APPENDIX E.9.2

2018 LAKE SEDIMENTATION MONITORING REPORT

Mary River Project 2017 - 2018
Lake Sedimentation Monitoring Report

Prepared for:
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March 2019

Mary River Project 2017 - 2018
Lake Sedimentation Monitoring
Report

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Project Manager

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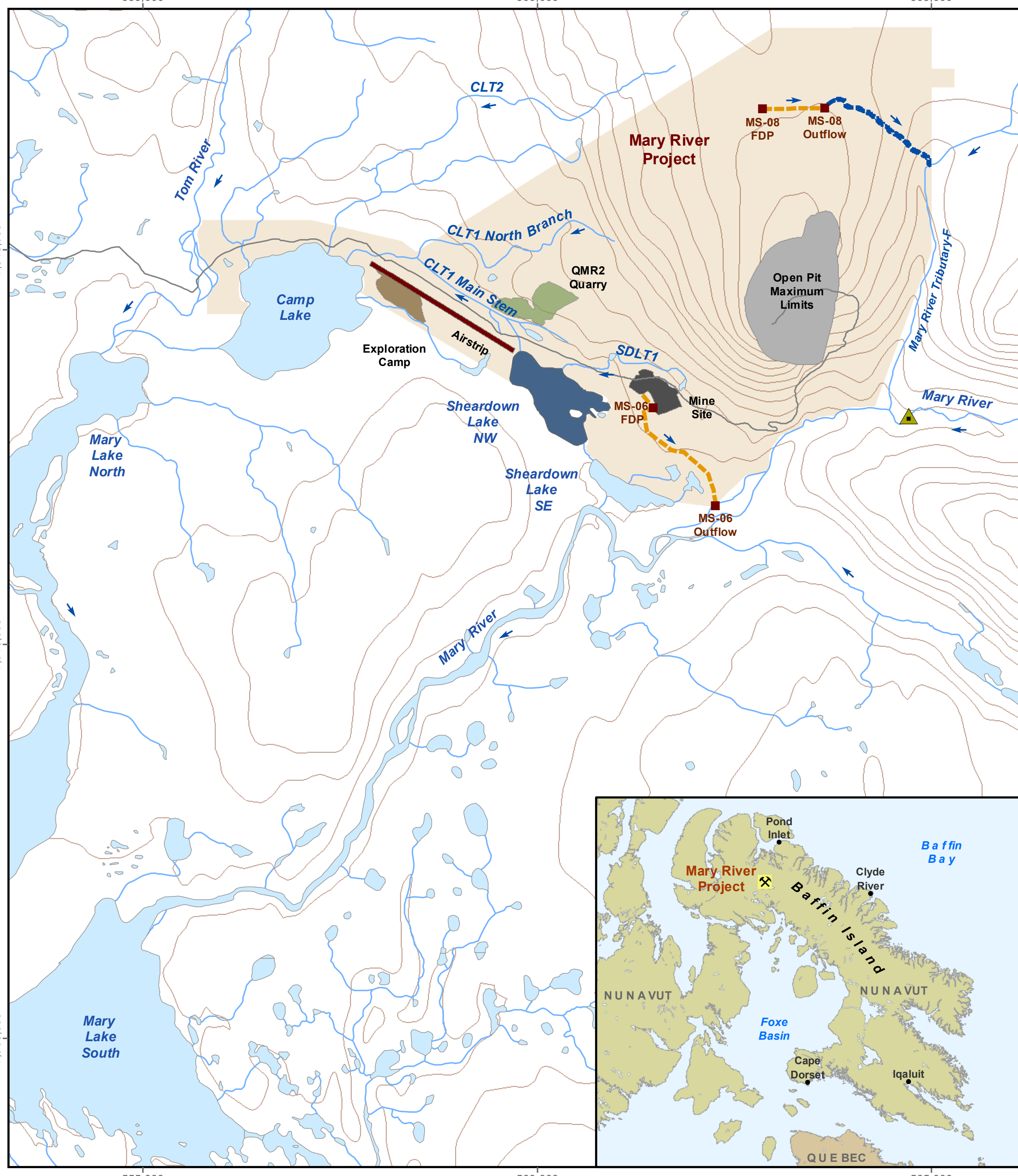
1 INTRODUCTION

The Mary River Project, owned and operated by Baffinland Iron Mines Corporation (Baffinland), is a high-grade iron ore mining operation located in the Qikiqtani Region of northern Baffin Island, Nunavut (Figure 1.1). Commercial mine operation, including open pit mining, ore haulage and stockpiling, and the crushing and screening of high-grade iron ore, commenced at the Mary River Project in mid-September 2014. The Mary River Project has the potential to result in increased sediment deposition in mine area waterbodies through fugitive dust deposition and surface runoff/ erosion from the mine site, as well as through increased biological productivity (e.g., eutrophication due to treated sewage discharge). In aquatic environments, these deposits may lead to physical habitat alteration (e.g., changes in substrate composition) and/or chemical alteration (e.g., changes in metal and/or nutrient concentrations, organic content) that, in turn, could alter biotic assemblages and lead to adverse ecological effects (e.g., physical smothering of organisms residing in existing substrate, direct response of organisms to changes in substrate chemistry).

To better understand rates of sediment deposition associated with the Mary River Project operation and the potential implications of this sediment deposition on aquatic biota, Lake Sedimentation Monitoring was included as a special investigation component of the mine Aquatic Effects Monitoring Plan (AEMP; Baffinland 2015; NSC 2014a). The primary issue of concern regarding greater sedimentation in lakes related to the Mary River Project operation is the potential effects to arctic charr (*Salvelinus alpinus*) populations, which can possibly be affected by:

- Changes in benthic invertebrate community structure and/or density due to habitat alteration that, in turn, alter the arctic charr food base;
- Loss of arctic charr spawning habitat resulting from accumulation of fine material on, and/or greater embeddedness of, substrate used by arctic charr for spawning; and,
- Accumulation of fine material on substrate used by arctic charr for spawning that, in turn, limits the amount of oxygen available in arctic charr spawning beds during the overwinter incubation period and results in reduced egg hatching success and/or reduced larvae survival following hatch (Berry et al. 2003).

The Mary River Project Lake Sedimentation Monitoring study is a year-round sampling program that was designed to track sedimentation rate (i.e., total dry weight of deposited sediment) at Sheardown Lake NW separately over ice-cover and open-water periods (Baffinland 2015; NSC 2014a,b, 2015; Minnow 2016, 2017, 2018). Sheardown Lake NW is expected to receive the highest amounts of sediment inputs through dust deposits and site runoff compared to other local



LEGEND

- Final Discharge Point (FDP)
- Mary River Cascade Barrier
- Discharge Line
- Overland Effluent Channel
- Sheardown Lake NW
- QMR2 Quarry
- Airstrip
- Exploration Camp
- Mine Site
- Mary River Project
- Open Pit Maximum Limits

Mary River Project Sheardown Lake NW Sedimentation Monitoring Location

0 1.25 2.5 5 km

Map Projection: UTM Zone 17N NAD 1983
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Figure 1.1

Document Path: S:\Projects\187202\187202.0025 - Baffinland 2018 AEMP\4 - GIS\Lake Sedimentation Study\18-25 Fig 1.1 Location.mxd waterbodies, and therefore this lake serves as the focus for the monitoring of lake sedimentation (Figure 1.1; NSC 2014b). Sedimentation monitoring was initiated at Sheardown Lake NW in 2013, with data collected from fall 2013 to fall 2014 serving as baseline for one full ice-cover period and one full open-water period. These baseline data, in turn, were intended to be used as a basis for the annual evaluation of potential effects of commercial Mary River Project operations on lake sedimentation (Minnow 2016, 2017, 2018). This report presents the results of the 2017-2018 Lake Sedimentation Monitoring study, including the evaluation of potential Mary River Project-related influences on sedimentation at Sheardown Lake NW in the fourth year following the onset of commercial mine operation in 2014.

Notably, additional sediment traps were installed at Sheardown Lake NW to collect dry bulk density information for recently deposited material in 2018. This sediment dry bulk density information, together with sedimentation rate data from 2017-2018 and from previous studies, were used as the basis for back-calculating the amount of sediment accumulation (i.e., thickness) for data collected as far back as the initial sedimentation monitoring in 2013-2014. The derivation of sediment accumulation estimates for Sheardown Lake NW using site-specific dry bulk density information has greater validity than the methods used to calculate sediment accumulation estimates in past studies. For this reason, the sediment accumulation estimates provided in this report supersede all estimates presented previously (i.e., in Minnow 2016, 2017, and 2018).

2 METHODS

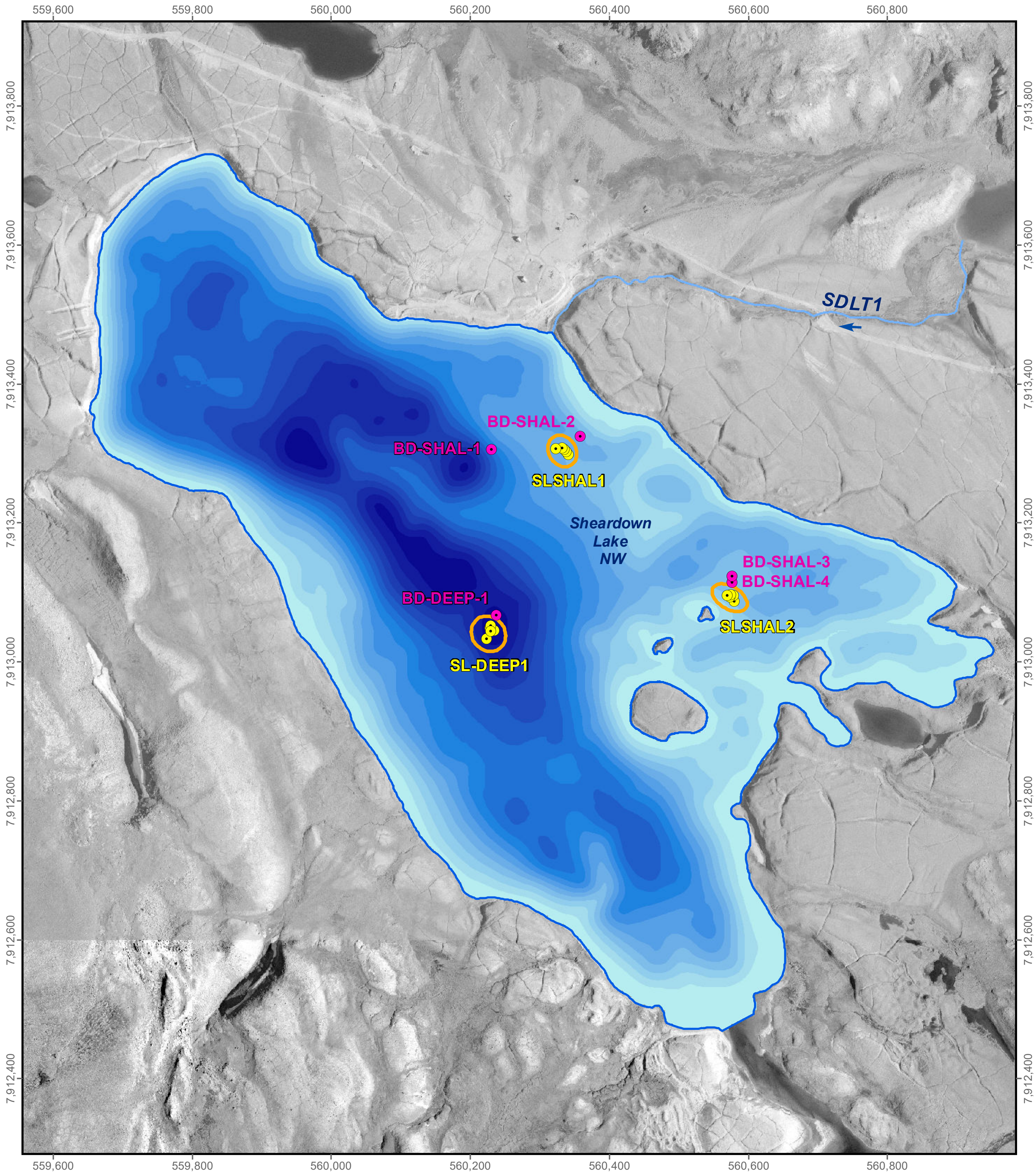
2.1 Design Improvements for the 2017 – 2018 Study

Sedimentation monitoring has consistently been conducted at Sheardown Lake NW using the same monitoring station locations, sampling gear, and approach since 2013 (Baffinland 2015; NSC 2014a,b, 2015; Minnow 2016, 2017, 2018). Although the approach applied over this duration has been successful for tracking changes in sedimentation rate ($mg/cm^{-2} \cdot day^{-1}$), sample volumes have consistently been insufficient to allow estimation and tracking of changes in sediment accumulation (i.e., deposit thickness). *In lieu* of sufficient sample volumes to determine sedimentation accumulation, dry bulk density (DBD) data[1] from similar sedimentation studies conducted at Canadian Shield lakes in northern Ontario (Minnow Environmental Inc. unpublished data) and from a tributary to Sheardown Lake (referred to as SDLT1) were used to estimate the amount of sediment accumulation at Sheardown Lake NW in previous studies (Minnow 2016, 2017, 2018). As a result of higher biological productivity, the calculation of annual accumulation thickness using the Canadian Shield lake dry bulk density information was recognized as an overestimate actual accumulation thickness for sediment deposits at Sheardown Lake NW (Minnow 2016). In 2017, the dry bulk density of fine material collected instream and/or along the shoreline at SDLT1 as part of the mine's annual Core Receiving Environment Monitoring Program was used to calculate an estimate of sediment accumulation. However, because the properties of sediment deposited in high-energy stream environments are likely to differ from that of sediment deposited in comparatively low-energy lake environments, estimates of the amount of sediment accumulation in Sheardown Lake NW also remained uncertain using the SDLT1 dry bulk density data. In order to obtain a more reliable, improved, estimate of sediment accumulation at Sheardown Lake NW, the design of the 2017 – 2018 study shifted to include the direct collection of sedimentation dry bulk density data from Sheardown Lake NW.

2.2 Station Locations

Three sedimentation monitoring stations that were established during the initial study and used consistently from 2014 to 2017 were again used to evaluate sedimentation rate and accumulation at Sheardown Lake NW in 2017-2018 (Figure 2.1; Table 2.1). The initial selection of station locations in 2013 took into account dominant benthic habitat types present in the lake as well as habitat considered important for supporting the resident arctic charr population. These considerations resulted in the establishment of Shallow Depositional, Shallow Hard-Bottom, and

[1] Sediment dry bulk density information, together with sedimentation rate data, is required in order to estimate the amount of sediment accumulation (i.e., uncompacted sediment thickness) over time.



LEGEND

- Dry Bulk Density Replicate Site
- Sedimentation Rate Replicate Site
- Sedimentation Monitoring Station

Bathymetry (m)

0- 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
18 - 20
20 - 22
22 - 24
24 - 26
26 - 28
28 - 30

Sheardown Lake NW Lake Sedimentation Monitoring Locations, 2017-2018

0 125 250 500 Meters

N W E S

Map Projection: UTM Zone 17N NAD 1983
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Figure 2.1

Document Path: S:\Projects\187202\187202.0025 - Baffinland 2018 AEMP\4 - GIS\Lake Sedimentation Study\18-25 Fig 2.1 Sheardown Lake Bathymetry.mxd

Table 2.1: Sediment Trap Replicate Station Coordinates, Habitat Information and Deployment and Retrieval Information, Sheardown Lake NW Sedimentation Monitoring Study, 2017 - 2018

Station	Station Replicate	Location (UTM; Zone 17W)		Station Depth (m)	Substrate	Ice - Cover Period (2017 - 2018)			Open-Water Period (2018)		
		Easting	Northing			Date Deployed	Date Retrieved	Set Duration (days)	Date Deployed	Date Retrieved	Set Duration (days)
Shallow 1 (SL SHAL1)	SL-SHAL-1A	560341	7913299	10.2	silt	14-Sep-17	17-Jul-18	306	17-Jul-18	20-Sep-18	65
	SL-SHAL-1B	560338	7913303	10.0	silt	14-Sep-17	nr	-	-	-	-
	SL-SHAL-1C	560335	7913306	9.6	silt	14-Sep-17	nr	-	-	-	-
	SL-SHAL-1D	560332	7913308	10.6	silt	14-Sep-17	nr	-	-	-	-
	SL-SHAL-1E	560323	7913307	10.3	silt	14-Sep-17	nr	-	-	-	-
Shallow 2 (SL SHAL2)	SL-SHAL-2A	560579	7913088	6.8	cobble	14-Sep-17	16-Jul-18	305	16-Jul-18	20-Sep-18	66
	SL-SHAL-2B	560578	7913096	6.7	cobble	14-Sep-17	16-Jul-18	305	16-Jul-18	20-Sep-18	66
	SL-SHAL-2C	560573	7913094	6.5	cobble	14-Sep-17	17-Jul-18	306	17-Jul-18	20-Sep-18	65
	SL-SHAL-2D	560574	7913097	6.9	cobble	14-Sep-17	nr	-	-	-	-
	SL-SHAL-2E	560569	7913096	6.9	cobble	14-Sep-17	nr	-	-	-	-
Deep 1 (SL DEEP1)	SL-DEEP-1A	560234	7913045	30.0	silt	15-Sep-17	16-Jul-18	304	6-Aug-18	20-Sep-18	45
	SL-DEEP-1B	560228	7913049	28.9	silt	15-Sep-17	16-Jul-18	304	16-Jul-18	20-Sep-18	66
	SL-DEEP-1C	560223	7913033	27.0	silt	15-Sep-17	16-Jul-18	304	16-Jul-18	20-Sep-18	66
	SL-DEEP-1D	560229	7913052	28.3	silt	15-Sep-17	nr	-	-	-	-
	SL-DEEP-1E	560229	7913044	28.9	silt	15-Sep-17	17-Jul-18	305	17-Jul-18	20-Sep-18	65
Dry Bulk Density	BD-SHAL-1	560230	7913306	nc	silt	na	na	-	1-Aug-18	20-Sep-18	50
	BD-SHAL-2	560358	7913325	nc	silt	na	na	-	1-Aug-18	20-Sep-18	50
	BD-SHAL-3	560576	7913115	nc	silt	na	na	-	1-Aug-18	20-Sep-18	50
	BD-SHAL-4	560576	7913124	nc	silt	na	na	-	14-Aug-18	20-Sep-18	37
	BD-DEEP-1	560237	7913068	nc	silt	na	na	-	1-Aug-18	20-Sep-18	50

"na" indicates not applicable (no sediment traps deployed); "nc" indicates data not collected; "nr" indicates sediment trap not retreived

Deep Profundal stations for Sheardown Lake NW sedimentation monitoring based on the following rationale:

1. Shallow Depositional Station (SHAL1): Silt-loam represents the dominant substrate type in Sheardown Lake NW, and therefore increased sedimentation on habitat characterized by this substrate has the greatest potential to affect overall lake benthic invertebrate density and/or community structure. In turn, benthic invertebrate community changes in habitat of this type has a high potential to affect the arctic charr population of Sheardown Lake. Silt substrate in the lake littoral zone was targeted for placement of this station to represent a potentially high sediment deposition habitat. Because this station is located near the outlet from SDLT1, information acquired from this station also serves to evaluate the extent to which sediment releases from key lake tributaries affect sedimentation at Sheardown Lake NW.

2. Shallow Hard-Bottom Station (SHAL2): Increased sedimentation at hard-bottom areas could reduce the amount of habitat available to arctic charr for spawning and/or reduce arctic char within-year egg hatch/reproductive success. Therefore, this station was established on coarse substrate (i.e., gravel, cobble) in the lake littoral zone at an area considered to provide suitable spawning habitat for arctic charr.

3. Deep Profundal Station (DEEP1): Because the deep profundal area is the ultimate depositional zone within lakes, the highest sediment deposition rate can be expected to occur at the deepest point within the main basin of a lake. This station was established on silt substrate within the profundal zone of the main lake basin (30 m deep) to provide an estimate of 'maximum' sedimentation for Sheardown Lake NW.

2.3 Field and Laboratory Methods

2.3.1 Sedimentation Rate

Lake sedimentation rate was monitored at Sheardown Lake NW in 2017 – 2018 using sediment traps constructed of the same materials and dimensions as those employed since the initial study in 2013. Each sediment trap was constructed of three 50 cm long, 5 cm inside diameter polyvinyl chloride (PVC) pipes (i.e., 58.9 cm^2 surface area) sealed at the bottom and clamped together to create a single trap 'unit'. The sediment trap was designed to provide an aspect ratio of approximately 10:1, which meets the ≥ 5:1 aspect ratio generally recommended for cylindrical sediment traps to effectively monitor sediment deposition (Mudroch and MacKnight 1994). Each sediment trap unit was secured to a float-anchor system designed to maintain the trap in an upright position on the lake bottom for the duration of each deployment period. Under this system, the mouth of the sediment trap unit was situated approximately 1.5 m above the substrate.

Sedimentation was assessed separately for applicable ice-cover and open-water periods at Sheardown Lake NW. The seasonal timing of the ice breakup and freeze-up period at Sheardown Lake NW generally corresponds to mid-July and mid-September, respectively. For the 2017 – 2018 ice-cover period, five sediment traps were deployed at each Sheardown Lake NW station on the 14th or 15th of September 2017 (Table 2.1). Sediment traps deployed over the ice-cover period were individually fitted with a marker buoy and lowered to the bottom such that the marker buoy was submerged approximately 2 - 3 m below the water surface to attempt to avoid entrapment of the buoy by ice during winter. Supporting information collected at the time of deployment of each sediment trap included Global Positioning System (GPS) coordinates and water depth. Sediment traps for the 2017-2018 ice-cover period were retrieved on the 16th or 17th of July 2018 (304 - 305 day duration; Table 2.1). Because marker buoys were submerged, a grappling tool was required to secure the marker buoy and retrieve the sediment trap at the time of collection. Despite considerable effort to locate sediment traps during and subsequent to these dates, of the five sediment traps deployed at each station in September 2017, only 1, 3, and 4 sediment traps were able to be located at SL-SHAL-1, SL-SHAL-2, and SL-DEEP-1, respectively, in July 2018 (Table 2.1). The inability to locate sediment traps at the end of the ice-cover period was potentially the result of entrapment of the marker buoy by ice and subsequent relocation of the sediment trap. Because no materials were available for the construction of additional sediment traps, a full complement of sediment traps (i.e., 5) was not able to be deployed at each station for the open-water period (Table 2.1). Open-water period sediment traps were deployed as sediment traps became available in July 2018, but were all retrieved on the 20th of September 2018 (generally 65 - 66 day duration; Table 2.1).[2] For the open-water period, traps were lowered to the lake floor on individual lines fitted with a surface marker buoy so that they could be seen from the lake surface.

Sediment trap retrieval involved pulling the entire unit to the surface very slowly to prevent sediment re-suspension in, and/or sediment loss from, each sediment trap. The entire contents of the trap, including all water and deposited sediment, was transferred into a 20 L plastic container pre-labelled with station identification and collection date information. Ambient water was used to rinse all sediment from each sediment trap, applied as a pressurized spray where appropriate. Upon complete removal of all material within the sediment trap, the sediment traps were redeployed at approximately the same locations of retrieval. Following collection of all sediment from individual traps, the sample containers were sealed and stored upright in the dark until submission to the analytical laboratory. The lake sedimentation samples were shipped to

[2] One sediment trap from Station SL-DEEP-1 was unintentionally not deployed until August 6th, 2018 during the open-water study period, resulting in a 45 day total set duration (Table 2.1).

ALS Canada Ltd. (ALS; Waterloo, ON) for analysis of sediment total dry weight. At the laboratory, the sedimentation samples were filtered through a pre-weighed 0.70 µm glass fiber filter. The filter apparatus and container were rinsed three times to ensure complete removal of all sediment. The filter and residual sample material was dried at 105°C for two hours, allowed to cool for one hour, and then weighed to the nearest milligram using an appropriate balance with draft shield. As in previous studies, low sample volumes were encountered for each sediment trap replicate, and each station, for both of the 2017 - 2018 ice-cover and open-water period samples, precluding any additional analysis of the sedimentation material (e.g., sediment metal concentrations, dry bulk density).

2.3.2 Sediment Accumulation (Dry Bulk Density)

Sediment dry bulk density information, collected in order to estimate the amount of sediment accumulation for separate ice-cover and open-water periods, was collected for the open-water period in 2018 using sediment traps of differing dimensions to those used for the collection of sedimentation rate data. Dry bulk density (DBD) sediment traps were constructed of a single 75 cm long, 15.2 cm inside diameter acrylonitrile-butadiene-styrene (ABS) pipe (i.e., 182 cm^2 surface area) that was capped at the bottom end.[3] Each sediment trap unit was secured to a float-anchor system designed to maintain the trap in an upright position on the lake bottom for the duration of the deployment period. The mouth of the DBD sediment trap was designed to sit approximately 1.5 m above the substrate, mirroring the same distance above bottom that the mouth of sediment traps used to monitor sedimentation rate were situated.

Five DBD sediment traps were deployed in Sheardown Lake NW during the open-water period on August 1st, 2018 (Table 2.1; Figure 2.1). The DBD sediment traps were slowly lowered to the bottom using an individual line outfitted with a surface marker buoy at each location, at which time GPS coordinates were also recorded. The DBD sediment traps were retrieved on September 20th, 2018 (Table 2.1). The retrieval process involved pulling each DBD sediment trap to the surface very slowly to prevent sediment re-suspension in, and/or sediment loss from, each trap. Upon retrieval, all water overlying the particulate material in each DBD sediment trap was siphoned off with care taken to minimize disturbance of the sediment. All particulate material remaining in the DBD sediment trap was then transferred to a sample jar using plastic and/or silicon implements (i.e., spoons and spatulas). Sample material from all five DBD sediment traps were treated in this manner and, due to the limited amount of sample volume, composited to create a single dry bulk density sample for Sheardown Lake NW. Following collection of all sediment from individual traps, the sample container was sealed and stored cool in an upright

[3] The resulting DBD sediment traps had an aspect ratio of 5:1, meeting the recommended aspect ratio for cylindrical sediment traps to effectively monitor sediment deposition (Mudroch and MacKnight 1994).

position until submission to the analytical laboratory. The sediment accumulation sample was shipped to Saskatchewan Research Council (SRC; Saskatoon, SK) for analysis of dry bulk density. At the laboratory, dry bulk density was determined using the pycnometer method.

2.4 Data Analysis

Sedimentation (deposition) rate was calculated for each replicate sediment trap using the equation (Kemp et al. 1974):

$$\textit{Sedimentation rate}\ (mg/cm^{-2}day^{-1}) = \frac{\textit{dry weight}\ (mg)}{\textit{total area}\ (cm^2)} \div \textit{deployment time period (day)}$$

The sedimentation data were evaluated statistically, where sample replication allowed, as follows: 1) spatial comparisons among the three stations for separate ice-cover and open-water periods; 2) comparisons between the ice-cover and open-water periods at each station; and, 3) temporal comparisons at each station among baseline (i.e., 2013-2014), 2014-2015, 2015-2016, 2016-2017, and 2017-2018 data sets separately for ice-cover and open-water periods.[4] For the statistical analysis, raw data were assessed for normality and homogeneity of variance and log-transformed as necessary to meet test assumptions prior to conducting Analysis-of-Variance (ANOVA) and *post hoc* tests, where appropriate. In instances where normality could not be achieved through data transformation, non-parametric Mann-Whitney U-test statistics were used to validate pair-wise statistical results, and Kruskal-Wallis H-tests were used to validate multiple station/year statistical results from the ANOVA using log-transformed data. Similarly, in instances in which normal data exhibited unequal variance despite log transformation, Student's t-tests assuming unequal variance were used to validate the statistical findings of the ANOVA tests for two-group comparisons. For multiple station or year comparisons, Tukey's Honestly Significant Difference (HSD) or Tamhane's *post hoc* tests were conducted in cases in which normal data with equal and unequal variance, respectively, were encountered. All statistical comparisons were conducted using SPSS Version 12.0 software (SPSS Inc., Chicago, IL).

Estimation of the uncompacted thickness (mm) of sediment accumulation was calculated separately for each of the ice-cover and open-water periods using the equation (Kemp et al. 1974):

$$Accumulation\ thickness\ (mm/period^{-1}) = \frac{Sedimentation\ rate\ (mg/mm^{-2}period^{-1})}{Dry\ bulk\ density\ (mg/mm^{-3})}$$

[4] Because only a single replicate sedimentation rate sediment trap was able to be retrieved at SL-SHAL-1, the statistical analysis described in this statement/paragraph was not possible for this station.

Sedimentation dry bulk density results for Sheardown Lake NW collected for the open-water period in 2018 were used to calculate sediment accumulation thickness for the 2017-2018 ice-cover and open-water periods. In addition, the 2018 sedimentation dry bulk density information, together with sedimentation rate data from previous studies, were used as the basis for calculating the amount of sediment accumulation that occurred during ice-cover and open-water periods for all of the previous sedimentation monitoring studies (i.e., since 2013-2014) to facilitate the tracking of changes in sediment accumulation over time. Adverse effects on fish egg survival have been documented for a sediment accumulation thickness exceeding approximately 1 mm during the egg incubation period (Morgan et al. 1983; Fudge and Bodaly 1984; Berry et al. 2011). Therefore, an accumulation thickness of 1 mm was used as a threshold for potential effects to arctic charr egg incubation associated with sediment deposits at the Mary River Project. On Baffin Island, arctic charr spawning occurs in autumn (September-October) and although egg hatch occurs in early April, larval emergence generally does not occur until ice breakup in mid-July (Scott and Crossman 1998). Because this period essentially mirrors the ice-cover period used in this study, accumulation thickness for the ice-cover period was used to evaluate potential effects of depositing sediment on arctic charr egg survival at Sheardown Lake NW.

3 RESULTS

3.1 Sedimentation Rates

3.1.1 2017 – 2018 Season

Within Sheardown Lake NW, sedimentation rates were lower at the shallow littoral stations (i.e., SHAL1 and SHAL2) than at the deep profundal station (i.e., main basin Station DEEP1) during both the 2017-2018 ice-cover and 2018 open-water periods (Figure 3.1; Appendix Tables A.1 and A.2). The occurrence of highest sedimentation rate at the deepest area of Sheardown Lake NW was consistent with normal lake deposition patterns (see Wetzel 2001) and previous sedimentation studies (Minnow 2016, 2017, 2018; Figure 3.1). Sedimentation rates were similar between the two shallow littoral stations (Stations SHAL1 and SHAL2), which suggested that sediment inputs associated with closer proximity to the SDLT1 outlet at Station SHAL1 were not disproportionately high (Figure 3.1; Appendix Tables A.1 to A.3).

Sedimentation rates were significantly higher during the open-water period compared to the ice-cover period at all Sheardown Lake NW sedimentation monitoring stations (Appendix Table A.5).[5] Sedimentation rates ranged from 3.0 to 4.4 times greater during the open-water period than during the ice-cover period, potentially reflecting greater surface runoff sources of sediment generated by the mine and/or naturally greater amounts of autochthonous material generated (e.g., settling/decay of plankton) during the open-water period. Nevertheless, on average, approximately 58% of the total sediment deposited at the Sheardown Lake NW stations from September 2017 to September 2018 occurred over the ice-cover period, reflecting the much longer time of ice-cover compared to open-water through a typical year in the arctic.

Annual sedimentation extrapolated from the 2017-2018 Sheardown Lake NW data indicated approximately 28.3 and 24.1 mg/cm^2/year of sediment deposition at the SHAL1 and SHAL2 littoral stations, respectively, and 34.7 mg/cm^2/year of sediment deposition at the DEEP1 profundal station. These annual rates were within the range of those observed at other Canadian arctic lakes (e.g., 7 to 50 mg/cm^2/year; Lockhart et al. 1998) and much lower than at proglacial lakes in south-east Greenland (e.g., mean of 790 mg/cm^2/year; Hasholt et al. 2000). Therefore, the annual

[5] As a result of low sample replication at SHAL1 for the 2017-2018 study, no statistical analysis was conducted between ice-cover and open-water periods at SHAL1, or between stations using the SHAL1 data. However, examination of the numerical data indicated that sedimentation rate data from Station SHAL1 were within the range of values observed at Station SHAL2 for each respective ice-cover and open-water period. In turn, this suggested that differences between SHAL1 ice-cover and open-water periods, and between SHAL1 and DEEP1 stations, were likely to reflect the differences shown using SHAL2 comparisons for like endpoints.

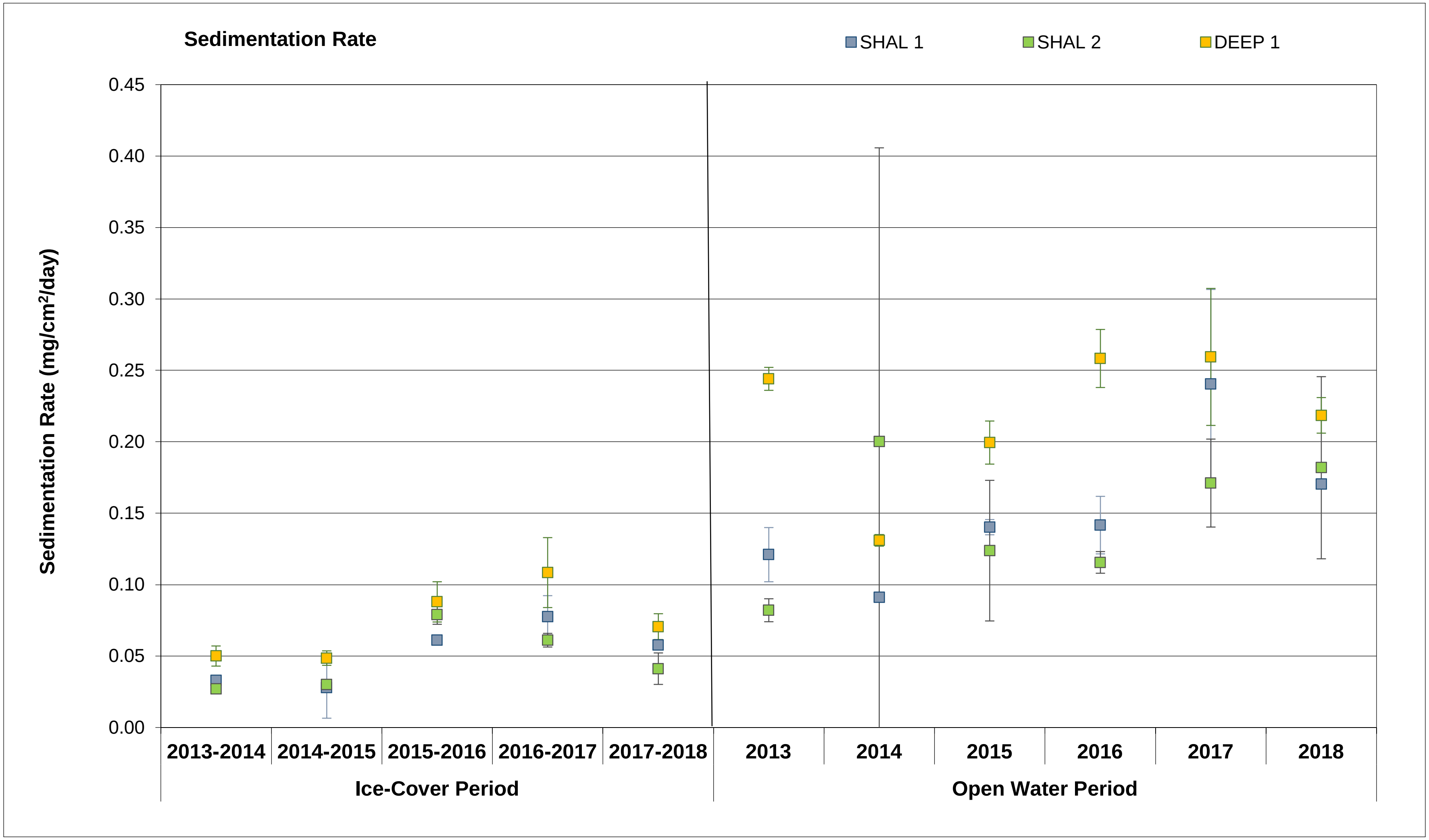

Figure 3.1: **Sedimentation Rates During Ice-Cover and Open-Water Periods at Sheardown Lake NW over Mine Baseline (2013 - 2014) and Operational (2015 - 2018) Phases, Mary River Project Lake Sedimentation Monitoring Study**

sedimentation rate at Sheardown Lake NW over the study period was within a range that is typical for Canadian arctic lakes.

3.1.2 Temporal Comparisons

Sedimentation rates over the 2017-2018 ice-cover period did not differ significantly at SHAL2, but were significantly higher at DEEP1, compared to the rate reported during the mine baseline study (2013-2014) and over the first year of mine operation (2014-2015) at each respective station (Figure 3.1; Appendix Tables A.6 to A.8).[6] Because Station SHAL2 is located at representative arctic charr spawning habitat, the absence of differences in sedimentation rate between the 2017-2018 ice-cover period and the baseline ice-cover period at SHAL2 indicated that adverse effects to arctic charr spawning/reproductive success due to sedimentation were unlikely over the 2017-2018 egg incubation period.

Open-water period sedimentation rates at station SHAL1 were higher in 2018 (and 2017) than during 2013 and 2014 baseline conditions, whereas the open-water period sedimentation rates at stations SHAL2 and DEEP1 in 2018 were within the range of baseline conditions (Figure 3.1).[6,7] Although higher sedimentation rates at SHAL1 in 2018 compared to baseline suggested greater sediment inputs potentially associated closer proximity to the SDLT1 outlet, low sample replication in 2018 combined with the absence of replicate data reported in the 2013 baseline study resulted in uncertainty regarding temporal interpretation of the open-water period data for this station.[6,7]

Annualized sedimentation rates at all three Sheardown Lake NW stations were higher in 2017-2018 (24.1 to 34.7 mg/cm^2/year) than total annual rates shown during 2013-2014 baseline monitoring (14.3 to 21.2 mg/cm^2/year; from NSC 2014a) and during 2014-2015 monitoring (15.5 to 24.5 mg/cm^2/year) at the onset of commercial mine operations (Figure 3.2).[8] Nevertheless, total annual sedimentation rates in 2017-2018 at each of the three sedimentation monitoring stations were generally lower than the annual sedimentation rates shown during the two previous years of mine operation (i.e., 2015-2016 and 2016-2017), indicating lower mine-related input of sediment to the lake during the most recent monitoring period (Figure 3.2). Overall, the temporal data indicated higher total annual sedimentation rates at Sheardown Lake NW since the baseline

[6] No temporal statistical analysis was possible using the 2017-2018 SHAL1 data due to low sample replication at SHAL1 for the 2017-2018 study. As described in Footnote 5 above, examination of the relative changes in sedimentation rate over time suggest that results for SHAL1 may mirror similar changes at SHAL2.

[7] Temporal statistical analysis of open-water period sedimentation rates was not able to include 2013 baseline data as the replicate data for this year were not reported. The results of temporal statistical analysis for open-water periods from the 2014 baseline and 2015-2018 mine operational periods are provided in Appendix Tables A.6 – A.8.

[8] Annual sedimentation data calculated as the sum of the September to July ice-cover period data and July to September open-water period data.

(2013-2014) and initial year of commercial mine operation (2014-2015), but no indication of an increasing trend in annual sedimentation rates since 2015-2016.[8]

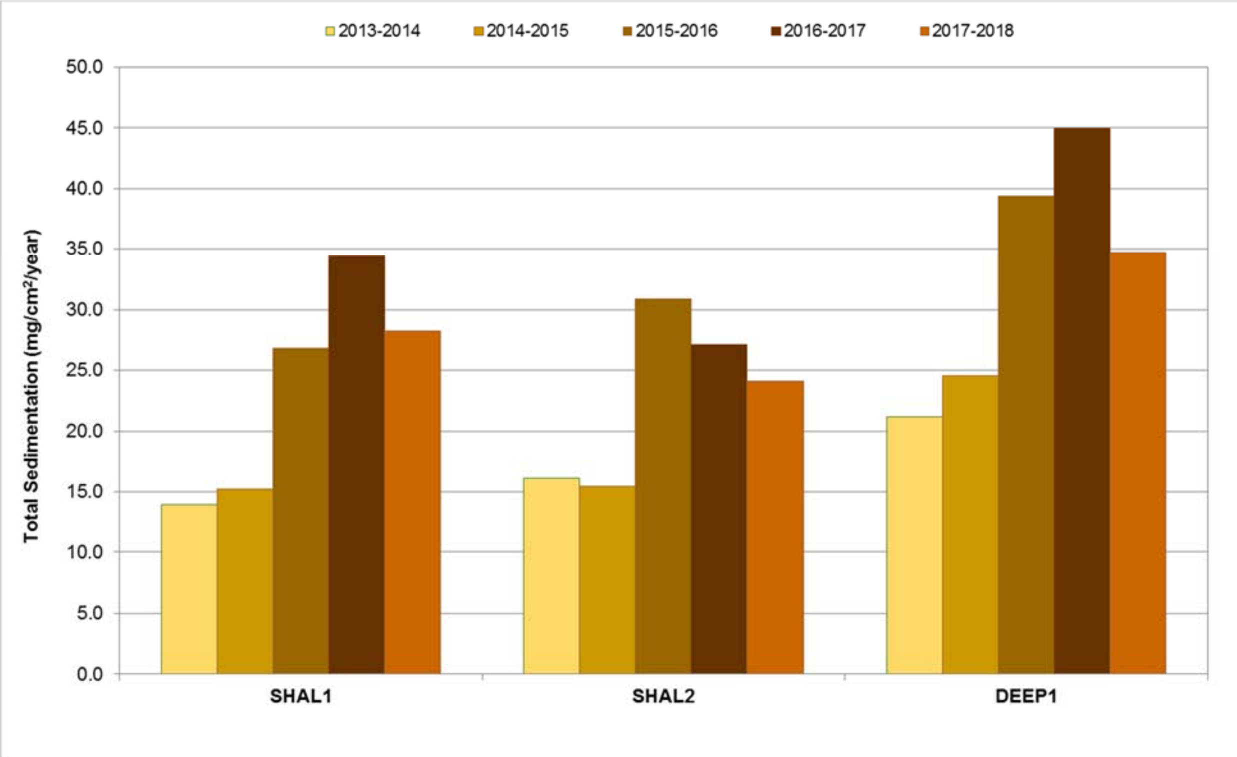

Figure 3.2: Temporal Comparison of Total Annual Sedimentation Rates at Sheardown Lake NW, 2013 to 2018

Note: Annual sedimentation data calculated as the sum of the September to July ice-cover period data and July to September open-water period data.

3.2 Sediment Accumulation Estimate

The bulk density of a composite sample of sedimentation material collected at Sheardown Lake NW over the open-water period in 2018 was 2.94 g/cm^3 (laboratory report provided in Appendix A).[9] Sediment accumulation estimates derived for the 2017-2018 ice-cover and open-water periods using this bulk density value and corresponding sedimentation rate information ranged from 0.083 mm/year at shallow littoral Station SHAL2 to 0.12 mm/year at the profundal Station

[9] Bulk density values used to derive sediment accumulation (thickness) previously were lower (i.e., 0.197 g/cm^3 based on data from sediment traps set at Canadian Shield lakes in Northern Ontario, and 1.284 g/cm^3 based on sediment collected in-stream and along the shoreline of a tributary to Sheardown Lake NW) than bulk density information for sedimentation material collected directly from Sheardown Lake in 2018. As indicated previously, the derivation of sediment accumulation estimates for Sheardown Lake NW using site-specific dry bulk density information has greater validity than the methods used to calculate sediment accumulation estimates in past studies. For this reason, the sediment accumulation estimates provided herein supersede all estimates presented in previous reports.

DEEP1 (Figure 3.3).[10] The sediment accumulation thicknesses estimated at all Sheardown Lake NW stations for the September 2017 to September 2018 period were comparable to annual sediment accumulation reported at profundal depths of an Alaskan arctic lake (0.16 ± 0.08 mm/year; Cornwell 1985), but were otherwise low compared to other arctic lakes. For instance, annual sediment accumulation ranged from 0.27 ± 0.12 to 1.2 ± 0.32 mm/year (average of 0.54 mm/year) among seven arctic lakes in western Greenland (Sobek et al. 2014), which was in line with annual sediment accumulation reported globally for lakes located north of approximately 65˚ latitude with maximum depths greater than 10 m (range 0.3 – 1.5 mm/year; see Brothers et al. 2008).

Adverse effects on fish egg survival have been reported at sediment accumulation thicknesses exceeding approximately 1 mm during the egg incubation period (Morgan et al. 1983; Fudge and Bodaly 1984; Berry et al. 2011). The sediment accumulation thickness estimated for the 2017-2018 arctic charr egg incubation/larval pre-emergence period (i.e., approximately mid-September to mid-July; Scott and Crossman 1998) at Sheardown Lake NW varied from 0.04 ± 0.01 mm at

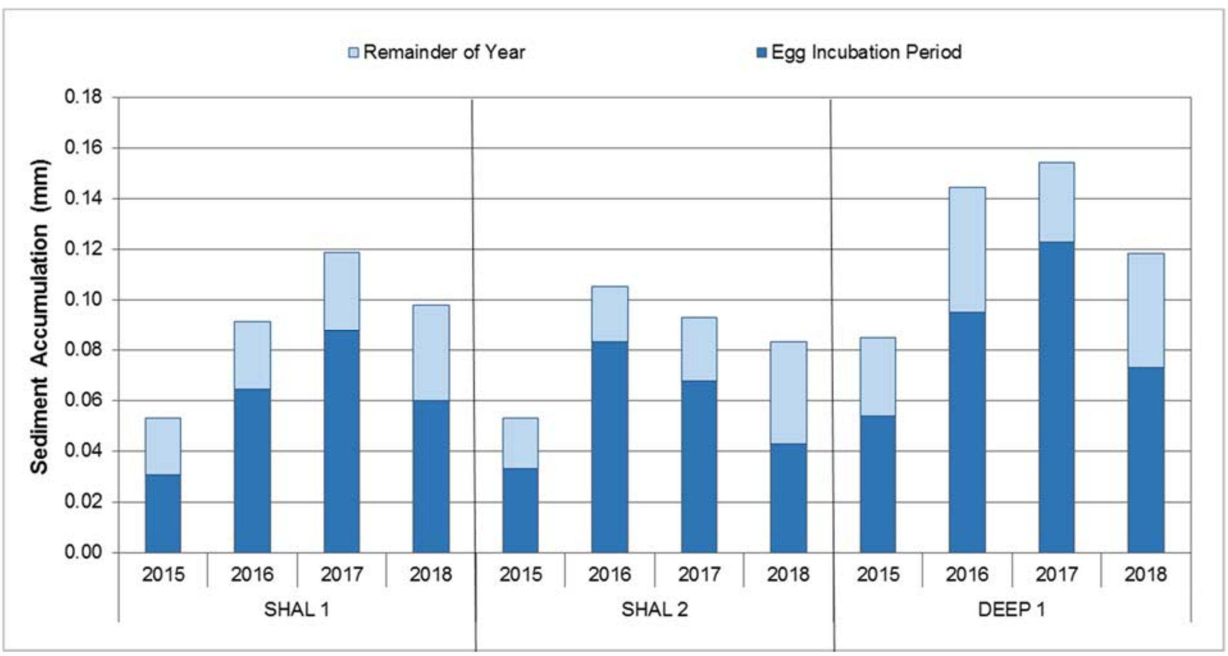

Figure 3.3: Sediment Accumulation Estimates for Arctic Charr Egg Incubation Period and Total Year Calculated using Sedimentation Rate Information together with 2018 Sedimentation Bulk Density Data, 2015 to 2018

[10] Annual sedimentation accumulation estimates reflect September to July ice-cover period data (2017-2018) and July to September (2018) open-water period data.

the littoral hard-bottomed station (i.e., SHAL2) to 0.06 mm at the littoral silt-bottomed station (i.e., SHAL1) when derived using the Sheardown Lake NW sedimentation bulk density data (Figure 3.3). Therefore, 2017-2018 sediment accumulation over the duration of the expected arctic charr egg incubation period was well below the 1 mm sediment thickness reported to influence egg hatch/larval pre-emergence success. Accordingly, no adverse effects to arctic charr reproductive success were likely at Sheardown Lake NW as a result of sedimentation over the 2017-2018 incubation period.

Because dry bulk density was kept constant for the calculation of sediment accumulation over all ice-cover and open-water periods since 2015, temporal comparisons of sediment accumulation mirrored the changes in sedimentation rates discussed above (Section 3.1.2; Figures 3.1 and 3.3). Notably, sedimentation accumulation estimates were much lower based on calculations conducted using Sheardown Lake NW actual sedimentation dry bulk density information than on calculations conducted using the sedimentation dry bulk density information collected at Canadian Shield lakes in Northern Ontario that were reported previously (i.e., Minnow 2016, 2017, 2018). This confirmed the hypothesis provided in these earlier reports that sediment accumulation estimates for Sheardown Lake NW that were derived using sedimentation dry bulk density from Northern Ontario lakes were likely to be highly conservative and therefore overestimated the amount of sediment accumulation that was actually occurring (Minnow 2016, 2017, 2018).

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Lake Sedimentation Monitoring has been included as a special investigation component of the Mary River Project AEMP since 2013–2014. The objective of this monitoring is to track sedimentation and evaluate the potential for adverse influences on resident arctic charr populations due to sedimentation at a representative lake (Sheardown Lake NW) within the immediate area of mine influence. The principal conclusions of 2017–2018 lake sedimentation monitoring study are:

- Sheardown Lake NW sedimentation rates were higher in the 2017-2018 ice-cover period than during the mine baseline (2013-2014) and early operational (2014-2015) ice-cover periods, but those over the 2018 open-water period were within the range of the mine baseline and early operational phases. Annualized sedimentation rates for the combined 2017-2018 ice-cover and 2018 open-water periods were higher than those during the 2013-2014 baseline and 2014-2015 mine early operational phases. Temporally, sedimentation rates have not shown a consistent increase from 2014-2015 to 2017-2018. Despite higher overall annual sedimentation in 2017-2018 compared to baseline conditions, sedimentation rates at Sheardown Lake NW in 2017-2018 (as well as for all previous study years) were within the range observed among typical Canadian arctic lakes that have not been influenced by anthropogenic activities.
- Annual sediment accumulation thickness estimates for Sheardown Lake NW based on the 2017-2018 monitoring data, calculated using site-specific dry bulk density information, were comparable to or lower than annual estimates for arctic lakes of comparable size and/or depth. The sediment accumulation thickness estimated for the 2017–2018 arctic charr egg incubation/larval pre-emergence period at Sheardown Lake NW was well below the threshold effect level of 1 mm of sediment deposition. Overall, these results indicated that no effects on arctic charr reproductive success were likely at Sheardown Lake NW as a result of sedimentation rates/accumulation over the 2017-2018 egg incubation/larval pre-emergence period.
- Sediment accumulation thickness estimates for Sheardown Lake NW that were calculated using site-specific sedimentation dry bulk density information were much lower than those calculated using sedimentation dry bulk density information collected at Canadian Shield lakes in Northern Ontario. This confirmed the hypothesis stated in previous reports that Sheardown Lake NW sediment accumulation estimates derived using sedimentation dry

bulk density from Northern Ontario lakes were very like to overestimate the actual amount of sediment accumulation at lakes near the mine.

4.2 Recommendations

The properties of sediment being deposited at Sheardown Lake NW have the potential to change between ice-cover and open-water periods (e.g., due to differing planktonic productivity, inputs from tributary sources), as well as among years (e.g., climatic influences, mine-site influences). These changes in sediment properties will be reflected in the dry bulk density, which in turn, are used to determine an estimate of sediment accumulation for the time periods indicated above. Therefore, in order to provide definitive estimates of sediment accumulation thickness for these time periods, it is recommended that sediment traps devoted to the collection of material for dry bulk density analysis continue to be deployed at Sheardown Lake NW as part of the Lake Sedimentation Monitoring program for all future studies.

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APPENDIX A

SUPPORTING SEDIMENTATION INFORMATION

Table A.1: Sediment Trap Results for the 2017 - 2018 Ice-Cover Period at Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2017 - 2018

Station	Station Replicate	Original Set Location (UTM; Zone 17W)		Station Depth (m)	Date Deployed	Date Retrieved	Set Duration (days)	Total Dry Weight (g)	Sedimentation Rate ($mg/cm^2/day$)
		Easting	Northing						
Shallow 1 (SL SHAL1)	SL-SHAL-1A	560341	7913299	10.2	14-Sep-17	17-Jul-18	306	1.040	0.058
	SL-SHAL-1B	560338	7913303	10.0	14-Sep-17	nr	-	-	-
	SL-SHAL-1C	560335	7913306	9.6	14-Sep-17	nr	-	-	-
	SL-SHAL-1D	560332	7913308	10.6	14-Sep-17	nr	-	-	-
	SL-SHAL-1E	560323	7913307	10.3	14-Sep-17	nr	-	-	-
						Average	**306**	**1.040**	**0.058**
						Standard Deviation	**-**	**-**	**-**
Shallow 2 (SL SHAL2)	SL-SHAL-2A	560579	7913088	6.8	14-Sep-17	16-Jul-18	305	0.637	0.035
	SL-SHAL-2B	560578	7913096	6.7	14-Sep-17	16-Jul-18	305	0.966	0.054
	SL-SHAL-2C	560573	7913094	6.5	14-Sep-17	17-Jul-18	306	0.613	0.034
	SL-SHAL-2D	560574	7913097	6.9	14-Sep-17	nr	-	-	-
	SL-SHAL-2E	560569	7913096	6.9	14-Sep-17	nr	-	-	-
						Average	**305**	**0.739**	**0.041**
						Standard Deviation	**0.6**	**0.197**	**0.011**
Deep 1 (SL DEEP1)	SL-DEEP-1A	560234	7913045	30.0	15-Sep-17	16-Jul-18	304	1.400	0.078
	SL-DEEP-1B	560228	7913049	28.9	15-Sep-17	16-Jul-18	304	1.250	0.070
	SL-DEEP-1C	560223	7913033	27.0	15-Sep-17	16-Jul-18	304	1.040	0.058
	SL-DEEP-1D	560229	7913052	28.3	15-Sep-17	nr	-	-	-
	SL-DEEP-1E	560229	7913044	28.9	15-Sep-17	17-Jul-18	305	1.370	0.076
						Average	**304**	**1.265**	**0.071**
						Standard Deviation	**0.5**	**0.163**	**0.009**

"nr" indicates sediment trap was not retreived.

Table A.2: Sediment Trap Results for the 2018 Open-Water Period at Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2017 - 2018

Station	Station Replicate	Original Set Location (UTM; Zone 17W)		Station Depth (m)	Date Deployed	Date Retrieved	Set Duration (days)	Total Dry Weight (g)	Sedimentation Rate ($mg/cm^2/day$)
		Easting	Northing						
Shallow 1 (SL SHAL1)	SL-SHAL-1A	560341	7913299	10.2	17-Jul-18	20-Sep-18	65	0.652	0.170
	SL-SHAL-1B	560338	7913303	10.0	-	-	-	-	-
	SL-SHAL-1C	560335	7913306	9.6	-	-	-	-	-
	SL-SHAL-1D	560332	7913308	10.6	-	-	-	-	-
	SL-SHAL-1E	560323	7913307	10.3	-	-	-	-	-
						Average	**65**	**0.652**	**0.170**
						Standard Deviation	**-**	**-**	**-**
Shallow 2 (SL SHAL2)	SL-SHAL-2A	560579	7913088	6.8	16-Jul-18	20-Sep-18	66	0.623	0.160
	SL-SHAL-2B	560578	7913096	6.7	16-Jul-18	20-Sep-18	66	0.512	0.132
	SL-SHAL-2C	560573	7913094	6.5	17-Jul-18	20-Sep-18	65	0.971	0.254
	SL-SHAL-2D	560574	7913097	6.9	-	-	-	-	-
	SL-SHAL-2E	560569	7913096	6.9	-	-	-	-	-
						Average	**66**	**0.702**	**0.182**
						Standard Deviation	**0.6**	**0.239**	**0.064**
Deep 1 (SL DEEP1)	SL-DEEP-1A	560234	7913045	30.0	16-Jul-18	20-Sep-18	66	0.565	0.213
	SL-DEEP-1B	560228	7913049	28.9	16-Jul-18	20-Sep-18	66	0.919	0.236
	SL-DEEP-1C	560223	7913033	27.0	16-Jul-18	20-Sep-18	66	0.807	0.208
	SL-DEEP-1D	560229	7913052	28.3	-	-	-	-	-
	SL-DEEP-1E	560229	7913044	28.9	17-Jul-18	20-Sep-18	65	0.830	0.217
						Average	**66**	**0.780**	**0.218**
						Standard Deviation	**0.5**	**0.151**	**0.013**

Table A.3: Sedimentation (mg/cm^{-2}·day^{-1}) Summary Statistics for Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2017-2018

Study Period	Station	Sample Size	Mean	Standard Deviation	Standard Error	95% Confidence Interval		Minimum	Maximum
						Lower Bound	Upper Bound		
Ice-Cover 2017 - 2018	SHAL 1	1	0.058	.	.	.	.	0.058	0.058
	SHAL 2	3	0.041	0.011	0.006	0.014	0.068	0.034	0.054
	DEEP1	4	0.071	0.009	0.005	0.056	0.085	0.058	0.078
Open-Water 2018	SHAL 1	1	0.170	.	.	.	.	0.170	0.170
	SHAL 2	3	0.182	0.064	0.037	0.023	0.340	0.132	0.254
	DEEP1	4	0.218	0.013	0.006	0.199	0.238	0.208	0.236

Table A.4: Statistical Comparison of Sedimentation among Sheardown Lake NW Stations for Ice-Cover and Open-Water Periods, Lake Sedimentation Monitoring Study, 2017 - 2018

Study Period	Pair-wise comparisons[a]				
	(I) Area	(J) Area	Significant Difference Between 2 Areas?	p-value	Statistical Test[a,b]
Ice-Cover 2017 - 2018	SHAL1	SHAL2	nc	na	na
	SHAL1	DEEP1	nc	na	na
	SHAL2	DEEP1	YES	0.0114	ANOVA
Open-Water 2018	SHAL1	SHAL2	nc	na	na
	SHAL1	DEEP1	nc	na	na
	SHAL2	DEEP1	NO	0.4252	$t\text{-test}_{UEV}$

[a] Statistical tests include Analysis of Variance (ANOVA) for normal, homogeneous data, t-test assuming unequal variance ($t\text{-test}_{UEV}$) for normal, non-homogeneous data, and Mann-Whitney U-test (MW U-test) for non-normal data sets.

[b] Untransformed data were normally distributed and homogenous, and therefore no data transformation was used for pair-wise comparisons.

"nc" indicates not calculable (sample replication too small at one or both study areas); "na" indicates not applicable.

Table A.5: Statistical Comparison of Sedimentation (mg/cm²/day) Between the 2017-2018 Ice-Cover and 2018 Open-Water Periods at Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2017 - 2018

Station	Statistical Test Results			Summary Statistics						
	Significant Difference Between Areas?	*p* -value	Statistical Analysis[a]	Period	N	Mean	Standard Deviation	Standard Error	Minimum	Maximum
SHAL1	na	na	na	Ice-Cover 2017-2018	1	0.058	.	.	0.058	0.058
				Open-Water 2018	1	0.170	.	.	0.170	0.170
SHAL2	YES	0.020	α , γ	Ice-Cover 2017-2018	3	0.041	0.011	0.006	0.034	0.054
				Open-Water 2018	3	0.182	0.064	0.037	0.132	0.254
DEEP1	YES	0.000	α , γ	Ice-Cover 2017-2018	4	0.071	0.009	0.005	0.058	0.078
				Open-Water 2018	4	0.218	0.013	0.006	0.208	0.236

[a] Data analysis included: α - data untransformed; β - data log transformed; γ - single factor ANOVA test conducted; δ - single-factor ANOVA test results validated using Mann-Whitney U-test; and, ε - single-factor ANOVA test results validated using t-test assuming unequal variance.

Highlighted values indicate significant difference between study areas based on ANOVA p-value less than 0.10.

Table A.6: Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2018) Phases at Sheardown Lake NW Shallow Station 1 (SHAL1) during Ice-Cover and Open-Water Periods, Lake Sedimentation Monitoring Study, 2013 - 2018

Seasonal Period	Overall 4-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Staistical Test[b]	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Ice-Cover	YES	0.00039	ANOVA[b]	2013 - 2014	2014 - 2015	NO	0.4180	Tukey's HSD[b]
				2013 - 2014	2015 - 2016	YES	0.0793	
				2013 - 2014	2016 - 2017	YES	0.0177	
				2013 - 2014	2017 - 2018	-	-	
				2014 - 2015	2015 - 2016	YES	0.0025	
				2014 - 2015	2016 - 2017	YES	0.0006	
				2014 - 2015	2017 - 2018	-	-	
				2015 - 2016	2016 - 2017	NO	0.7533	
				2015 - 2016	2017 - 2018	-	-	
				2016 - 2017	2017 - 2018	-	-	
Open-Water	YES	0.00004	ANOVA[d]	2014	2015	YES	0.0080	Tukey's HSD[b]
				2014	2016	YES	0.0119	
				2014	2017	YES	0.0000	
				2014	2018	-	-	
				2015	2016	NO	1.0000	
				2015	2017	YES	0.0206	
				2015	2018	-	-	
				2016	2017	YES	0.0311	
				2016	2018	-	-	
				2017	2018	-	-	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Untransformed data were non-normally distributed; log-transformation resulted in normally distributed data. and thus the log-transformed data were used for statistical tests.

[c] Untransformed data were normally distributed, and thus un-transformed data used for statistical tests.

[d] Log transformed data remained non-normally distributed, and thus statistical results validated using non-parametric KW and MW tests, as appropriate.

Table A.7: Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2018) Phases at Sheardown Lake NW Shallow Station 2 (SHAL2) during Ice-Cover and Open-Water Periods, Lake Sedimentation Monitoring Study, 2013 - 2018

Seasonal Period	Overall 5-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Staistical Test[b]	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Ice-Cover	YES	< 0.001	ANOVA[c]	2013 - 2014	2014 - 2015	NO	0.7037	Tamhane's [c]
				2013 - 2014	2015 - 2016	YES	0.0004	
				2013 - 2014	2016 - 2017	YES	0.0004	
				2013 - 2014	2017 - 2018	NO	0.8319	
				2014 - 2015	2015 - 2016	YES	0.0002	
				2014 - 2015	2016 - 2017	YES	0.0001	
				2014 - 2015	2017 - 2018	NO	0.9171	
				2015 - 2016	2016 - 2017	YES	0.0179	
				2015 - 2016	2017 - 2018	NO	0.1253	
				2016 - 2017	2017 - 2018	NO	0.5392	
Open-Water	NO	0.69871	ANOVA[c]	2014	2015	NO	0.9993	Tamhane's [c]
				2014	2016	NO	0.9983	
				2014	2017	NO	1.0000	
				2014	2018	NO	1.0000	
				2015	2016	NO	1.0000	
				2015	2017	NO	0.8173	
				2015	2018	NO	0.9541	
				2016	2017	NO	0.1268	
				2016	2018	NO	0.9079	
				2017	2018	NO	1.0000	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Untransformed data were non-normally distributed; log-transformation resulted in normally distributed data. and thus the log-transformed data were used for statistical tests.

[c] Untransformed data were normally distributed, and thus un-transformed data used for statistical tests.

[d] Log transformed data remained non-normally distributed, and thus statistical results validated using non-parametric KW and MW tests, as appropriate.

Table A.8: **Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2018) Phases at Sheardown Lake NW Deep Station (DEEP1) during Ice-Cover and Open-Water Periods, Lake Sedimentation Monitoring Study, 2013 - 2018**

Seasonal Period	Overall 5-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Staistical Test[a]	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Ice-Cover	YES	0.00248	Kruskal-Wallis H-test	2013 - 2014	2014 - 2015	NO	0.9048	Mann-Whitney U-test
				2013 - 2014	2015 - 2016	YES	0.0286	
				2013 - 2014	2016 - 2017	YES	0.0286	
				2013 - 2014	2017 - 2018	YES	0.0571	
				2014 - 2015	2015 - 2016	YES	0.0159	
				2014 - 2015	2016 - 2017	YES	0.0159	
				2014 - 2015	2017 - 2018	YES	0.0159	
				2015 - 2016	2016 - 2017	NO	0.3429	
				2015 - 2016	2017 - 2018	YES	0.0286	
				2016 - 2017	2017 - 2018	NO	0.1143	
Open-Water	YES	0.00000	ANOVA[b]	2014	2015	YES	0.0005	Tamhane's [b]
				2014	2016	YES	0.0001	
				2014	2017	YES	0.0539	
				2014	2018	YES	0.0004	
				2015	2016	YES	0.0063	
				2015	2017	NO	0.5347	
				2015	2018	NO	0.5277	
				2016	2017	NO	1.0000	
				2016	2018	YES	0.0690	
				2017	2018	NO	0.8886	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Untransformed data were non-normally distributed; log-transformation resulted in normally distributed data. and thus the log-transformed data were used for statistical tests.

[c] Untransformed data were normally distributed, and thus un-transformed data used for statistical tests.

[d] Log transformed data remained non-normally distributed, and thus statistical results validated using non-parametric KW and MW tests, as appropriate.

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DPulp

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Date of Report: Oct 31, 2018

Column Header Details

Density in g/cc (Density)

Sample Number	Density g/cc
Sample #1	2.94
Sample #1 R	2.94

Rock Density By Pycnometer Method.