Manitoba Infrastructure
Lake Manitoba Outlet Channel

Sediment Transport Modeling to Manage Excess Sediment Concentrations During Commissioning

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Table of Contents

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1. Introduction

The initial operation of the Lake Manitoba Outlet Channel (LMOC) during commissioning will mobilize and transport loose earth material that may remain on the channel bed following construction. This is expected to result in an immediate increase in TSS concentrations leading to sediment deposition in Birch Bay.

Numerical sediment transport modeling was undertaken to examine the increase in TSS concentrations and associated sediment deposition in Birch Bay during commissioning, as well as the impact that controlled gate operation measures can have to limit the increase in TSS concentrations.

This report documents the modeling analyses performed and simulation results.

2. Methodology and Assumptions

The goal of the sediment transport analysis conducted was to estimate TSS concentrations and total sediment volume/mass leaving the LMOC for a scenario that is representative of project commissioning, and to determine the fate of the eroded channel sediment once it leaves the channel and enters Birch Bay. The results of the analyses presented herein can also be utilized to help inform assessments that may be required for evaluating sediment transport scenarios during future operation of the channel.

Sediment transport from the channel bed was modeled using a two-dimensional MIKE21 model, while a general assessment of the fate of the sediment exiting the LMOC into Birch Bay was performed using a Delft3D sediment transport model.

A series of LMOC water control structure (WCS) gate operation scenarios were developed to analyze how the release of sediment from the channel could be controlled in order to meet environmental targets. The target 24-hour average TSS concentration for sediment leaving the LMOC is understood to be 25 mg/l as advised by MI EA Team. The following sections describe the assumptions made in developing these scenarios and how they were implemented with both the MIKE21 (channel) and Delft3D (lake) models.

2.1 Channel Modeling

It is expected that some loose sediment may remain on the bottom of the channel following its construction. Once channel commissioning commences and the control structure gates are opened, it is assumed that all of this loose sediment is available to be eroded and transported downstream towards Lake St. Martin. Sediment erosion and transport of this material was modeled using MIKE21's Sand Transport (ST) module to estimate the potential sediment concentration and volume leaving the LMOC into Birch Bay under various gate operation scenarios. The following sections describe the assumptions and methodology applied to estimate the sediment concentration and volume leaving the LMOC.

2.1.1 *General Model Description*

A two-dimensional MIKE21 model was developed to estimate erosion and transportation of sediment within the LMOC during project commissioning. The MIKE21 ST module was applied in addition the standard Hydrodynamic (HD) module to complete these estimates. The rationale for the use of the MIKE21 ST module is discussed further in Section 2.1.3.

The MIKE 21 channel model was split into two parts at the LMOC control structure to simplify the representation of control structure operations under the various scenarios analyzed and to expedite the overall modeling process. This resulted in one model representing the approximately 21 km reach upstream of the control structure (referred to as the “Upstream” MIKE21 model) and second model for the approximately 3 km reach downstream of the control structure (the “Downstream” MIKE21 model).

The Upstream and Downstream MIKE21 model geometries were defined using information from the latest three-dimensional CAD model of the channel, inlet, and outlet. Therefore, the two MIKE21 models represent the entire LMOC from Watchorn Bay (Lake Manitoba) to Birch Bay (Lake St. Martin), including the inlet and outlet excavations. The full extent of the LMOC cross-section between where it daylights on each side of the channel centerline is represented in the model.

The existing one-dimensional HEC-RAS model, developed as part of channel design activities, was used to simulate hydraulic conditions through the control structure for each scenario. Results from the HEC-RAS model (i.e., water levels, velocities, and flows) were applied as boundary conditions to both the Upstream and Downstream MIKE21 models, thereby connecting the two models while ensuring that gate operations are appropriately represented.

2.1.2 *Hydraulic Modeling and Assumptions*

2.1.2.1 *Mesh Sizing*

In the MIKE21 model, two-dimensional hydraulic and sediment transport calculations are discretized within a series of mesh elements representing the model domain. The latest version of MIKE21 uses a flexible mesh approach, meaning that mesh elements of various sizes can be used to represent the geometry of a particular area. In the case of the LMOC models, three different mesh size sub-domains were defined: the channel base (i.e., the 12 to 22 m wide bottom of the trapezoidal cross-section), the channel side slopes, and the upstream and downstream approaches to the control structure. The channel domain was divided this way in order to define smaller elements in more hydraulically-complex areas and larger elements in simpler regions in an effort to minimize computational time while maintaining model accuracy. A series of model iterations were performed to determine sensitivity of results to the selected mesh sizing. Element sizes defined for each of the channel areas are summarized in Table 2-1. It was determined that these element sizes are appropriate for representing the LMOC for both hydrodynamic and sediment transport calculations within MIKE21 for the purposes of this analysis.

Table 2-1: Summary of MIKE21 Mesh Element Sizes

Model Area	Max. Element Area (m^2)	Approximate Max. Element Triangle Width (m)
Channel base	8	4
Channel side slopes	12.5	5
Control Structure approaches	2	2

2.1.2.2 Model Verification

Results from the MIKE21 HD component were analyzed and verified prior to activating the ST module. Preliminary hydraulic MIKE21 results were compared against those from the existing HEC-RAS model in order to verify the MIKE21 model to the degree possible in the absence of actual calibration data (i.e., measured water levels or velocities). Some minor adjustments to MIKE21 HD parameters such as bed resistance (i.e., Manning's roughness) were made to ensure water surface profiles generated from MIKE21 reasonably match those of HEC-RAS. Final Manning's *n* roughness values for the Upstream and Downstream models were 0.028 and 0.032, respectively. The different roughness values reflect a composite roughness of the channel which takes into account the increased hydraulic roughness that will exist on the upper portion of the channel side slopes where vegetation will grow. It is anticipated that vegetation will not grow on channel bed or portions of the side slopes that are below the normal operating levels of both Lake Manitoba and Lake St. Martin when the channel is not in operation. When the channel is opened, water levels downstream of the control structure will increase and a greater portion of the channel's wetted perimeter will be in contact with side slope vegetation, and therefore subjected to increased flow resistance. Upstream of the control structure, the water levels will drop such that for most of the channel length the water will not be in contact with side slope vegetation, and therefore will be subjected to reduced flow resistance.

Figure 2-1 and Figure 2-2 illustrate water surface profile comparisons between HEC-RAS and MIKE21 for two gate opening conditions: gates open 1 m, and gates fully open.

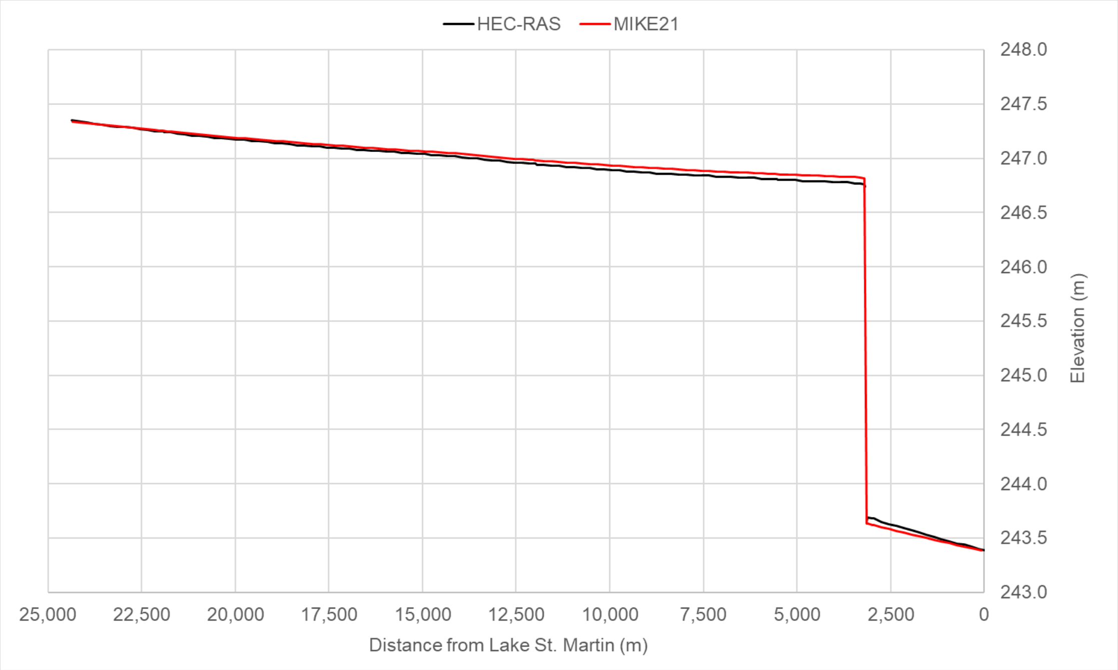


Figure 2-1: MIKE21 vs. HEC-RAS Water Surface Profile Comparison, Gates Open 1 m

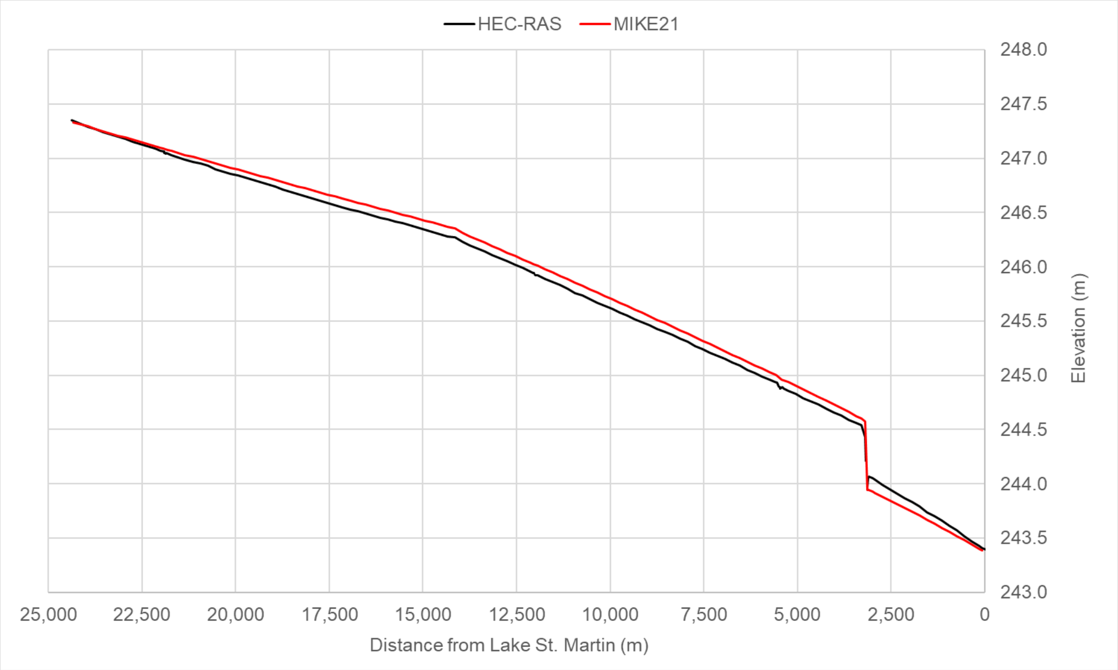


Figure 2-2: MIKE21 vs. HEC-RAS Water Surface Profile Comparison, Gates Fully Open

The water surface profile comparison plots illustrate a strong match between the HEC-RAS and MIKE21 hydrodynamic results. Average differences between MIKE21 and HEC-RAS water surface elevations along the channel length are approximately 0.02 m and 0.05 m for the “Gates Open 1 m” and “Gates Fully Open” scenarios, respectively. Therefore, the MIKE21 LMOC models were deemed appropriate for further application to the sediment transport analyses.

2.1.3 Sediment Transport Modeling and Assumptions

While the soil underlying the LMOC consists of consolidated till (Section 2.1.3.2), the material available for erosion following construction is expected to have broken down into smaller particles during construction due to factors such as the implemented construction practices, drying/cracking of exposed surface material, etc. Additionally, geotechnical soil properties of the in-situ till indicates low cohesion. Therefore, the loose sediment is expected to consist of individual non-cohesive particles.

Based on the above considerations, MIKE21’s ST module, which is an advanced 2D sand transport model that simulates non-cohesive sediment transport under the influence of currents and waves, was selected for the purposes of this assessment. The MIKE21 model was applied to analyze the erosion and movement of the sediment remaining in the LMOC following construction and to estimate the TSS concentrations exiting the channel under a range of conceptualized commissioning scenarios.

The Van Rijn sediment load equation was used for the sediment transport modeling of the LMOC, where the total load was set to be transported in suspension. MIKE21 ST simulates suspended sediment transport based on the transport equation developed by Galapatti, which includes three mechanisms for non-cohesive suspended sediment transport: advection, settling, and diffusion.

Note that only suspended load sediment transport was applied within MIKE21 ST. It was assumed that all material eroded from the base of the channel becomes entrained in the water column and is therefore transported downstream as suspended sediment, rather than bed load. This assumption was made since any bed load transport upstream of the LMOC control structure may not be able to pass through the structure’s raised setting, and hence provides more conservative TSS concentration estimates.

2.1.3.1 Initial Channel Sediment Quantity

The potential erodible material from construction activities that may be readily transported as TSS during commissioning was estimated as a key input to the channel sediment transport analysis. It is noted that estimates of this nature are subjective and are based on many variables, some of which are very difficult to quantify as their likelihood of occurrence and contribution to the total volume of erodible/loose material is dependent on the construction activities and other variables. Variables to consider include the anticipated construction methodologies, duration of the channel construction works, seasons of construction, weather conditions, typical behavior of the exposed surfaces of the soil stratums at the channel slopes and at the base of the channel, as well as wetting and drying cycles of the exposed slopes during construction.

Due to the complexities and subjective nature of estimating the quantity of loose sediment which may be available to erode from the LMOC during commissioning, for the purpose of this sediment modeling assessment, a 5 mm thick layer of loose fine particles uniformly distributed across the channel was considered reasonable. A similar approach was applied for various components of the Keeyask Generating Station (approach and discharge channels for both the Powerhouse and Spillway Structures) to estimate the TSS concentrations that could be anticipated during testing and commissioning of the Powerhouse units and Spillway Gates.

2.1.3.2 Channel Sediment Gradation

Channel sediment transport analyses were performed using a selection of representative material types and corresponding uniform particle sizes. This approach allows for the development of a TSS “envelope” within which the actual TSS observed in the field can be expected to fall. Furthermore, the method of simulating sediment transport using a single grain size, rather than a specific gradation, allows for a more appropriate representation within the MIKE21 ST module, as described in Section 2.1.3.

The most recent available geotechnical field data provide an approximate material gradation in the LMOC study area (Hatch Ltd., 2020). Based on the assumption that the majority of the material left in the channel following construction will be from the till zone, geotechnical lab testing results provide the following average material distribution:

- 13% clay
- 46% silt
- 29% sand
- 12% gravel.

Therefore, two material types were assumed for the LMOC sediment analysis to represent the range of sediment gradation of the till:

- Medium silt (0.032 mm particle size)
- Very fine sand (0.125 mm particle size).

Based on the available geotechnical data for the existing till layer, it is assumed that the majority of actual sediment remaining in the channel following construction will fall between the above two material types. The assumed porosity and specific gravity of the initial sediment layer were 0.4 and 2.65, respectively. These values were selected to represent the disturbed, unconsolidated sediment that is assumed to be remaining along the channel after construction.

2.1.3.3 Modeling Assumptions

The following assumptions have been made for the sediment transport modeling:

- Two representative grain sizes have been modeled to represent the variation in sediment gradation within the channel.
  - Medium silt (D_{50} = 0.032 mm)
  - Very fine sand (D_{50} = 0.125 mm).
- Each of the two representative grain sizes (0.032 mm and 0.125 mm) are modeled separately, each with the starting assumed erodible bed thickness of 5 mm (Section 2.1.3.1).
- The same bed roughness from the hydraulic model (Section 2.1.2.2) was used to represent the bed roughness for sedimentation
- The three control structure gates are operated in unison (e.g., a 0.5 m gate opening modeling scenario has all three gates raised at the same time and open 0.5 m).

Although the MIKE21 ST module is a “state of the art” model for sediment transport, there are a number of limitations inherent with any sedimentation modeling, as it is subject to considerable uncertainty due to complex interaction between the turbulence in the flow, shear stress near the bed and the presence of bedforms.

2.2 Lake Modeling

The FLOW and MOR modules available in the Deflt3D Flexible Mesh suite (Delft3D FM Suite 2020.02 HMWQ) and the coupled structured WAVE Delft3D module (Release 4) were used to evaluate the plume dispersion of sediments exiting the LMOC during its initial operation.

The FLOW module is a multi-dimensional (2D or 3D) hydrodynamic (and transport) simulation program which calculates non-steady flow and transport processes that can result from several kinds of boundary conditions such as astronomical constituents, water levels, velocities, combinations of water levels and velocities and discharges (Delft, 2019a).

The MOR module is implemented through the FLOW module and it computes sediment transport (suspended, bed, and total load) of cohesive and non-cohesive material and morphological changes. Both currents and waves act as driving forces and a wide variety of transport formulae have been incorporated. For the suspended load this module connects to the 2D or 3D advection-diffusion solver of the FLOW module; density effects may be considered (Delft, 2019b).

The Delft3D WAVE module implements the numerical modeling system SWAN (Simulating WAves Nearshore), developed at the Delft Technical University in the Netherlands, which is based on the wave action balance equation (or energy balance in the absence of currents) with sources and sinks (TU Delft, 2019).

The Delft3D-FM model is enabled to run the flow and sediment modules on unstructured grids, therefore allowing for increased model resolution in areas of interest without the need to nest over multiple grids. The wave (structured) and flow/sediment (unstructured) grids can be coupled and information is exchanged between the grids.

The Delft3D model was considered appropriate for the purposes of the sediment transport modeling in the lake given its ability to simulate sediment transport under the combined flow from a channel outlet and oscillatory currents generated by wind waves in lake environments, which has been proven on numerous projects.

For the present study, simulations were conducted in 2D mode (depth-averaged) using Cartesian grid co-ordinates. The wave outer grid covers the entire south basin of Lake St Martin, while the inner wave and flow grid are restricted to Birch Bay.

2.2.1 Currents and Wind

Currents for the transport of sediments within the Delft3D model were based on the discharge conditions modeled in MIKE21 for each gate opening scenario as described in Section 2.3, and by wind generated waves. The water level in Lake St. Martin (Birch Bay) was set to a constant elevation of 243.38 m (798.5ft).

A statistical analysis of the Dauphin Airport anemometer data obtained from Environment Canada for the period of record 1953-2018, highlights that winds blow mainly from the West (approximately 15% of the time), as shown in Figure 2-3 and have average hourly speeds of approximately 5 m/s, as presented in Figure 2-4. In order to simulate average conditions during commissioning, it was decided to run the model based on a typical annual event. Figure 2-5 shows the selected 96-hour wind timeseries that was used for each Scenario.

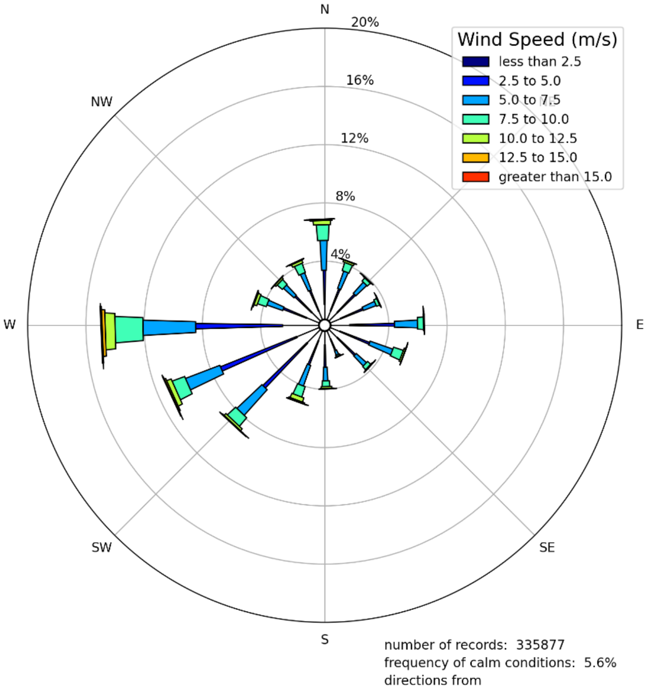


Figure 2-3: Wind Dauphin Airport (1953-2018 - Open Water Season April to October)

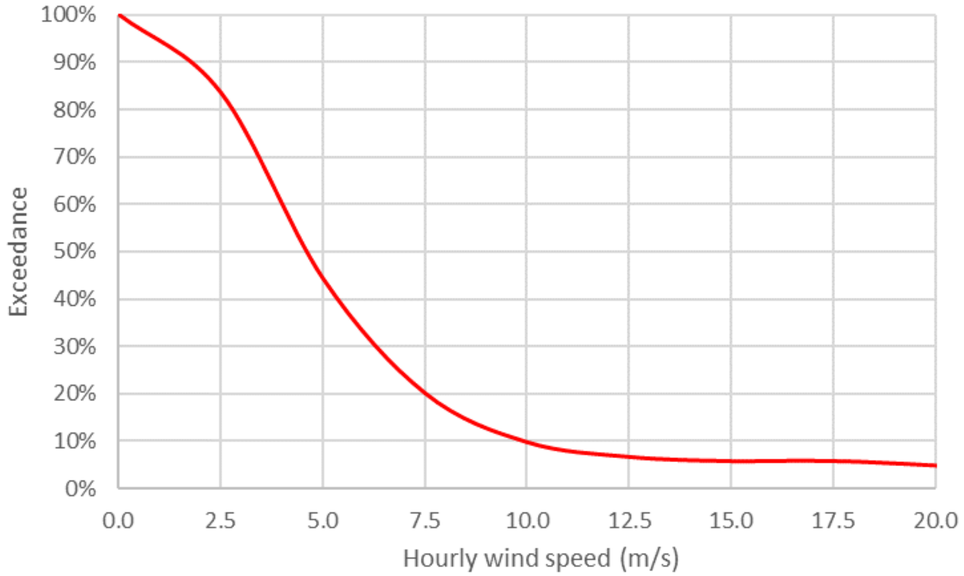


Figure 2-4: Hourly Wind Speed Exceedance (1953-2018 - Open Water Season April to October)

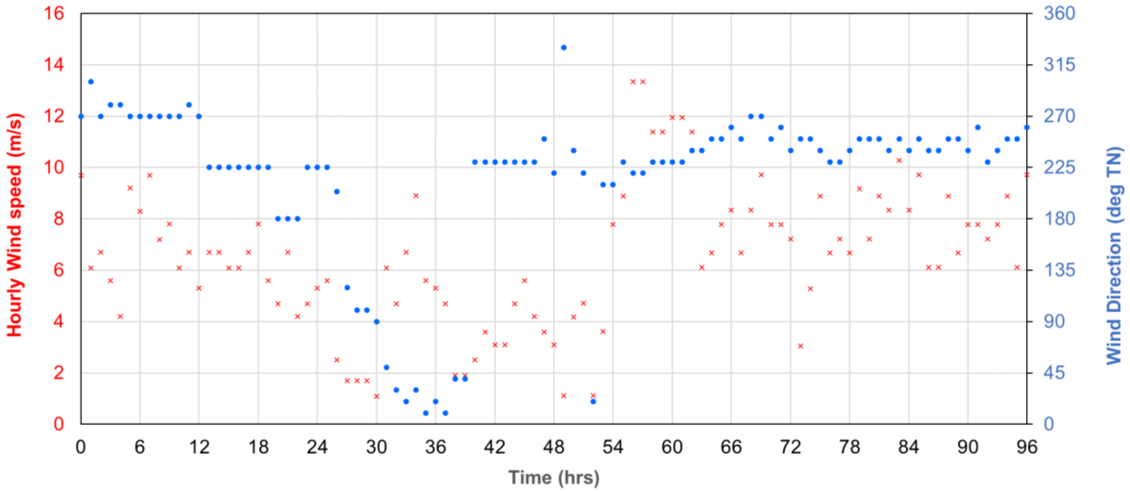


Figure 2-5: Typical Annual Wind Speed and Direction

2.2.2 *Sediment Transport*

In accordance with the sediments sizes modeled in MIKE21, two representative sediment fractions were modeled in Delft3D:

- Medium silt, with a D_{50} of 0.032 mm
- Very fine sand, with a D_{50} of 0.125 mm.

Delft3D applies a piecewise log-uniform distribution when using a uniform D_{50} value, based on the following relation:

- $D_{10} = 0.75\ D_{50}$
- $D_{90} = 1.5\ D_{50}$.

The transport of the silt fraction was modeled using the advection-diffusion equation for mud provided in Delft3D, as defined by the Partheniades-Krone formulations.

The transport of the sand fraction was modeled using the Van Rijn equation which accounts for bedload and suspended load transport under combined currents and waves.

The 96-hour TSS timeseries computed by the MIKE21 model for each flow scenario (presented in Sections 3.1.1, 3.2.1, and 3.3.1) were specified at the Delft3D model channel boundary, located 900 m upstream of the LMOC outlet to ensure stable flow conditions. The portion of the LMOC from the outlet to a location 900 m upstream is common between the MIKE21 and the Delft 3D models, which also allows comparison to be made between the two models.

To ensure that the assessment of sediments entering Birch Bay from the operation of the LMOC is not affected by typical sediment transport patterns within the lake, the bed of the Delft3D model was defined as non-erodible (i.e., the only source of sediment is from the channel boundary).

2.3 Commissioning Scenarios

2.3.1 Hydraulic Conditions

It was assumed that average water levels would be present on both Lake Manitoba and Lake St. Martin (Birch Bay) during the project commissioning phase. Therefore, the following average lake levels were applied for all scenarios analyzed:

- Lake Manitoba (Watchorn Bay) – 247.35 m (811.5 ft)
- Lake St. Martin (Birch Bay) – 243.38 m (798.5 ft).

These lake levels were applied as constant upstream and downstream boundary conditions within the MIKE21 model, as described in Section 2.1.1. Passage of flow through the LMOC is defined by the gate operations associated with each of the following sediment management scenarios. Note that it was assumed that all three gates operate simultaneously under all of the scenarios analyzed.

2.3.2 Base Case

Previous hydraulic modeling efforts using the HEC-RAS model have shown that opening the LMOC control structure gates as quickly as possible from fully closed to fully open will result in a large release of water and creation of a significant flood wave downstream of the structure (with a very high short-term rate of flow). As this is undesirable, a more controlled gate opening sequence was developed so as to maintain flows through the channel downstream of the control structure at or below 212 m^3/s (i.e., comfortably within the design limits for the channel). This gate opening sequence is as follows:

- 0-2 m open (0.1 m/min); hold for 4 hours
- 2-3 m open (0.1 m/min); hold for 1 hour
- 3-4 m open (0.1 m/min); hold for 1 hour
- 4-9 m open (1.0 m/min).

This scenario was selected to represent the Base Case operation of the WCS for this assessment. Figure 2-6 illustrates the gate opening sequence and corresponding flow through the control structure as computed by the HEC-RAS model.

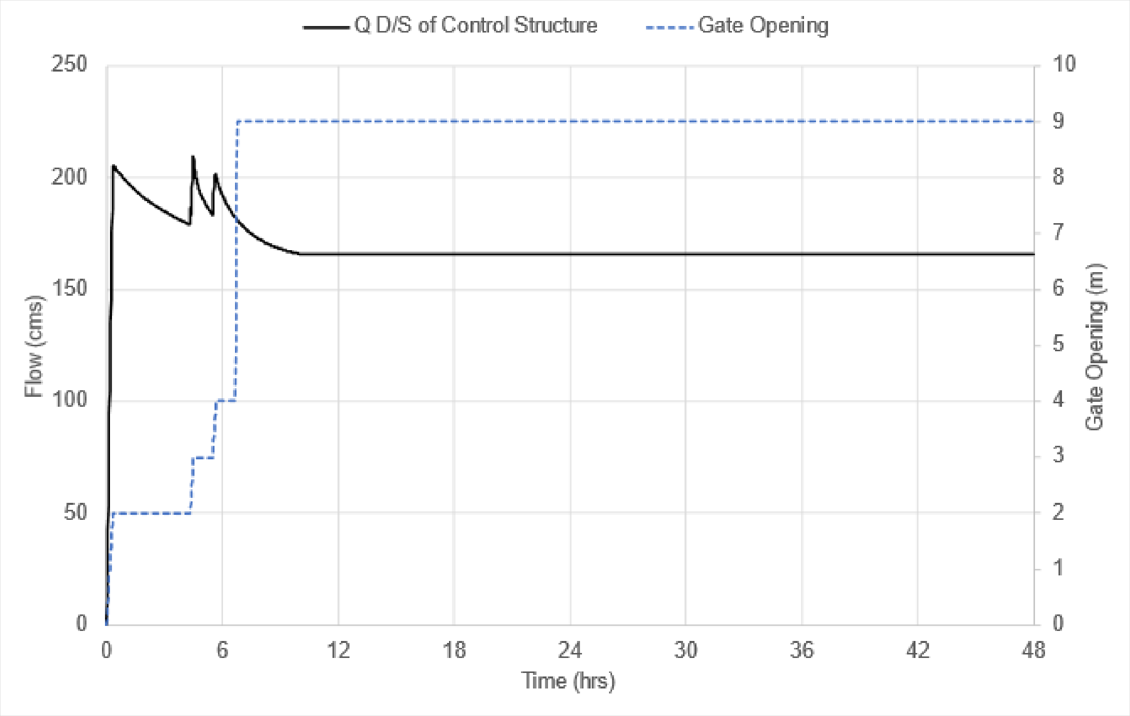


Figure 2-6: Base Case Scenario – Gate Opening and Flow

The Base Case scenario was developed to represent a project commissioning gate opening sequence that is optimized from a hydraulic perspective, with gates opened as quickly as possible while limiting the resulting downstream flood wave. However, such a scenario would represent a “worst case” sediment transport condition since the gates are still opened relatively quickly, resulting in a rapid increase in channel velocities and shear stresses, thereby mobilizing and transporting a significant amount of the initial sediment thickness remaining in the channel after construction.

This scenario was represented in the MIKE21 model, and the sediment transport results are presented later in Section 3.1. Note that the MIKE21 model was initialized from a “gates closed” configuration where the Lake Manitoba and Lake St. Martin water surface elevations are set to 247.35 m (811.5 ft) and 243.38 m (798.5 ft), respectively, and the initial 5 mm sediment thickness is applied uniformly throughout the channel. As noted previously, HEC-RAS water level, velocity, and discharge results from the Base Case scenario were used as boundary conditions at the control structure for the Upstream and Downstream MIKE21 models. All sediment eroded and mobilized from the Upstream MIKE21 model is added as a sediment inflow at the upstream extent of the Downstream MIKE21 model, thereby representing passage of sediment through the control structure. It is assumed that no sediment is retained by the control structure (i.e., all sediment mobilized upstream of the control structure passes through the gates and continues into the Downstream reach).

2.3.3 *Closed to 1 m Open*

In addition to the Base Case scenario described above, it was determined that smaller gate openings should also be analyzed in order to examine the corresponding sediment erosion and transport response. A smaller controlled gate opening scenario was developed to determine the degree to which the release of sediment from the LMOC could be managed by gate operations during commissioning.

A “Closed to 1 m Open” scenario was developed wherein all three control structure gates are raised from fully closed to 1 m open at a rate of 0.1 m/min. Figure 2-7 illustrates this gate opening sequence, simulated using HEC-RAS, and corresponding flow through the control structure.

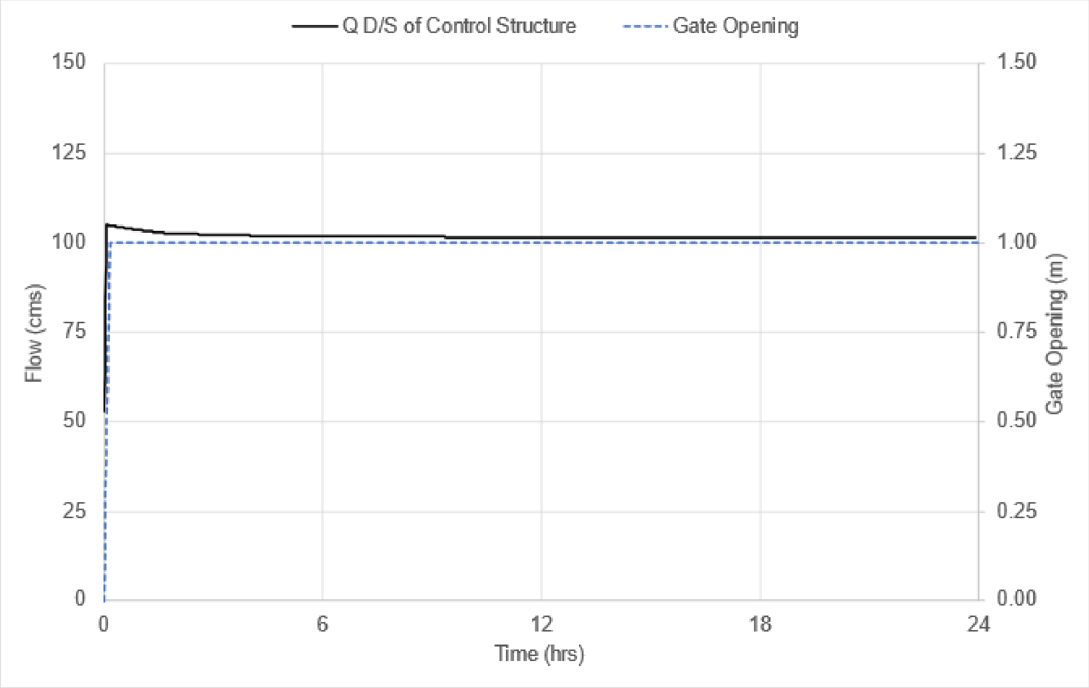


Figure 2-7: Closed to 1 m Open Scenario – Gate Opening and Flow

This scenario was also represented in the MIKE21 model; sediment transport results are shown in Section 3.2. Note that while Figure 2-7 illustrates the 1 m gate opening being held for 24 hours, MIKE21 modeling iterations and examination of TSS results led to the gates continuing to be held at 1 m gate open for a total of 168 hours (7 days). As with the Base Case scenario, the MIKE21 models for the "Closed to 1 m Open" scenario were initialized from a "gates closed" configuration (Lake Manitoba and Lake St. Martin water surface elevations at 247.35 m [811.5 ft] and 243.38 m [798.5 ft], respectively), and the initial 5 mm sediment thickness is applied uniformly throughout the channel.

HEC-RAS water level, velocity, and discharge results were used as boundary conditions at the control structure for the Upstream and Downstream MIKE21 models. All sediment eroded and mobilized from the Upstream MIKE21 model is added as a sediment inflow at the upstream extent of the Downstream MIKE21 model, thereby representing passage of sediment through the control structure. It is assumed that no sediment is retained by the control structure (i.e., all sediment mobilized upstream of the control structure passes through the gates and continues into the Downstream reach).

2.3.4 Open 1 m to 1.5 m

The "Closed to Open 1 m" scenario was expanded upon by further increasing the gate openings to 1.5 m. This was assumed to occur following 7 days at a 1 m opening, with the gates being raised an additional 0.5 m at a rate of 0.1 m/min. Figure 2-8 illustrates the gate opening sequence and corresponding flow downstream of the control structure (from analysis in HEC-RAS). Note that the time scale begins at 168 hours to represent the continuation from the "Closed to 1 m Open" scenario.

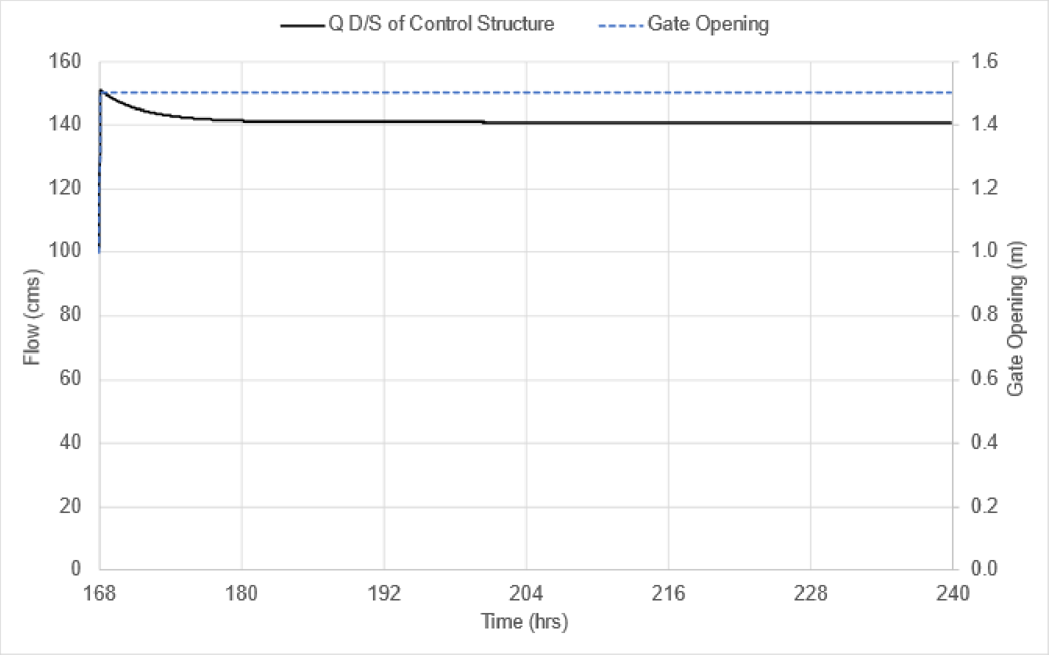


Figure 2-8: Open 1 m to 1.5 m Scenario – Gate Opening and Flow

This scenario was also represented in the MIKE21 model; sediment transport results are shown in Section 3.3. Note that the MIKE21 model for the “Open 1 m to 1.5 m” was initialized from the end point of the “Closed to 1 m Open” scenario, thereby creating a continuous 11 day scenario wherein the control structure gates are operated as follows:

- 0-1 m open (0.1 m/min), hold for 168 hours (7 days)
- 1-1.5 m open (0.1 m/min), hold for 96 hours (4 days).

In this case, the MIKE21 model was not initialized with a 5 mm sediment thickness, but with the thickness of sediment remaining following the 7 day simulation of the “Closed to 1 m Open” scenario. Similarly, hydraulic conditions (i.e., water levels and velocities) at the start of the “Open 1 m to 1.5 m” scenario simulation were taken from the final timestep of the “Closed to 1 m Open” scenario. Again, HEC-RAS water level, velocity, and discharge results from the “Open 1 m to 1.5 m” scenario were used as boundary conditions at the control structure. All sediment eroded and mobilized from the Upstream MIKE21 model is added as a sediment inflow at the upstream extent of the Downstream MIKE21 model, thereby representing passage of sediment through the control structure. It is assumed that no sediment is retained by the control structure (i.e., all sediment mobilized upstream of the control structure passes through the gates and continues into the Downstream reach).

3. Results and Discussion

The sediment management scenarios described in Section 2.3 were represented in the Upstream and Downstream MIKE21 models where both hydraulic and sediment transport calculations were performed over the full LMOC domain for each scenario. MIKE21 sediment transport results (i.e., streamflow and TSS concentrations) were extracted and analyzed for each scenario at a cross-section located approximately 900 m upstream of the channel’s confluence with Birch Bay. This location was used as the starting point of the Delft3D lake model, and the MIKE21 results from this location were input directly into the Delft3D model. The Delft3D model was used to analyze the dispersion and deposition of the sediment that exits the LMOC and enters Birch Bay under typical wind and wave conditions.

TSS concentration results from the MIKE21 model are plotted for both material types (medium silt and very fine sand) that were analyzed. In addition, a timeseries representing TSS concentrations for a hypothetical “60/40 weighted” material are also included, which is calculated as follows:

$$TSS_{60/40} = 0.6(TSS_{silt}) + 0.4(TSS_{sand})$$

The “60/40 weighted” results are used as a representative mid-point between the results for the selected medium silt and very fine sand material types used in MIKE21, with the assumption that the actual sediment remaining in the channel post-construction would be slightly more silty than sandy. This weighting is somewhat arbitrary, but is informed by the available geotechnical field data. As stated previously, the intent of using two distinct particle types/sizes in the MIKE21 analysis allows for the construction of an “envelope” of TSS concentrations within which the actual material could be expected to fall.

3.1 Base Case

3.1.1 Channel Modeling Results

The Base Case gate operation scenario was represented in the MIKE21 LMOC models and sediment transport results were extracted. Figure 3-1 illustrates TSS concentrations at a location 900 m upstream of the LMOC outlet under the Base Case operation scenario.

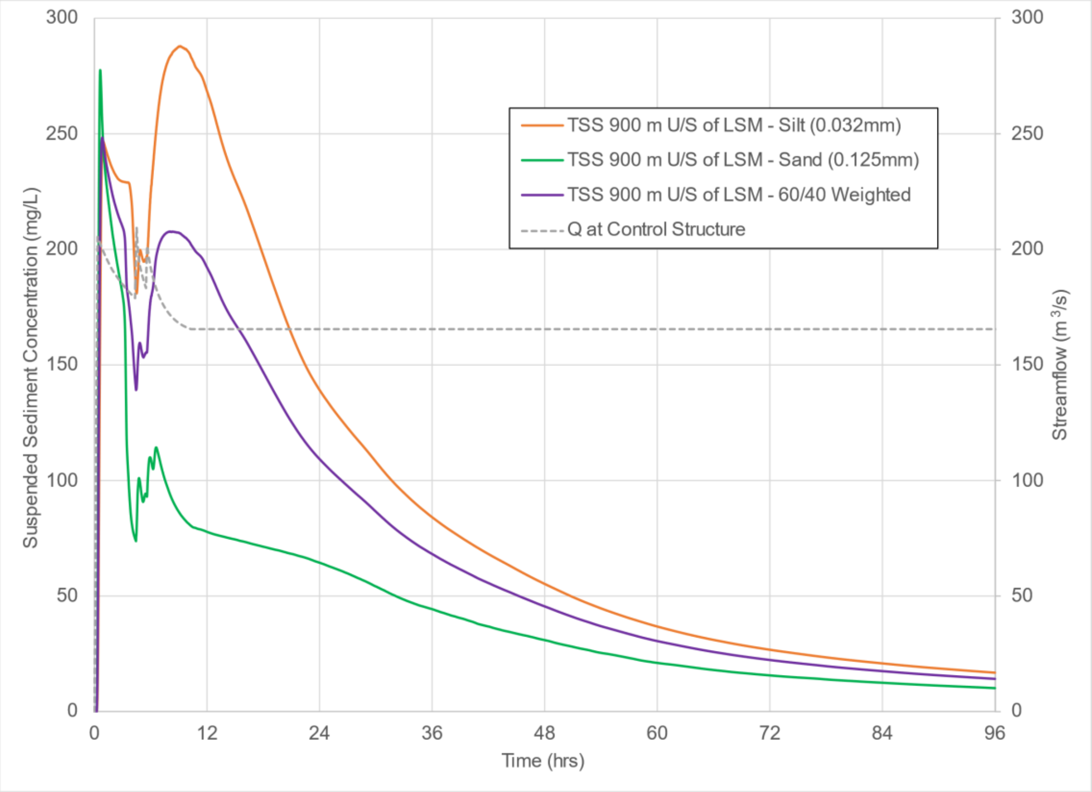


Figure 3-1: TSS Concentrations Near Channel Outlet – Base Case Scenario

MIKE21 results for the Base Case operation scenario illustrate TSS concentrations rapidly increasing as the gates are initially opened, with TSS concentrations for silt and sand reaching initial short term peaks of approximately 288 mg/l and 277 mg/l, respectively. Note that both materials exhibit an initial “spike” within the first hour of the gates’ initial operation, during which time the gates are opened 2 m from the closed position. This initial peak in sediment concentrations is predominantly from sediment being eroded and transported within the Downstream reach of the channel (i.e., downstream of the control structure). Much of the initial sediment layer is eroded from the downstream reach within this first hour, particularly in the case of the sand material, as velocities increase rapidly due to the gate operation.

Sediment erosion occurs somewhat more gradually within the Upstream reach as the gates are incrementally opened, which is represented by the secondary peak in TSS concentrations illustrated in Figure 3-1 (approximately 6 to 8 hours after the gates are first raised). The secondary peak in sediment concentration is significantly higher for the silt material than for the sand, likely due to the silt in the Upstream reach being mobilized more rapidly than the sand, while most of the Downstream sand material is rapidly transported out of the channel once the gates open initially. Additionally, there is a much higher TSS concentration of silt versus sand being transported from the Upstream reach. Sediment concentrations begin to recede as hydraulic conditions stabilize at the “full open” gate setting, with silt and sand TSS concentrations dropping below 25 mg/l after approximately 75 and 55 hours, respectively. TSS concentrations for silt and sand are reduced to approximately 17 and 10 mg/l, respectively, by the end of the 4 day simulation.

As noted previously, the Base Case gate operation scenario is deemed to represent a “worst case” scenario in terms of sediment transport due to the relatively rapid gate opening that results in significant sediment erosion and transport. However, it is noted that TSS concentrations are expected to remain below 300 mg/l under such a scenario, and that the suspended sediment concentrations passing into Birch Bay are expected to drop below 25 mg/l within approximately 3 days or less.

3.1.2 *Lake Modeling Results*

As noted in Section 2.2, the dynamic discharge and TSS results extracted from the MIKE21 model were applied to the Delft3D channel boundary, located 900 m upstream of the outlet.

A number of observation points were set up in the Delft3D model. Figure 3-2 and Figure 3-3 show timeseries comparisons of the TSS concentrations between the MIKE21 and Delft3D model results at the observation point located approximately 500 m upstream of the LMOC outlet, for the base case silt and sand scenarios, respectively. Also shown for reference is the TSS concentration determined from the MIKE21 model at a location 900 m upstream of the channel outlet. Although the Delft3D model appears to underestimate the initial spike captured by the MIKE21 model, the overall agreement is good. Differences during the first hours of the simulation are attributed to the absence of an erodible bed in the Delft3D model and may also be due to model spin-up time combined with the lower flow velocity at the model boundary compared to further along the channel where flows are fully developed. The MIKE21 model flow velocity is already fully developed when it reaches the 900 m upstream channel location.

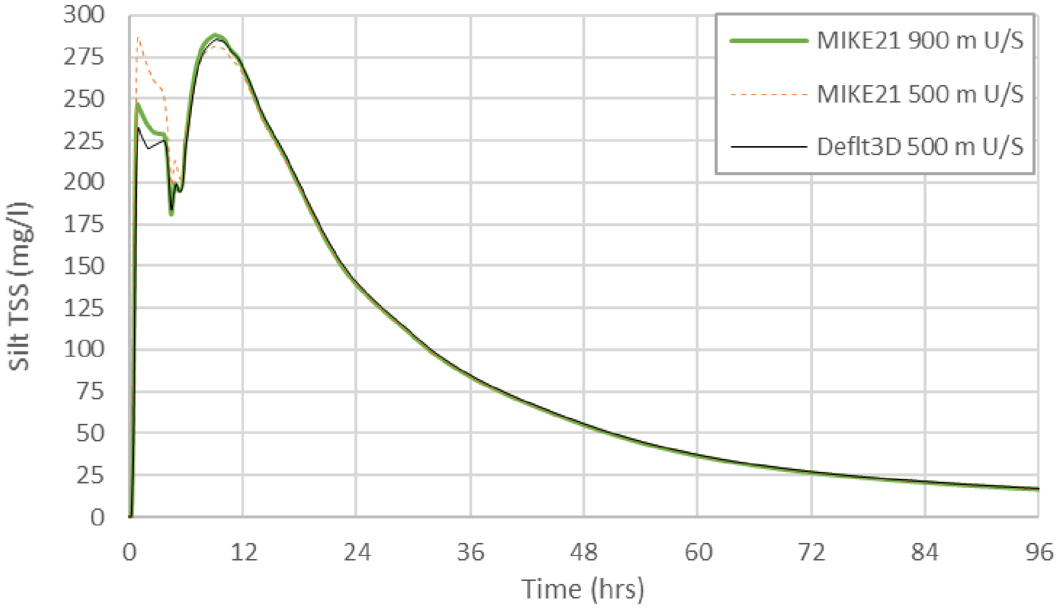


Figure 3-2: MIKE21 and Delft3D TSS Comparison Upstream of the Outlet Mouth – Base Case Scenario - Silt

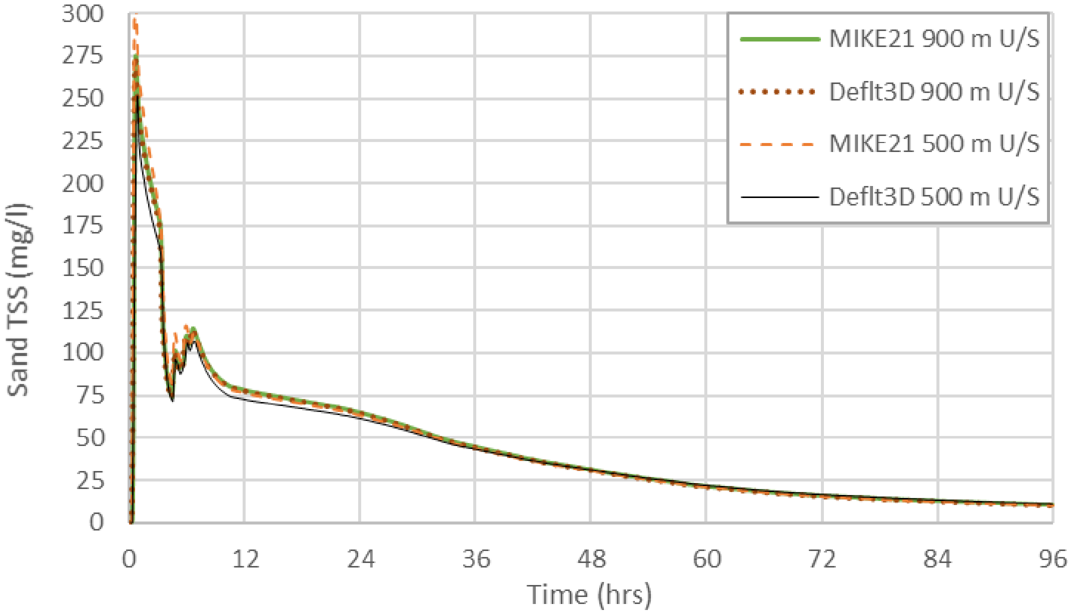


Figure 3-3: MIKE21 and Delft3D TSS Comparison Upstream of the Outlet Mouth – Base Case Scenario - Sand

Contour plots of the plume evolution over the 96-hour Delft3D simulation period, and of the total deposition at the end of the simulation, are presented in Figure 3-4 to Figure 3-7.

The model results for medium silt (Figure 3-4 and Figure 3-5) indicate that:

- During the first 24 hours, a daily average TSS concentration of ~210 mg/l enter Birch Bay. At the end of the 24-hour period, concentrations decrease by approximately 30%, with average concentrations of ~150 mg/l at the outlet mouth.
- By the end of the 96-hour simulation, TSS concentrations entering Birch Bay have decreased to approximately 20 mg/l.
- The sediments that have entered Birch Bay have deposited over an area of approximately 2.3 km^2, indicating that this is the approximate extent of the sediment plume under the simulated wind condition.
- Localized maximum depositions thickness of 2-4 cm are found at an approximate distance of 500 m from the outlet.

The model results for very fine sand (Figure 3-6 and Figure 3-7) indicate that:

- During the first 24 hours, a daily average TSS concentration of ~70 mg/l enters Birch Bay. At the end of the 24 hour period, concentration decreases by approximately 30%, with average concentrations of ~50 mg/l at the outlet mouth.
- By the end of the 96-hour simulation, TSS concentration entering Birch Bay have decreased to approximately ~15 mg/l.
- Sand material is readily deposited as it enters Birch Bay over an area of approximately 0.1 km^2, with localized thickness of up to approximately 6 cm.

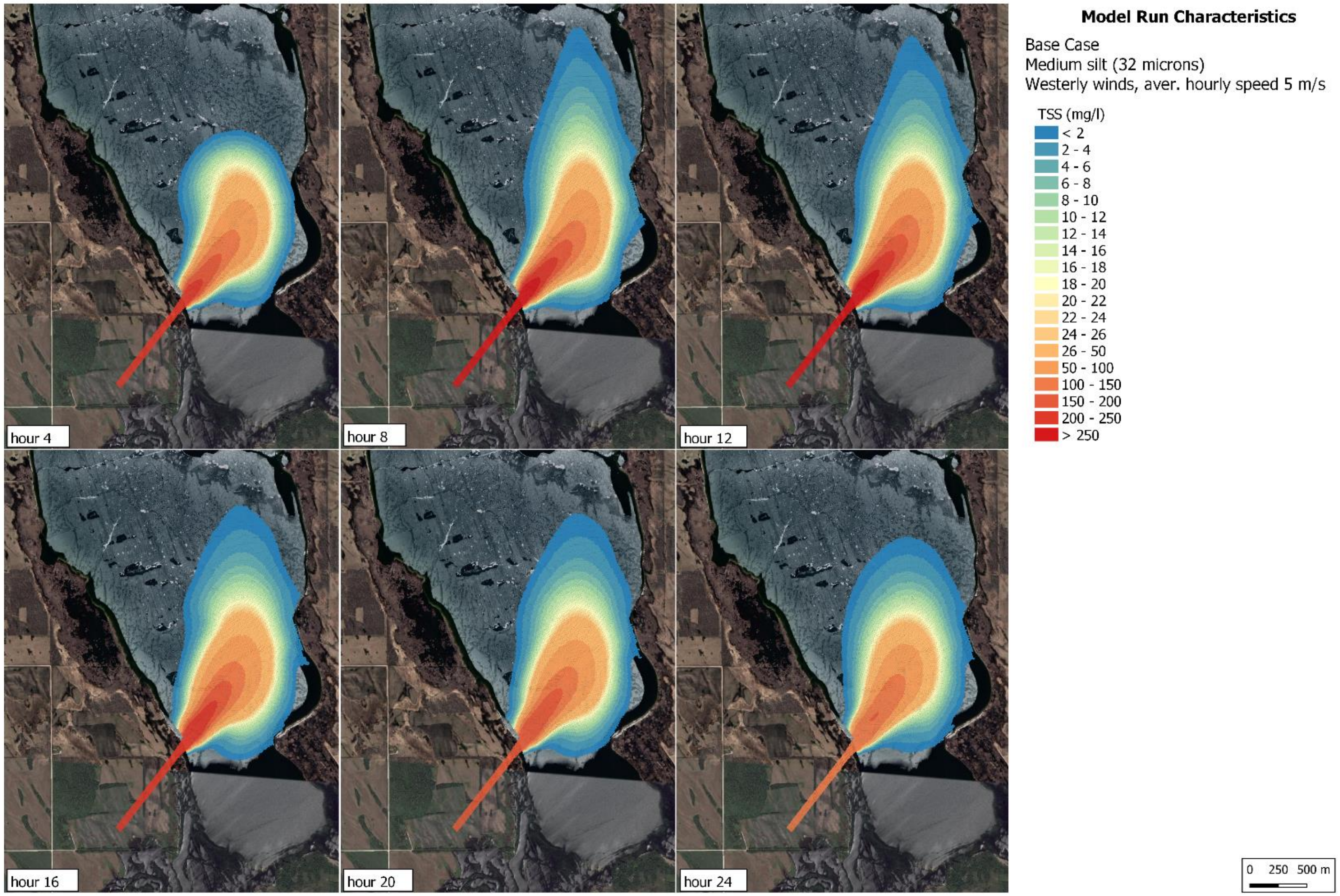


Figure 3-4: 24-hour Sediment Dispersion Plume Contours – Base Case, Silt Fraction

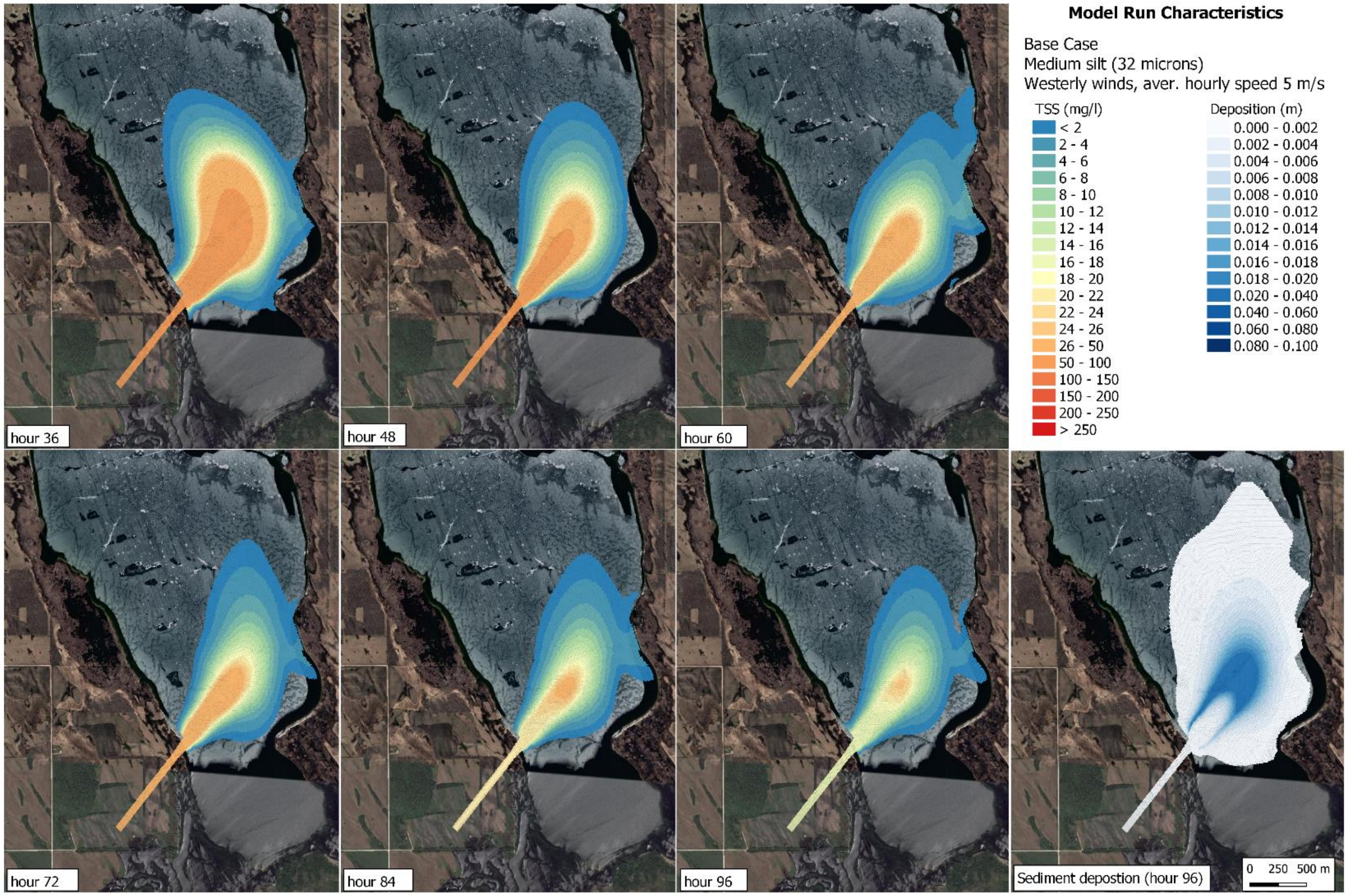


Figure 3-5: 96-hour Sediment Dispersion Plume Contours and Deposition – Base Case, Silt Fraction

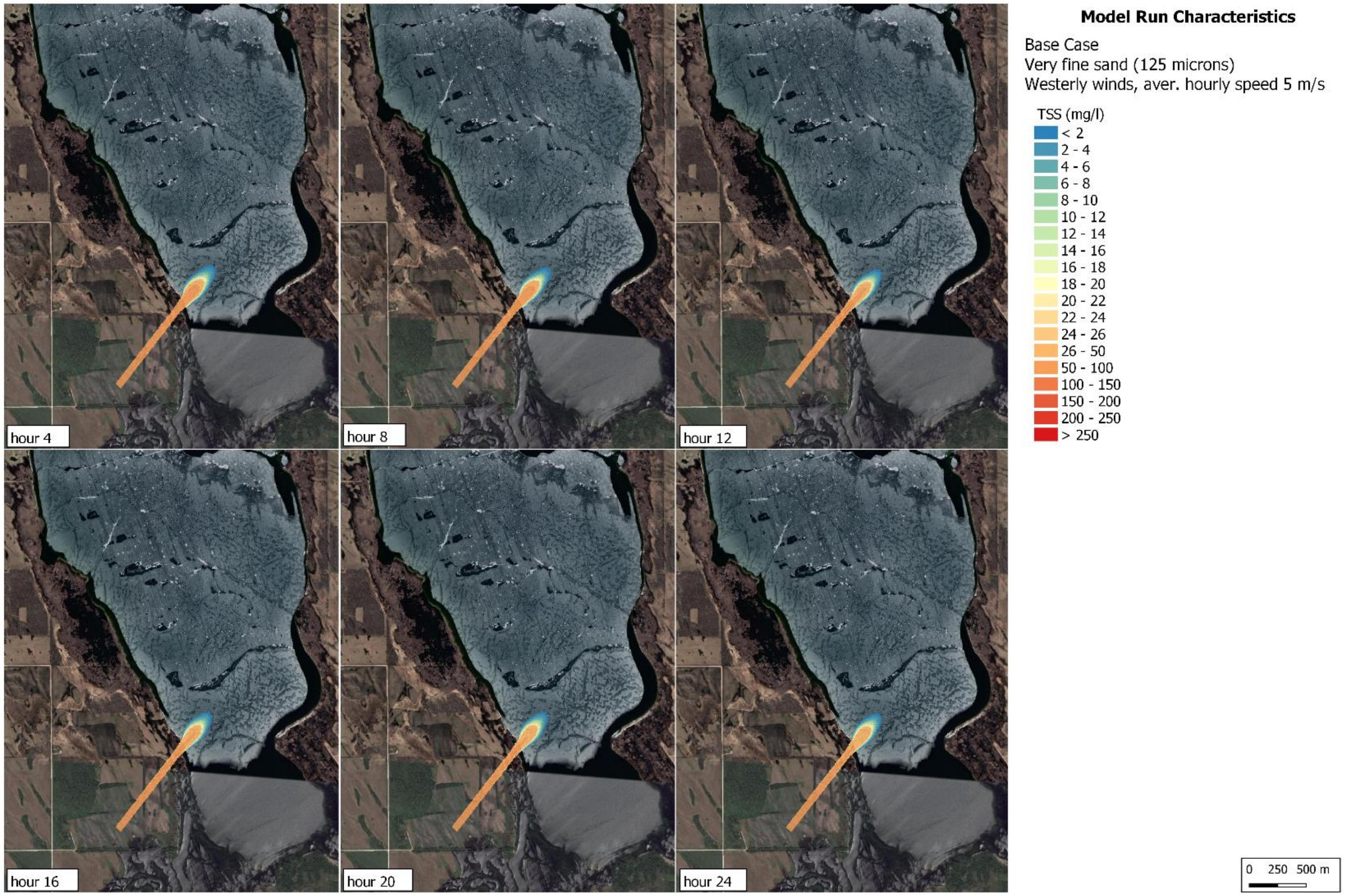


Figure 3-6: 24-hour Sediment Dispersion Plume Contours – Base Case, Sand Fraction

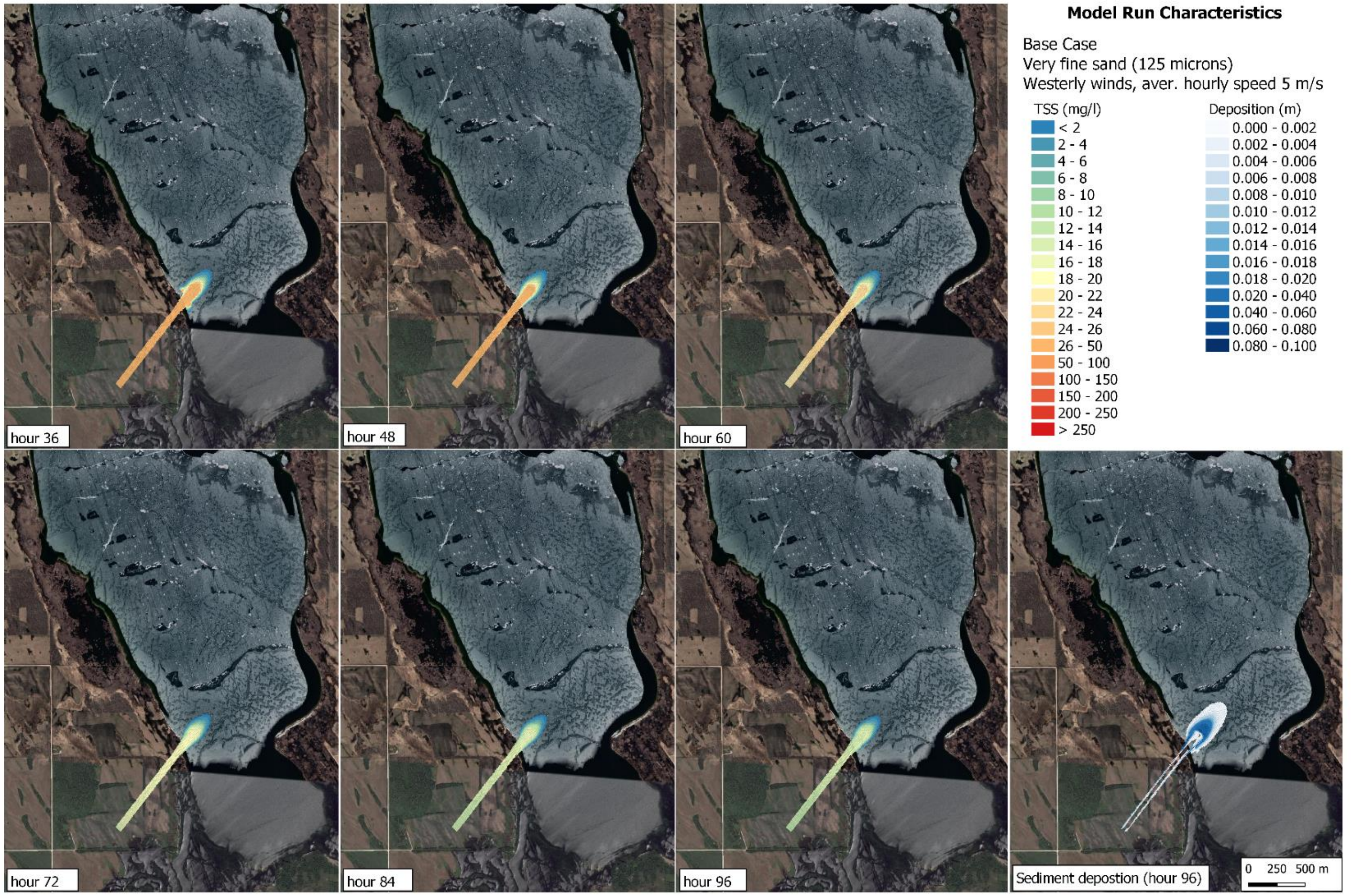


Figure 3-7: 96-hour Sediment Dispersion Plume Contours and Deposition – Base Case, Sand Fraction

3.2 Closed to 1 m Open Scenario

3.2.1 Channel Modeling Results

The “Closed to 1 m Open” gate operation scenario was represented in the MIKE21 LMOC models and sediment transport results were extracted. As noted previously, this scenario was developed to examine the TSS concentrations that result from opening the WCS gates from a closed to a 1 m open position. This scenario is intended to examine the degree to which sediment concentrations could be controlled using a more gradual gate opening sequence as compared to the Base Case scenario. Figure 3-8 illustrates simulated TSS concentrations at a location 900 m upstream of the channel’s outlet into Birch Bay.

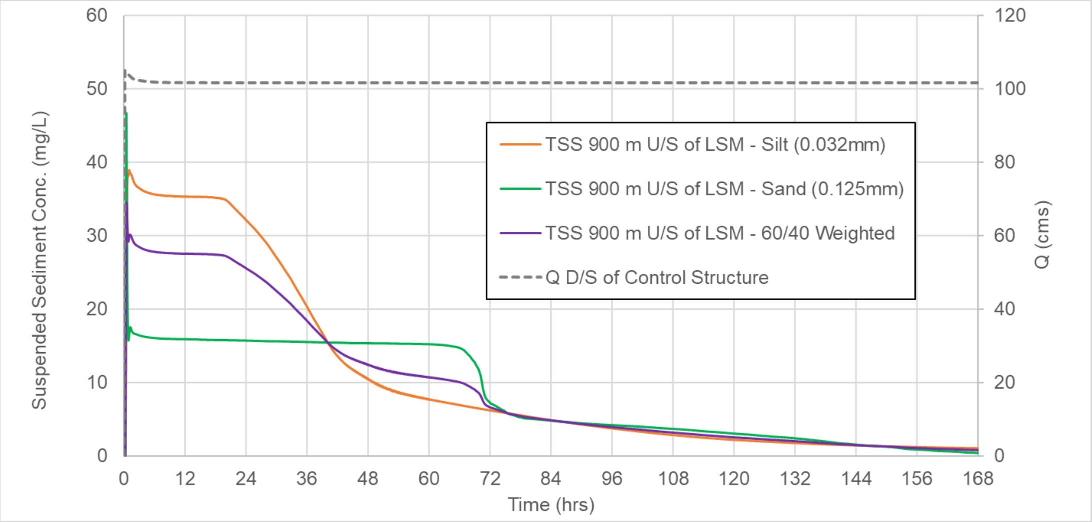


Figure 3-8: TSS Concentrations near Channel Outlet – “Closed to Open 1 m” Scenario

MIKE21 results from the “Closed to 1 m Open” scenario illustrate a rapid initial increase in TSS concentrations for both the silt and sand materials as the control structure gates are opened. The initial short-term TSS concentrations for the silt and sand materials peak at approximately 39 mg/l and 47 mg/l, respectively. Following these peaks, TSS concentrations stabilize at approximately 35 mg/l for silt, and just under 16 mg/l for sand. TSS concentrations for silt begin to recede after approximately 20 hours while the sand TSS concentration holds steady at just under 16 mg/l for approximately 65 hours before beginning to recede. The silt particles erode at a quicker rate under the applied shear stress than that of the sand. As such, more time is required for the sand particles to be mobilized from the channel bed. After three days, however, both particles converge to a similar lower TSS concentration and travel downstream. TSS concentrations for both materials drop below 2 mg/l after the full 7 day simulation.

Note that an examination of MIKE21 results showed that very little sediment is mobilized in the Upstream reach under the 1 m opening scenario; the vast majority of sediment reaching the channel outlet is being eroded within the Downstream reach. This result, combined with the low TSS concentrations simulated following the “Closed to 1 m Open” scenario, led to the determination that an appropriate sediment management approach could be to open the gates by a small amount to “flush” the sediment remaining in the Downstream reach before gradually raising the gates higher to begin mobilizing sediment in the Upstream reach in a controlled fashion.

The actual gate operation strategy applied during commissioning may be further refined, but is noted that the 1 m gate opening scenario results in TSS concentrations dropping below the 25 mg/l target after 1 to 2 days. Nevertheless, the end of the 7 day “Closed to 1 m Open” simulation was deemed an appropriate point to further raise the gates, given the near-zero TSS concentrations estimated following this 1 week period. It was determined through intermediate analyses that raising the gates further – to 1.5 m, in this case – would begin to mobilize some of the Upstream sediment and would therefore represent an appropriate next increment in the potential gate opening strategy during commissioning.

3.2.2 Lake Modeling Results

As noted in Section 2.2.2, the Delft3D model was run for 96-hour compared to the 7 days of the MIKE21 model. The selection of a shorter simulation period was driven by TSS concentrations having reached approximately 5 mg/l in the MIKE21 model as shown in Figure 3-8, and the longer modeling run times required for the Delft3D model due to the size of the model domain and the interaction between flows and waves.

Figure 3-9 and Figure 3-10 show timeseries comparisons of the TSS concentrations between the MIKE21 and Delft3D model results at the observation point located approximately 500 m upstream of the LMOC outlet, for the Closed to 1 m silt and sand scenarios, respectively. Also shown for reference is the TSS concentration determined from the MIKE21 model at a location 900 m upstream of the channel outlet. Contrarily to the comparisons performed on the Base Case scenario results, for this case, the Delft3D model shows variations in TSS compared to MIKE21. Despite the differences noted, by the end of the simulations, both models converge towards concentrations of approximately 5 mg/l for the silt and sand fraction.

The difference in results between the two models is manifested for a limited period of time due to the hydraulic conditions associated with the 1 m gate opening that approaches the critical shear stress threshold for particle movement. However, this initial difference in computed TSS does not change the overall sediment volume released into Birch Bay.

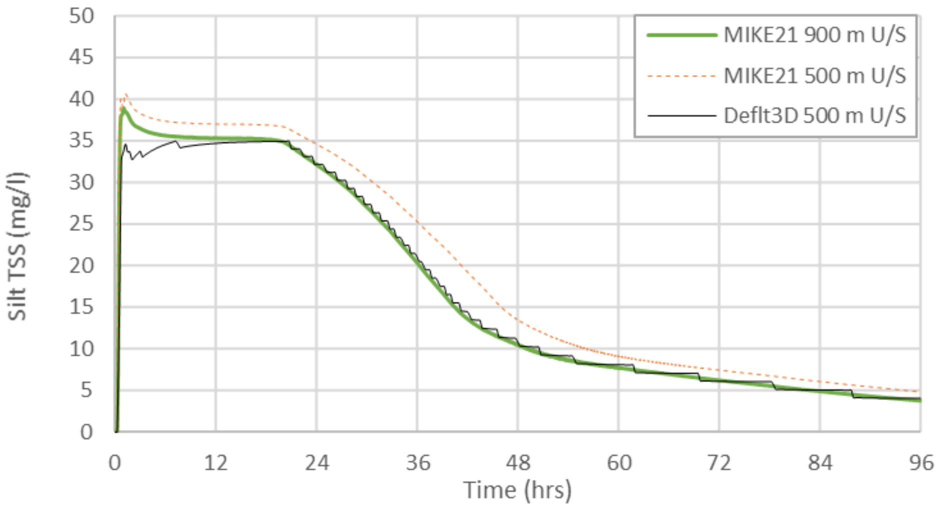


Figure 3-9: MIKE21 and Delft3D TSS Comparison Upstream of the Outlet Mouth – Closed to Open 1 m Scenario - Silt

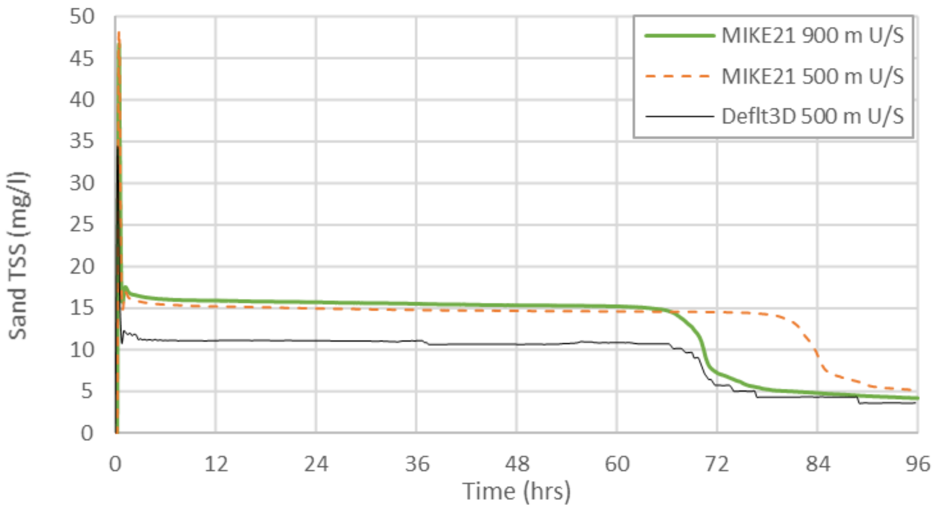


Figure 3-10: MIKE21 and Delft3D TSS Comparison Upstream of the Outlet Mouth – Closed to Open 1 m Scenario - Sand

Contour plots of the plume evolution over the 96-hour Delft3D simulation period, and of the total deposition at the end of the run, are presented in Figure 3-11 to Figure 3-14.

The model results for medium silt (Figure 3-11 and Figure 3-12) indicate that:

- During the first 24 hours, a daily average TSS concentration of ~30 mg/l enters Birch Bay. At the end of the 24 hour period, TSS concentrations remain unvaried.
- By the end of the 96-hour simulation, the majority of the material has deposited, leaving average TSS concentrations of 5 mg/l entering Birch Bay, as discussed above.

- Based on the area of the deposited material, the plume, which changes in direction based on wind direction and speed, reaches a maximum extent of approximate 1.0 km^2.
- The sediments deposited on the lakebed reach localized maximum layer thicknesses of approximately 0.6 cm.

The model results for very fine sand (Figure 3-13 and Figure 3-14) indicated that:

- During the first 24 hours, a daily average TSS concentration of approximately 5 mg/l is present at the outlet.
- Based on the area of the deposited material, the plume reached a maximum extent of approximately 0.03 km^2. The sediments deposited on the lakebed reach localized maximum layer thicknesses of approximately 0.4 cm.

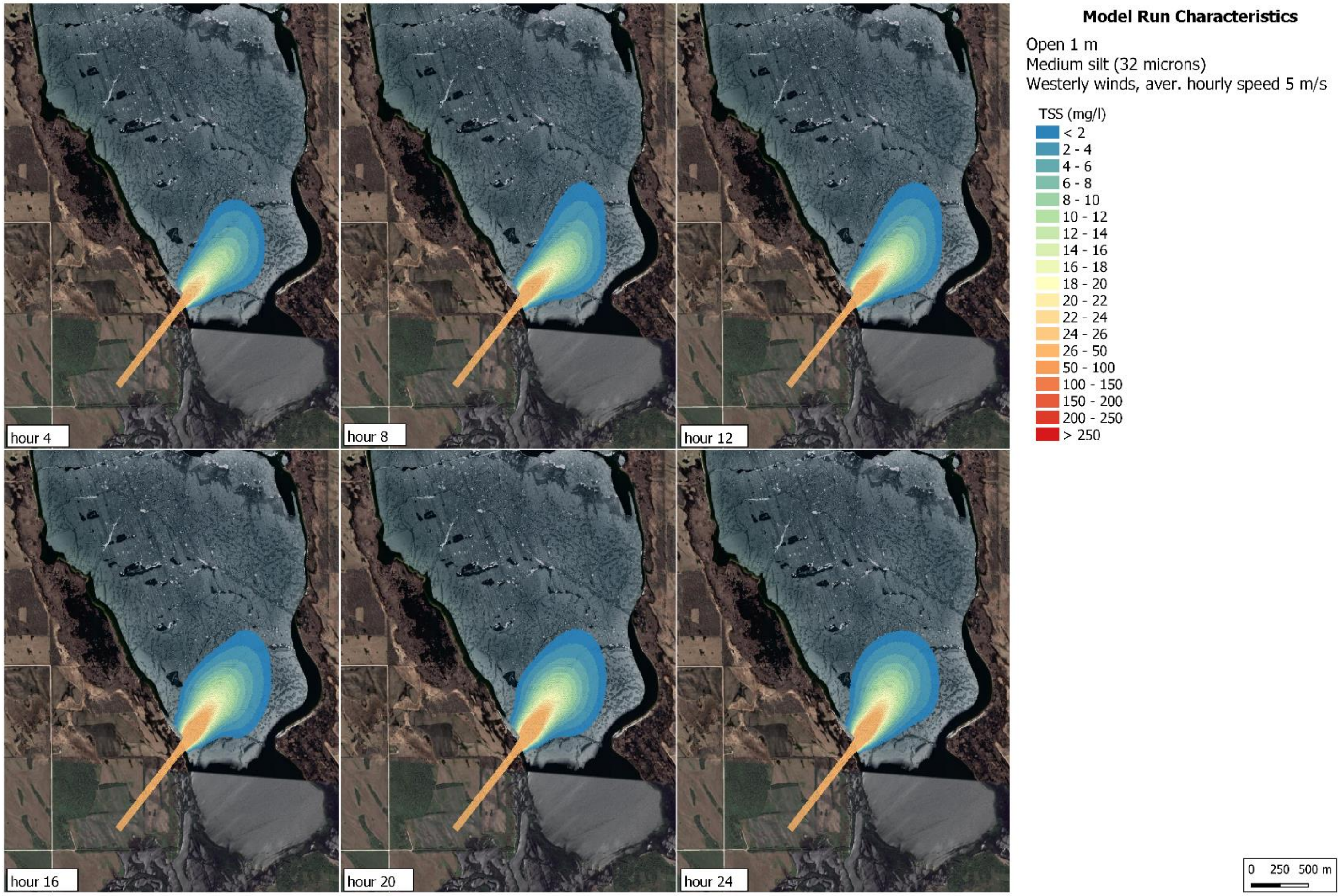


Figure 3-11: 24-hour Sediment Dispersion Plume Contours – Closed to Open 1 m Scenario, Silt Fraction

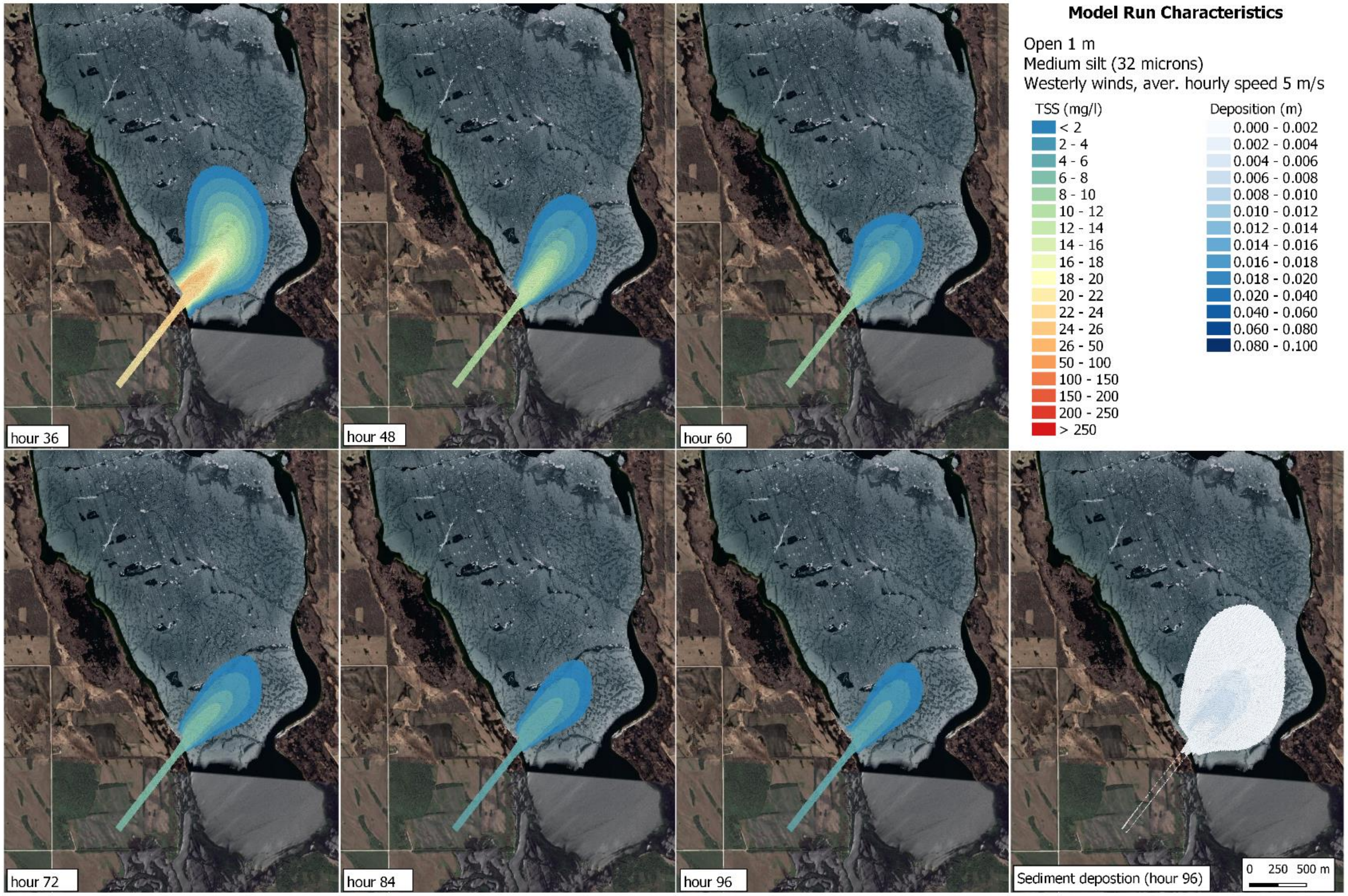


Figure 3-12: 96-hour Sediment Dispersion Plume Contours and Deposition – Closed to Open 1 m Scenario, Silt Fraction

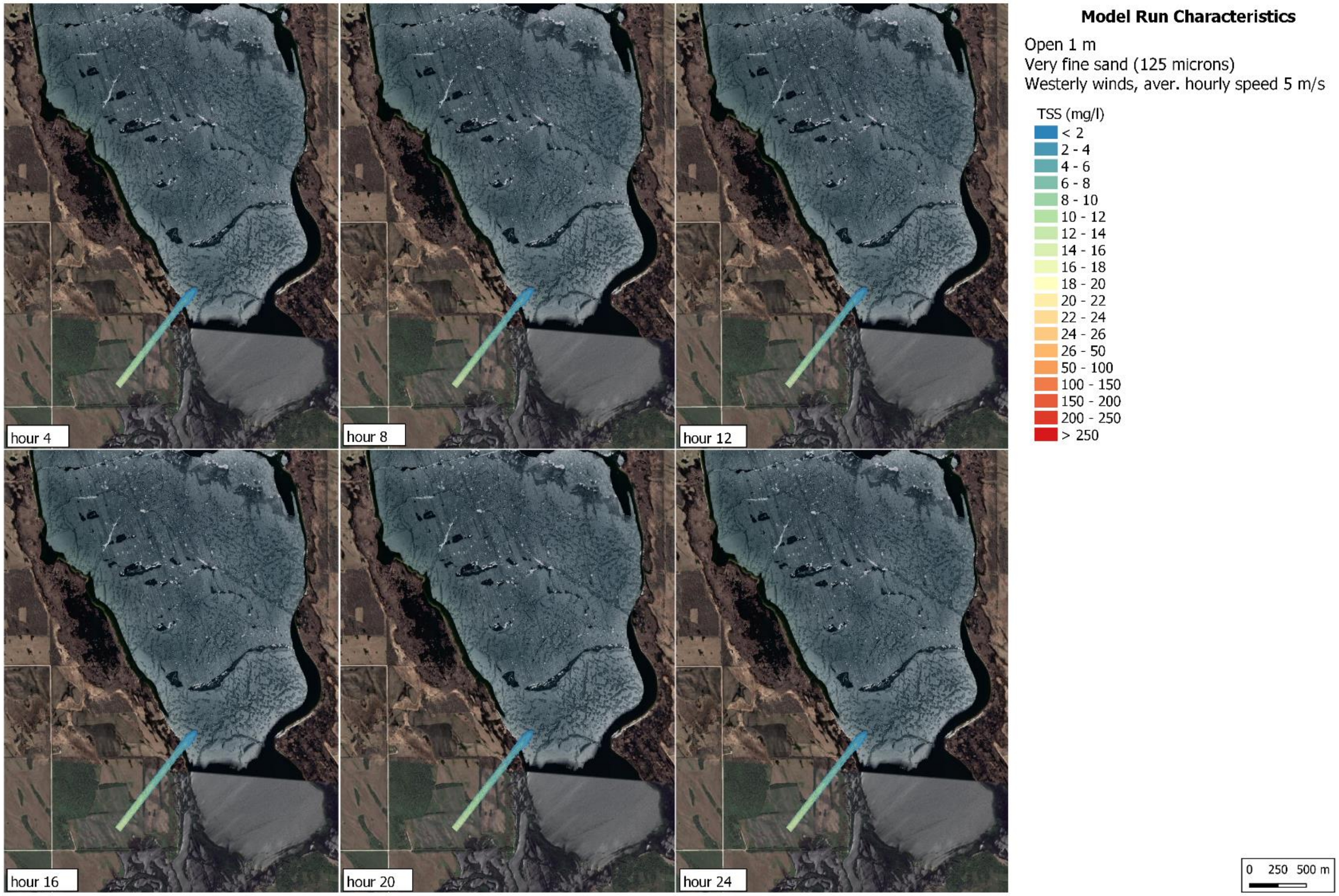


Figure 3-13: 24-hour Sediment Dispersion Plume Contours – Closed to Open 1 m Scenario, Sand Fraction

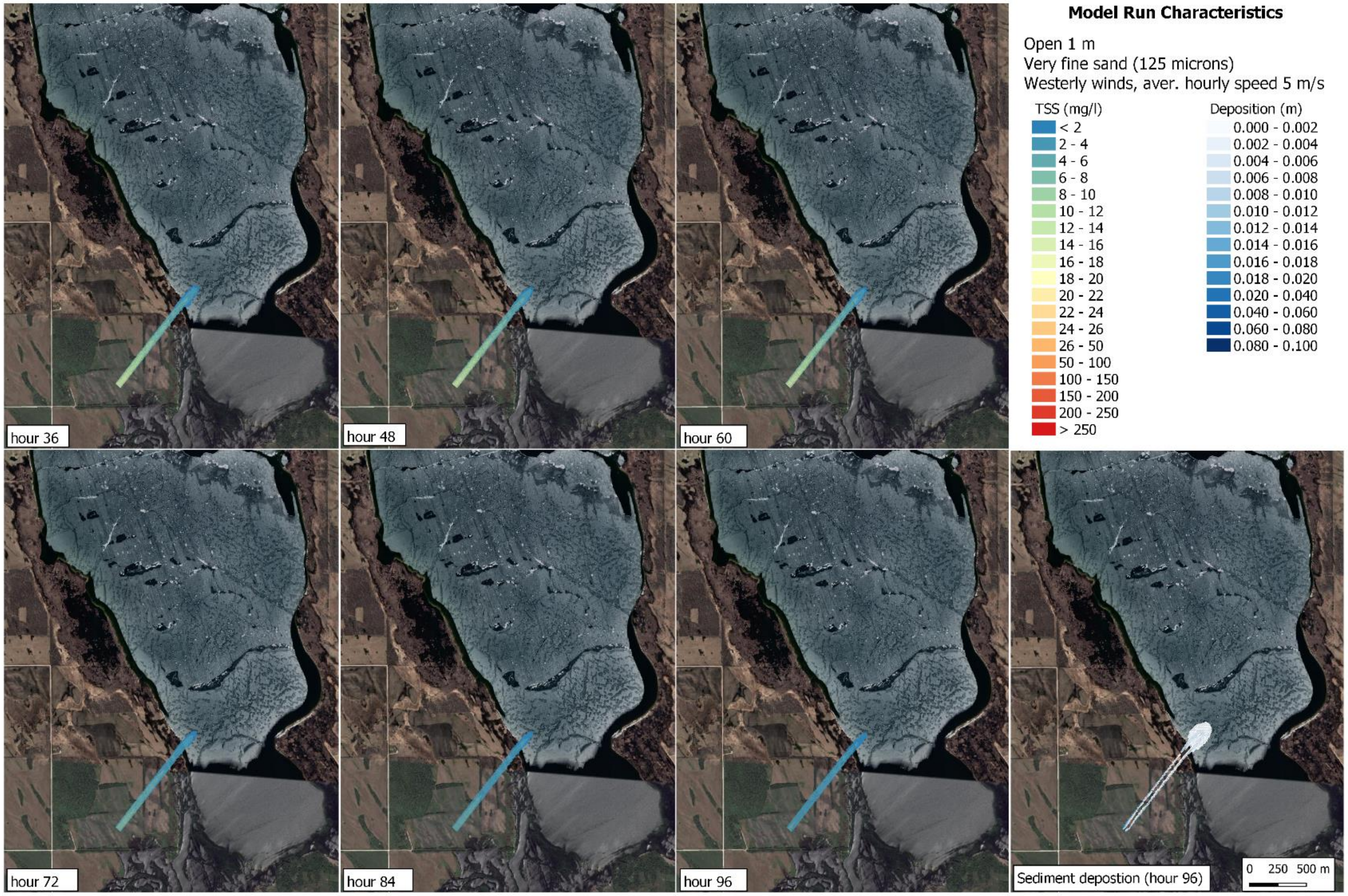


Figure 3-14: 96-hour Sediment Dispersion Plume Contours and Deposition – Closed to Open 1 m Scenario, Sand Fraction

3.3 Open 1 m to 1.5 m Scenario

3.3.1 Channel Modeling Results

The “Open 1 m to 1.5 m” gate operation scenario was represented in the MIKE21 LMOC models and sediment transport results were extracted. As noted previously, this scenario was intended to represent an extension of the “Closed to 1 m Open” scenario resulting in an overall gate opening sequence that reflects the gates first be raised from a closed to 1 m open position, holding at that setting for 7 days, and then raising the gates 0.5 m further for a total opening of 1.5 m. It was anticipated that this gate opening methodology would begin to mobilize sediment in the Upstream reach while maintaining TSS concentrations near the target daily average of 25 mg/l at the downstream end of the channel. Figure 3-15 illustrates simulated TSS concentrations at a location 900 m upstream of the channel’s outlet into Birch Bay under this scenario. Note that the x-axis (time, in hours) continues from the end point of the “Closed to 1 m Open” scenario described above in order to represent the continuous 11 day simulation.

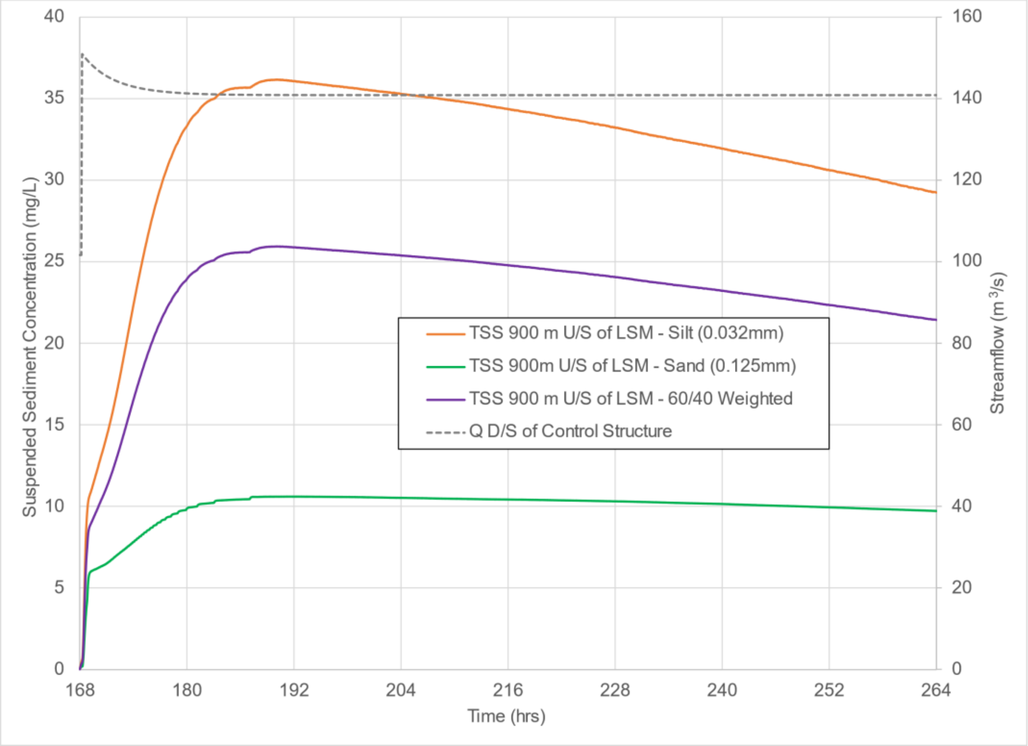


Figure 3-15: TSS Concentrations near Channel Outlet – “Open 1 m to 1.5 m” Scenario

The MIKE21 results show how TSS concentrations increase from near zero, where they ended after 7 days of operation at a 1 m gate opening, and reach peak concentrations of approximately 36 and 11 mg/l for silt and sand, respectively, about 20 hours after the gates are further raised to 1.5 m. The conceptual “60/40 weighted” material peaks at just over 25 mg/l. TSS concentrations then begin to slowly recede with final TSS concentrations for the silt and sand materials at the end of the full 11 day simulation (or 4 days with the gates at a 1.5 m opening) of approximately 29 and 9 mg/l, respectively.

TSS concentrations would continue to recede as the supply of loose sediment is depleted. Based on extrapolation of the rate of TSS recession, it would be expected that TSS concentrations would drop to approximately 5 and 7 mg/l after an additional 8 days (i.e., 19 days after the gates are initially opened).

3.3.2 Lake Modeling Results

Figure 3-16 and Figure 3-17 show timeseries comparisons of the TSS concentrations between the MIKE21 and Delft3D model results at the observation point located approximately 500 m upstream of the LMOC outlet, for the base case silt and sand scenarios, respectively.

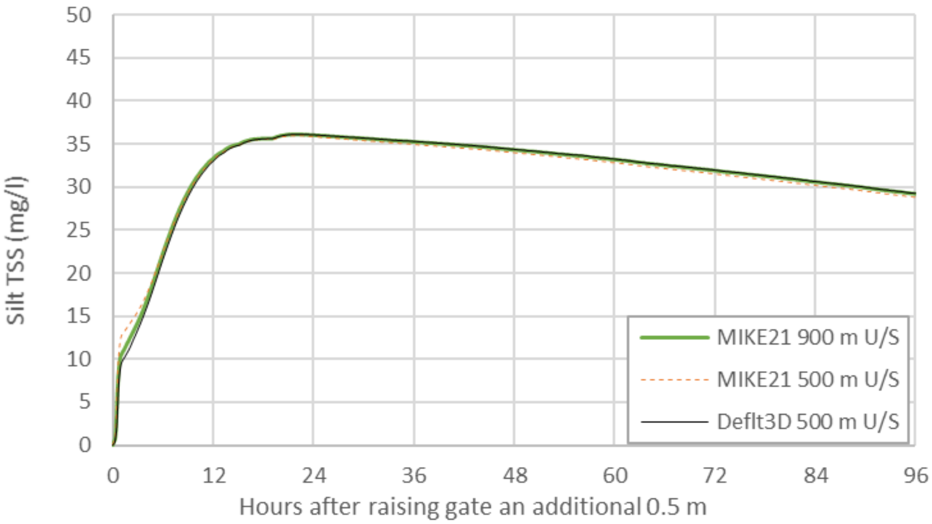


Figure 3-16: MIKE21 and Delft3D TSS Comparison Upstream of the Outlet Mouth – Open 1 m to 1.5 m Scenario - Silt

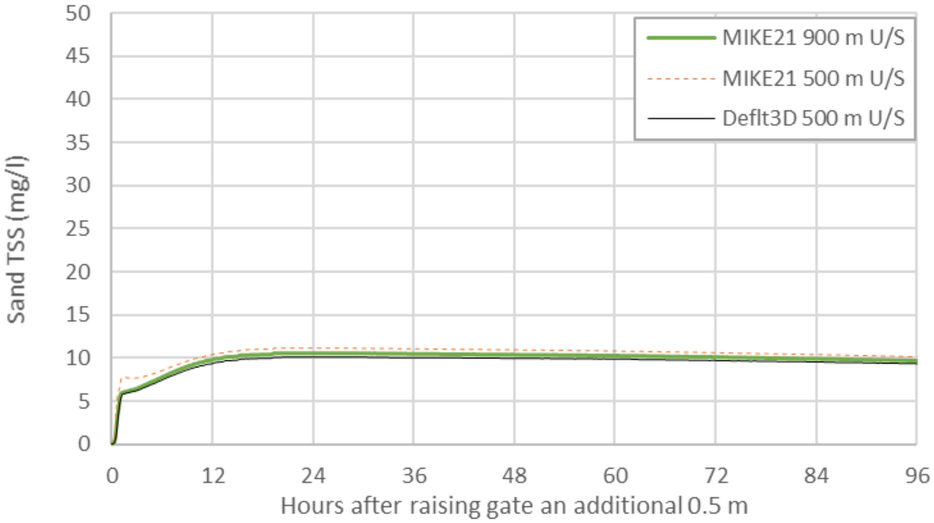


Figure 3-17: MIKE21 and Delft3D TSS Comparison Upstream of the Outlet Mouth – Open 1 m to 1.5 m Scenario - Sand

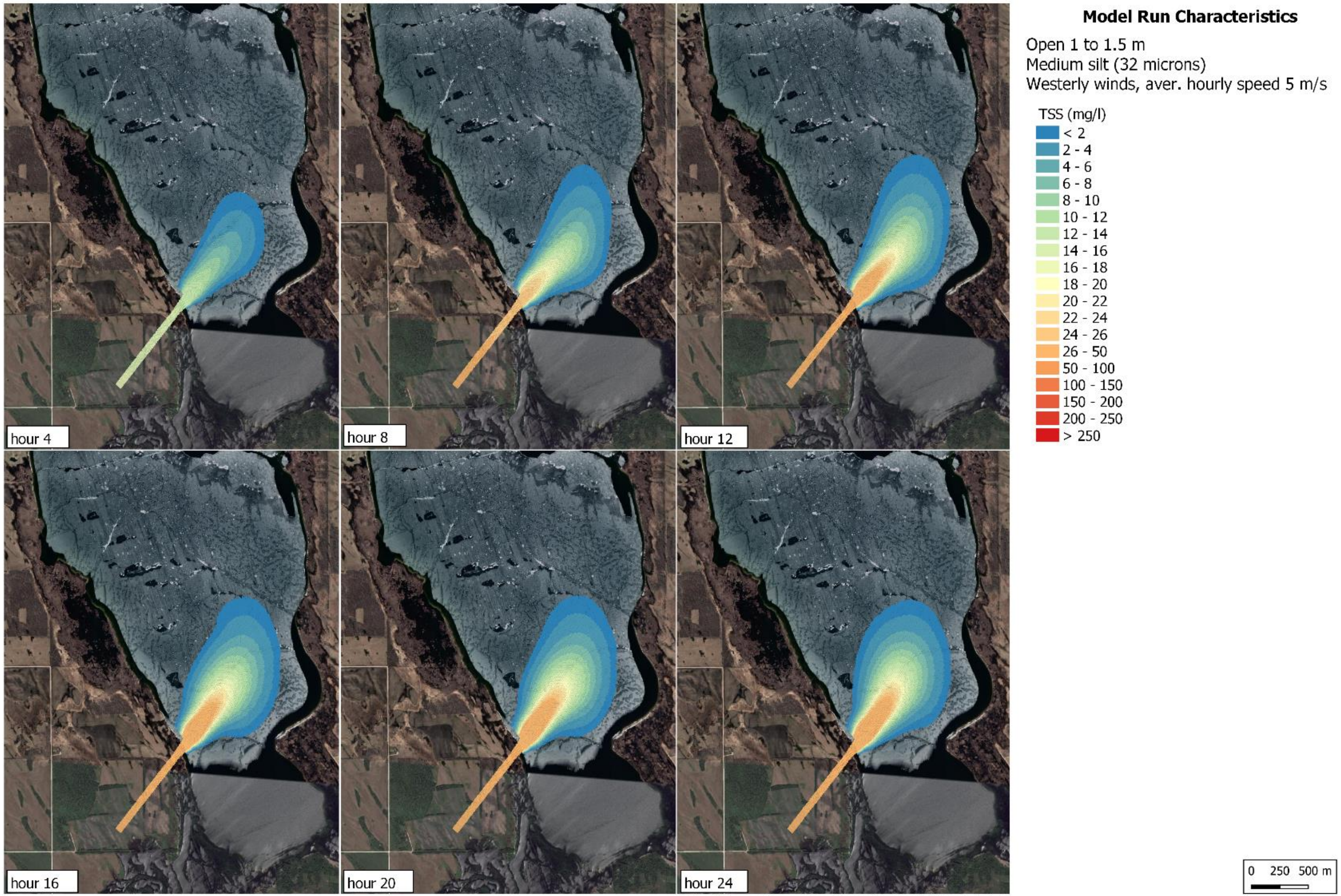
Contour plots of the plume evolution over the 96-hour Delft3D simulation period, and of the total deposition at the end of the run, are presented in Figure 3-18 to Figure 3-21.

The model results for medium silt (Figure 3-18 and Figure 3-19) indicate that:

- During the first 24 hours after the gates are raised by an additional 0.5 m, a daily average TSS concentration of ~20 mg/l enters Birch Bay. It is noted that concentrations in the first 4 hours do not exceed 16 mg/l and peak at approximately 36 mg/l after 20 hours. At the end of the 24 hour period, concentrations are still approximately 36 mg/l. By the end of the 96-hour simulation, TSS entering Birch Bay has not decreased significantly, with concentration still ranging around ~30 mg/l.
- Based on the area of the deposited material, the plume reaches a maximum extent of approximate 1.5 km^2. The sediment deposited on the lakebed reach localized maximum layer thicknesses of approximately 1.0 cm.

The model results for very fine sand fraction (Figure 3-20 and Figure 3-21) indicate that:

- During the first 24 hours, a daily average TSS concentration of ~7 mg/l enters Birch Bay. At the end of the 24 hour period, concentrations remain unvaried. By the end of the 96-hour simulation, TSS concentrations entering Birch Bay remain the same.
- Based on the area of the deposited material, the plume reached a maximum extent of approximate 0.06 km^2. The sediments deposited on the lakebed reached a maximum layer thickness of approximately 1.6 cm.



Note: Hours after raising the gate an additional 0.5 m

Figure 3-18: 24-hour Sediment Dispersion Plume Contours – Open 1 m to 1.5 m Scenario, Silt Fraction

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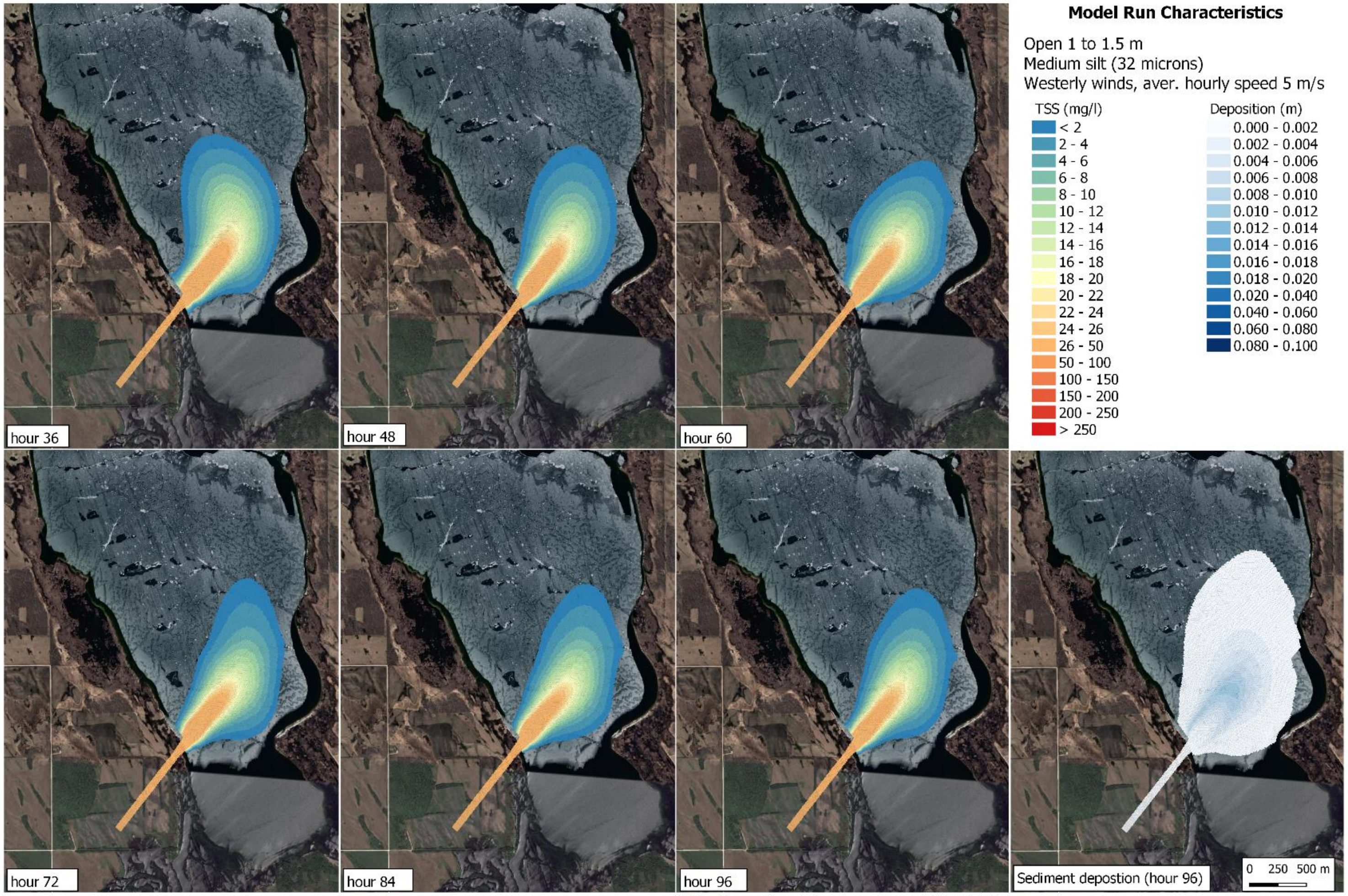
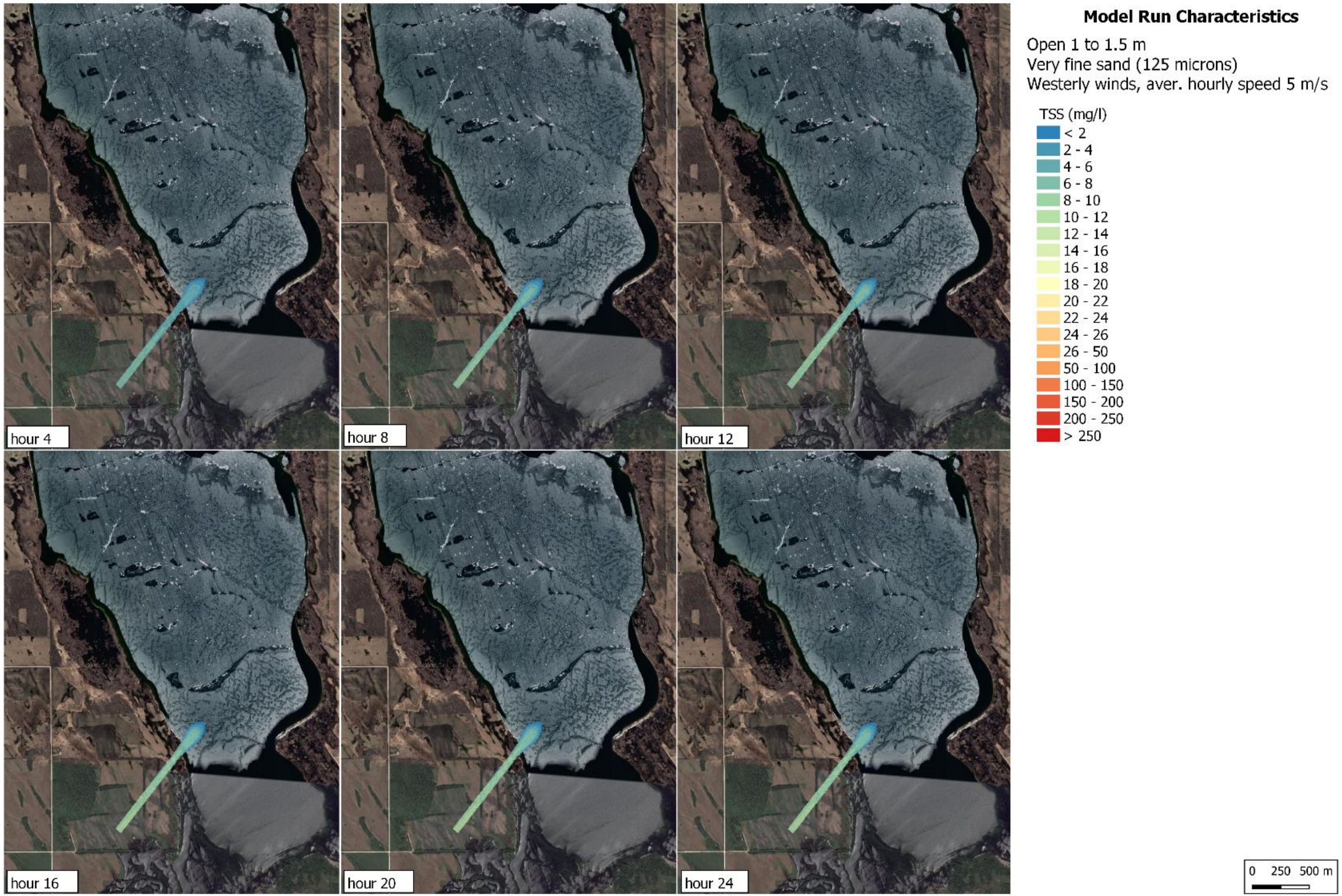


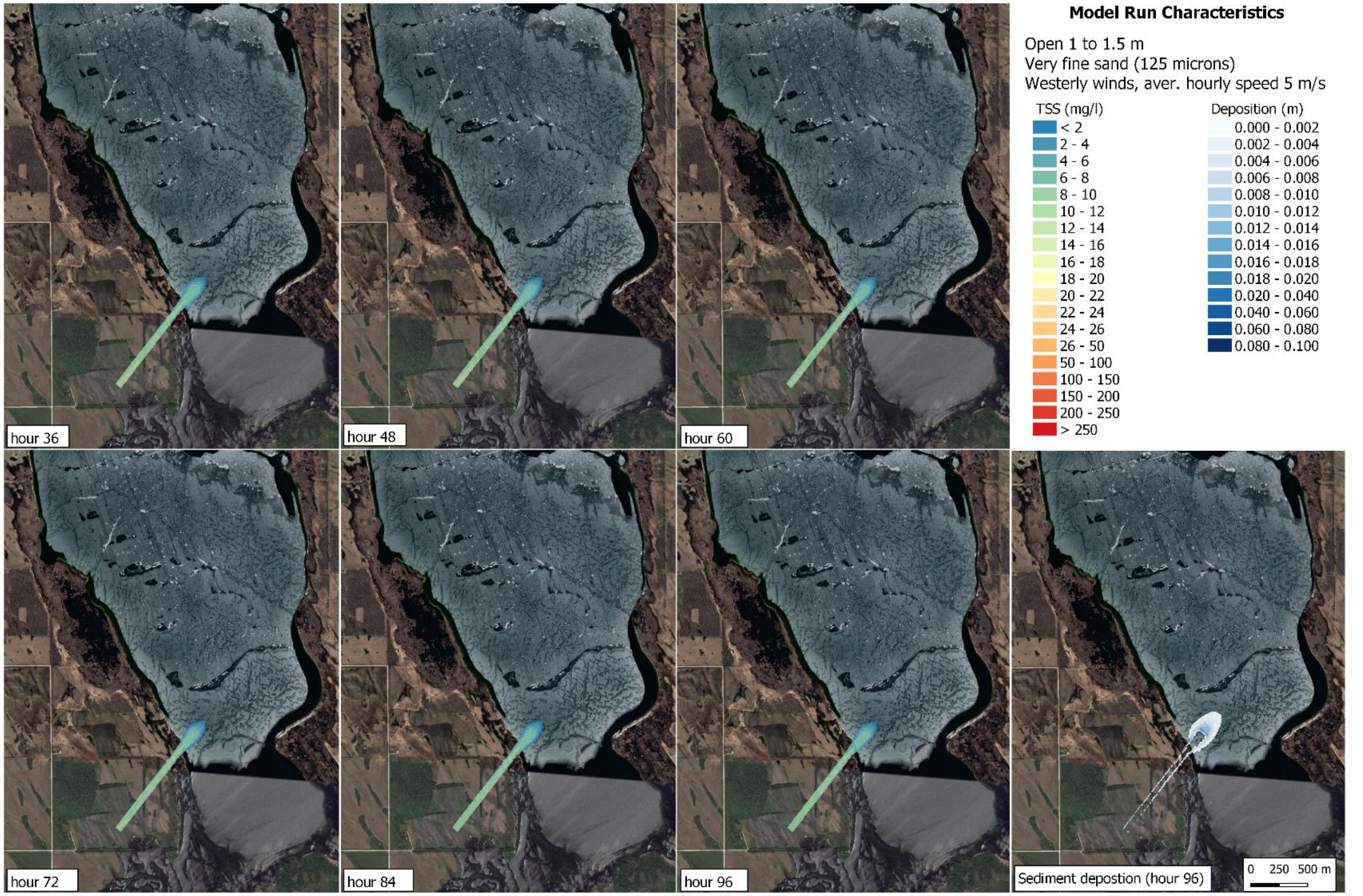
Note: Hours after raising the gate an additional 0.5 m

Figure 3-19: 96-hour Sediment Dispersion Plume Contours and Deposition – Open 1 m to 1.5 m Scenario, Silt Fraction



Note: Hours after raising the gate an additional 0.5 m

Figure 3-20: 24-hour Sediment Dispersion Plume Contours – Open 1 m to 1.5 m Scenario, Sand Fraction



Note: Hours after raising the gate an additional 0.5 m

Figure 3-21: 96-hour Sediment Dispersion Plume Contours and Deposition – Open 1 m to 1.5 m Scenario, Sand Fraction

3.4 Sediment Budget and Deposition

For the purposes of this analysis, an estimate of the total mass of sediment available for erosion and transportation during commissioning was based on the assumed 5 mm initial thickness being uniformly distributed over the base of the channel and side slopes up to the elevation of the steady-state water surface profile associated with the gates fully open. When taken over the length of the channel, this results in initial sediment coverage areas for the Upstream and Downstream reaches of approximately 1,300,000 m^2 and 200,000 m^2, respectively, resulting in a total initial sediment coverage area of 1,500,000 m^2, which also conservatively includes channel sections that would be protected by riprap. This coverage area was multiplied by the initial 5 mm layer thickness and then converted to total sediment mass using the assumed porosity and specific gravity values of 0.4 and 2.65, respectively, as described in Section 2.1.3.2. These calculations result in an estimated total mass of sediment that might be available for erosion/transport after construction of approximately 12,000 tonnes. This estimated value was compared against the sediment masses computed by the MIKE21 model that leave the channel to understand the proportion of the initially available sediment that becomes eroded and transported under the various commissioning scenarios analyzed.

As discussed in Section 2.1.3.2, two particle sizes (medium silt and very fine sand) were analyzed to develop a range of expected sediment quantities; results presented below reflect these ranges.

Model results for the Base Case gate operation scenario indicate that approximately 2,700 to 5,500 tonnes of the initial 12,000 tonnes of available loose material is flushed from the channel within 4 days.

Model results for the combined closed to 1.5 m open controlled gate opening scenarios indicate that approximately 1,200 to 2,400 tonnes of the initial 12,000 tonnes of available loose material is flushed from the channel within 11 days. Additional sediment will be mobilized as the gates are progressively raised until fully open, which is anticipated to result in an overall total mass of sediment transported into Birch Bay in the order of 5,000 tonnes over a duration of about 1 month from when the gates are initially opened. The rate at which the gates can be opened has not been optimized as part of this work, however, based on these findings, it is clear that the gate raising can be done in a manner to control the TSS concentrations, as required, which will be informed with real-time TSS monitoring data.

The difference between the total mass of sediment assumed to be available for transport and that actually transported into Birch Bay based on the model results is due to the lower velocities that are present along the upper channel side slopes which are not large enough to erode the sediment available in those areas. Additionally, the modeling results show that some of the material that is eroded from the channel is found to deposit progressively along lower portions of the channel side slopes in areas further downstream. Thus, there will likely be some sediment left within the channel following the initial operation during commissioning. It is possible that this sediment may become remobilized the next time the channel is operated. As such, controlled gate operations and monitoring may need to be performed to control TSS concentrations when the channel is put into operation in the future.

The total deposition in Birch Bay at the end of the 11 day combined closed to 1.5 m open scenarios (i.e., the Closed to 1 m followed by the Open 1 m to 1.5 m scenarios) is illustrated in Figure 3-22, which indicates a maximum deposition thickness between approximately 1.6 cm to 2.0 cm.

It should be noted that these sediment quantities are based on the assumption of a 5 mm thick layer of sediment being present after construction. However, the overall quantity of sediment will be dependent on the construction activities and level of cleanup performed prior to flooding of the channel.

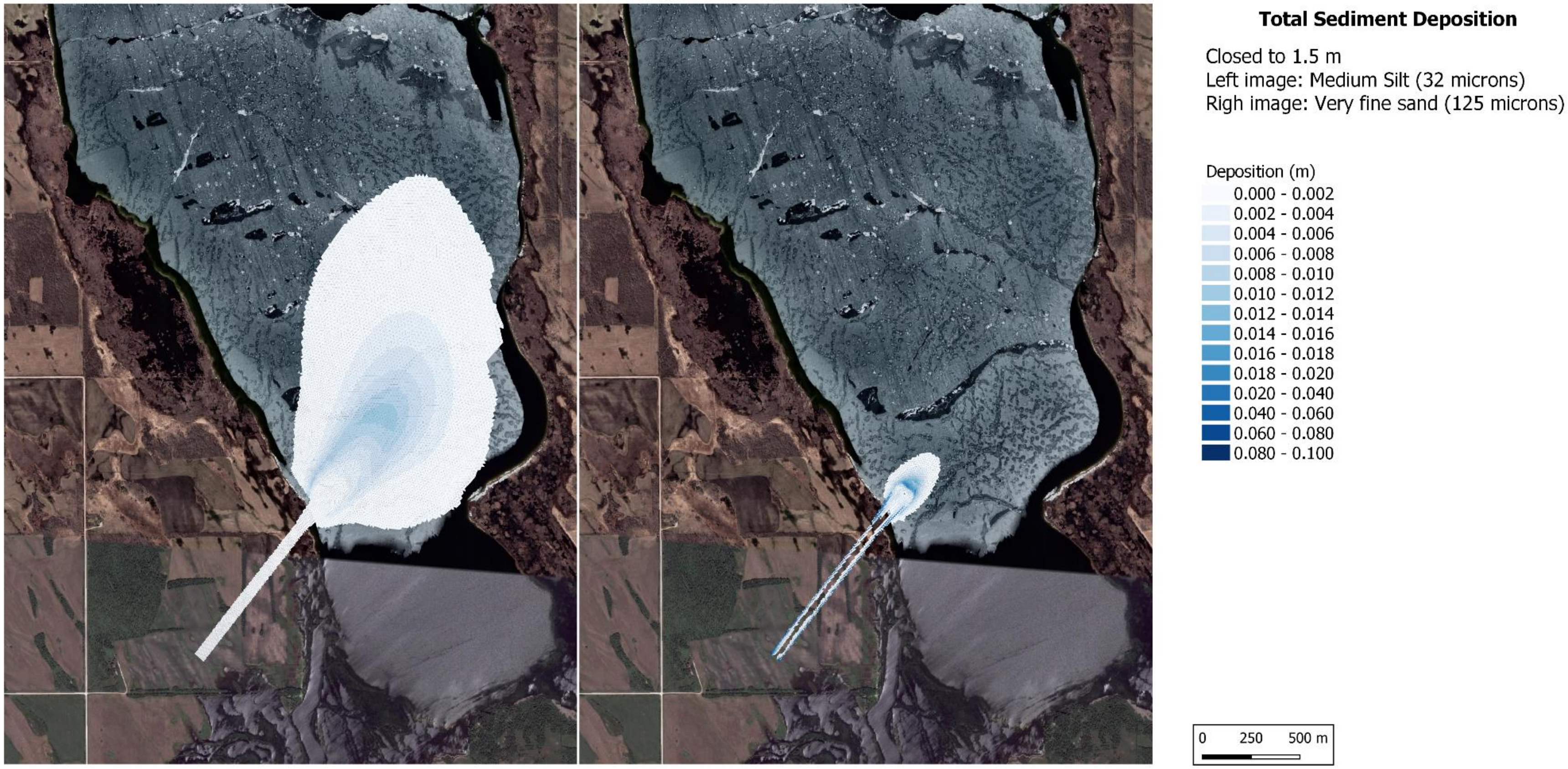


Figure 3-22: Total Sediment Deposition at End of Simulation - Closed to 1.5 m Silt Fraction (Left) , Sand Fraction (Right)

4. Empirical Assessment - Consideration of Clay

While numerical modeling has been carried out to assess the transport of silt and sand during commissioning of the LMOC, which constitute the majority of the till gradation within the Channel and also in Birch Bay, it is recognized that there is also be a small clay component which comprises approximately 10% to 15% of the till gradation. As such, an empirical assessment of transport of this component has also been carried out as a sensitivity analysis in order to understand the potential impact it may have in managing TSS concentrations. This empirical assessment considered the presence of a 0.75 mm thick layer of medium clay (about 15% of the initial 5 mm thick layer assumed in the slit and sand analysis) available to be transported that is conservatively assumed to be very fluffy and loose, and does not include any cohesivity.

Based on the empirical assessment, under the Base Case condition (relatively rapid gate opening), the presence of clay particles can potentially generate an instantaneous peak of approximately 850 mg/l before dropping near zero within 6 to 8 hours.

The concentrations, however, can be lowered by implementing a controlled gate opening procedure. For example, by initially raising the gates to an opening of 0.5 m for 1 day, the daily average concentration in the Channel just upstream of the Outlet could be limited to 50 mg/l which would be caused by mobilization of clay from the downstream reach. The clay particles from the upstream reach could be flushed out within the following day by further raising the gates another 0.5 m (i.e., 1 m total opening), which would result in an average 24-hr concentration of 190 mg/l in the Channel just upstream of the Outlet. Therefore, with such a two-step controlled gate opening approach, clay particles could be transported out of the Channel within a couple of days.

The gate opening procedure can be further optimized to reduce peak concentrations by raising the gates in smaller increments as has been demonstrated in the modeling work undertaken for the LSMOC (KGS, 2021). It should be noted that it is unlikely that the entirety of the clay particles that may be available for transport after construction would be very loose and without cohesivity, and therefore, would be expected to generate peak concentration much lower than those estimated in the empirical assessment.

The Delft 3D model discussed in Section 2.2 was utilized to assess the transport of clay particles in Birch Bay under an average westerly wind condition. The assessment shows that the TSS plume that can be potentially generated due to the presence of very loose non-cohesive clay particles will likely leave the model boundary within 4 days and would be expected to get dispersed in the larger water body of Lake St. Martin.

5. Summary

The initial operation of the LMOC during commissioning will mobilize loose earth material that may remain on the channel bed following construction and transport it into Birch Bay. This is expected to result in an immediate increase in TSS concentrations leading to sediment deposition in Birch Bay. Numerical modeling was undertaken to examine this potential during commissioning, as well as the impact that controlled gate operation measures can have to limit the increase in TSS concentrations.

The sediment transport from the LMOC bed was modeled using a two-dimensional MIKE21 sediment transport model of the channel. A general assessment of the fate of the sediment plume exiting the LMOC into Lake St. Martin (Birch Bay) was performed using a three-dimensional Delft3D sediment transport model.

Estimates of the potential material available to erode on the LMOC bed were made. While there are many variables that can impact this estimate, a 5 mm thick layer of fine particles uniformly distributed across the channel was used. It should be noted that the overall quantity of sediment will be dependent on the level of cleanup performed prior to flooding of the channel.

Based on the geotechnical investigation data, medium silt and very fine sand constitute the majority of the till gradation. The modeling utilized these two sediment types as representative particle sizes to estimate an envelope of sediment quantities, including TSS concentrations and sediment budgets.

The sediment transport modeling was performed under three gate opening scenarios: one to model a full closed-to-fully open gate opening procedure (called the Base Case scenario), and two controlled gate opening scenarios to represent a more gradual gate opening procedure.

Modeling of the Base Case gate operation scenario, which is deemed to represent a “worst case” scenario in terms of sediment transport (due to the relatively rapid gate opening), results in peak TSS concentrations of up to approximately 300 mg/l near the downstream end of the channel. However, the suspended sediment concentrations passing into Birch Bay are expected to drop below 25 mg/l within approximately three days. Modeling of the sediment plume entering Birch Bay indicates that TSS concentrations decrease as the sediment disperses under wind and waves. The finer silt particles travel in suspension into Birch Bay, depositing over an area of approximately 2.3 km^2, but the majority is expected to be deposited close to the LMOC outlet, with a localized maximum deposition thickness of 2 to 4 cm located within approximately 500 m of the outlet. Modeling indicates that the coarser sediment (i.e., sand) is expected to settle relatively quickly once it enters Birch Bay, with a localized deposition thickness of approximately 6 cm near the channel outlet.

Modeling of the controlled gate opening scenarios indicated that at a 1.0 m gate opening, the loose sediment from the downstream reach is expected to mobilize, while most of the sediment from the upstream reach is expected to remain on the bed due to the lower channel velocities. The model results indicate that there may be a short term initial peak of up to approximately 50 mg/l, followed by a sustained lower TSS concentration until the sediment from the downstream reach has been removed. Modeling results associated with a subsequent raising of the gates by 0.5 m (for a total opening of 1.5 m) indicate that the loose sediment within the upstream reach will begin to mobilize, resulting in TSS concentrations between 11 and 36 mg/l near the downstream end of the channel. Modeling of the combined controlled gate opening scenarios indicated that a localized deposition thickness of about 1.6 cm to 2.0 cm would be created within an area of Birch Bay near the outlet at the end of the 11 day simulation period.

Overall, the modeling results indicate that TSS concentrations resulting from the transport of loose material in the channel during commissioning can be managed through controlled gate operations. These operations would be informed through the use of real-time TSS monitoring data collected within the area.

The model results for the Base Case scenario show that around 2,700 to 5,500 tonnes of the estimated 12,000 tonnes of loose material that may initially be available to mobilize from the channel bed is flushed over a 4 day period. The model results for the controlled gate opening scenarios suggest that approximately 1,200 to 2,400 tonnes of the estimated 12,000 tonnes of loose material that may initially be available to be mobilized from the channel bed would be flushed within an 11 day period. Additional sediment will be mobilized as the gates are progressively raised until fully open, which is anticipated to result in an overall total mass of sediment transported into Birch Bay in the order of 5,000 tonnes over a duration of about one month from when the gates are initially opened. The difference in the mass of sediment mobilized into Birch Bay relative to the mass of sediment assumed to be initially available for transport indicates that there will likely be some sediment remaining within the channel following commissioning, primarily on the side slopes. It is possible that this sediment may become remobilized the next time the channel is operated. As such, controlled gate operations and monitoring may need to be performed to control TSS concentrations when the channel is put into operation in the future.

While the model results for the medium silt and very fine sand indicate that these materials will settle within Birch Bay, it should be noted that a small portion of finer particles present in the till could stay in suspension much longer and may travel beyond Birch Bay. An infrequent southerly wind may also result in the sediment plume extending beyond Birch Bay.

A sensitivity analysis shows that presence of clay may create high TSS concentrations in the channel for a few hours, which can be managed with controlled gate operations. The clay particles transported into Birch Bay area are expected to get dispersed in the larger water body of Lake St. Martin.

6. References

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