17(7), 1,000(8)	0, 0, 0	0%, 0%, 0%
Hardness, Dissolved (mg/L)	0.5	207.0	202.6	201.1	-----	-----	-----
Hardness, Total (mg/L)	0.5	208.8	205.2	206.5	-----	-----	-----
Iron, Dissolved (ug/L)	10	<10	<10	<10	-----	-----	-----
Iron, Total (ug/L)	10	380	100	200	-----	-----	-----
Lead, Dissolved (ug/L)	0.008	<0.008	<0.008	<0.008	-----	-----	-----
Lead, Total (ug/L)	0.008	0.3	<0.008	0.3	201(6), 8(7), 15(8)	0, 0, 0	0%, 0%, 0%
Magnesium, Diss. (mg/L)	0.05	18.95	18.68	18.63	-----	-----	-----
Magnesium, Total (mg/L)	0.05	19.22	18.99	19.16	-----	-----	-----
Manganese, Dissolved (ug/L)	3	<3	10	<3	-----	-----	-----
Manganese, Total (ug/L)	3	30	10	40	-----	-----	-----
Mercury, Dissolved (ug/L)	0.002	<0.002	<0.002	<0.002	-----	-----	-----
Mercury, Total (ug/L)	0.002	<0.002	<0.002	<0.002	1.7(6), 0.012(7), 0.05(8)	0, 0, 0	0%, 0%, 0%
Nickel, Dissolved (ug/L)	8	<8	<8	<8	-----	-----	-----
Nickel, Total (ug/L)	8	<8	<8	<8	854(6), 95(7), 100(8)	0, 0, 0	0%, 0%, 0%
Selenium, Dissolved (ug/L)	0.00006	0.002	0.002	0.001	-----	-----	-----
Selenium, Total (ug/L)	0.00006	0.001	0.001	0.001	20(6), 5(7), 50(8)	0, 0, 0	0%, 0%, 0%
Silver, Dissolved (ug/L)	0.005	6	0.4	0.7	-----	-----	-----
Silver, Total (ug/L)	0.005	7	0.7	4.3	14(6)	0	0%
Sodium, Dissolved (mg/L)	0.01	59.68	57.32	57.03	-----	-----	-----

Table 5. (Continued)

Parameter	Monitoring Results						
	Detection Limit	Sample Location			Water Quality Standards Attainment		
		Lonetree Island	Gull Island	Fox Island	ND WQS Criteria(C)	No. of WQS Exceedances	Percent WQS Exceedance
Sodium, Total (mg/L)	0.01	58.3	57.27	57.85	-----	-----	-----
Thallium, Dissolved (ug/L)	0.003	0.02	0.006	0.007	-----	-----	-----
Thallium, Total (ug/L)	0.003	0.03	0.02	0.009	0.24(7)	0	0%
Zinc, Dissolved (ug/L)	6	<6	<6	<6	-----	-----	-----
Zinc, Total (ug/L)	6	9	9	10	218(6,7), 7,400(8)	0, 0	0%, 0%
Microcystin (ug/L)	0.1	<0.1	<0.1	<0.1	-----	-----	-----
Cylindrospermopsin (ug/l)	0.1	<0.1	<0.1	<0.1	-----	-----	-----

<. = Not detected, less than detection limit

(A) Detection limits given for the parameters Water Temperature, Dissolved Oxygen (mg/L and % Sat.), pH, Specific Conductance, and Oxidation-Reduction Potential are resolution limits for field measured parameters.

(B) Criteria given for reference – actual criteria should be verified in appropriate State water quality standards.

(1) Criteria for Class 1 streams.

(2) Daily maximum criterion (monitoring results directly comparable to criterion).

(3) Daily minimum criterion (monitoring results directly comparable to criterion).

(4) Total ammonia criteria pH and temperature dependent. Criteria listed are for the median pH and temperature conditions.

(5) 30-day average criterion (monitoring results not directly comparable to criterion).

(6) Acute criterion for aquatic life.

(7) Chronic criterion for aquatic life.

(8) Human health criterion for surface waters.

Note: Some of North Dakota's criteria for metals (i.e. cadmium, chromium, copper, lead, nickel, silver, and zinc) are based on hardness. Criteria shown for those metals were calculated using the hardness value.

3.3 Phytoplankton and Algal Toxin Sample Results

The phytoplankton species and biovolume sample results have not yet been reported; however, field observation during sample collection did not indicate the presence of any significant algal blooms or thick algal matting in the Van Hook Arm. All samples for algal toxins (Microcystin and Cylindrospermopsin) were reported as not detected or less than the laboratory detection limit. One additional sample for algal toxins was collected at Gull Island in an isolated pond which had been perched near the shore as water receded. The results for this sample were also below the laboratory detection limit.

4 DISCUSSION

4.1 Sampled Sediment Metal Levels

The values reported for sediment metals concentrations appear to be typical of sediments found in Lake Sakakawea due to the similarity with those reported in previous studies examining sediment near the spillway intake channel (USACE, 2012). The fact that avian mortality events occur on the islands in the Van Hook Arm and not near the spillway intake channel indicate that sediment metals concentrations are not likely to play a role in the observed avian mortality events.

4.2 Sampled Water Metal Levels and Comparison to North Dakota Water Quality Standards

All sampled concentrations of heavy metals (mercury, cadmium, arsenic, chromium, thallium, and lead) were below North Dakota state water quality standards, and in many cases below laboratory detection limits. Dissolved metals are commonly used to assess the potential for adverse impacts to biota

due to their availability for potential uptake and bioaccumulation. Total metals are often bound to the sediment and appear in higher concentrations due to the amount of sediment present in the sample. Table 5 shows that both the dissolved and total fractions of heavy metals do not appear problematic regarding the avian mortality events.

4.3 Phytoplankton and Algal Toxin Concentrations

Field observation did not indicate that algal toxins in the water column were likely a concern regards to avian mortality at the time of sample collection. This was reinforced by the absence of detectable concentrations of algal toxins in the water samples collected at each of the islands.

5 CONCLUSIONS

The sampled levels of metals in the sediment and water to not appear problematic regarding the observed avian mortality events in the Van Hook Arm of Lake Sakakawea. Sampled levels of algal toxins also do not appear problematic regarding the observed avian mortality.

Based on observations during sample collection the avian mortality events in the Van Hook Arm of Lake Sakakawea could be attributed to avian botulism. A cursory review of the life cycle of *Clostridium botulinum*, the bacteria that produces botulinum toxin, indicates that all the conditions required for the proliferation of avian botulism were seemingly present and observable at the time the current sediment and water sampling occurred. The symptoms exhibited by effected bird species that were observed at the time of the current sample collection were consistent with those reported for avian botulism outbreaks at other locations.

6 REFERENCES

U.S. Army Corps of Engineers. 2012. Results of Sediment Sampling and Elutriate Testing at the Garrison Spillway Approach Channel, July 2012. Water Quality Team, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers.