ECOLOGY AND ENVIRONMENT, INC.

EIGHTEEN MILE CREEK SUPERFUND SITE OPERABLE UNIT 3 (OU3)

CONCEPTUAL SITE MODEL FOR SEDIMENT TRANSPORT

676552

EIGHTEEN MILE CREEK SUPERFUND SITE OPERABLE UNIT 3 (OU3)

CONCEPTUAL SITE MODEL FOR SEDIMENT TRANSPORT

ECOLOGY AND ENVIRONMENT, INC.

DRAFT FINAL

PROJECT NO.: 191-13410-00
CLIENT REF:ECOLOGY AND ENVIRONMENT, INC. (E & E)
DATE : FEBRUARY 17, 2020

WSP USA, INC.
50 LAKEFRONT BLVD., SUITE 111
BUFFALO, NY
USA 14202

T: +1 716-853-1220
WSP.COM

REVISION HISTORY

FIRST ISSUE		
October 29, 2019	Draft Report for E & E Review	
Prepared by:	Reviewed by:	Approved by:
Sundar Premasiri, WSP	Jordan Matthieu, WSP	Nicolas Guillemette, WSP
SECOND ISSUE		
November 5, 2019	Draft Report for USACE Review	
Prepared by:	Reviewed by:	Approved by:
Sundar Premasiri, WSP	Jordan Matthieu, WSP Preetam Kuchikulla, E & E Marcia Galloway, E & E	Nicolas Guillemette, WSP
FINAL REPORT		
February 17, 2020	FINAL Report	
Prepared By	Reviewed by	Approved by
Sundar Premasiri, WSP Jordan Matthieu, WSP	Preetam Kuchikulla, E & E Marcia Galloway, E & E	Nicolas Guillemette, WSP Neil Brown, E & E

SIGNATURES

PREPARED BY

March 26, 2020

Sundar Premasiri, Ph.D., P.Eng.
Senior Hydrotechnical/Coastal Engineer

Date

March 26, 2020

Jordan Matthieu, M.Sc., P.Eng.
Senior Hydrotechnical/Coastal Engineer

Date

APPROVED[1] BY

March 26, 2020

Nicolas Guillemette, M.Sc., P.Eng.
National Manager, Coastal Engineering & Marine Works

Date

[1] Approval of this document is an administrative function indicating readiness for release and does not impart legal liability on to the Approver for any technical content contained herein. Technical accuracy and fit-for-purpose of this content is obtained through the review process. The Approver shall ensure the applicable review process has occurred prior to signing the document.

Completion of Independent Technical Review

Project:	Eighteen Mile Creek Superfund Site, Operable Unit (OU) 3 - Remedial Investigation/Feasibility Study
Deliverable:	Draft Final Conceptual Site Model for Sediment Transport
Revision and Date:	February 17, 2020

Ecology and Environment, Inc., member of WSP, has completed the above-referenced deliverable. Notice is hereby given that an independent technical review, that is appropriate to the level of risk and complexity inherent in the project, has been conducted as defined in the Contractor Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level obtained; and reasonableness of the result, including whether the product meets the customer's needs consistent with law and existing United States Army Corps of Engineers' policy. The independent technical reviewers confirmed that all comments were responded to and the changes made in the document as stated. The independent technical review was accomplished by following signatories. Comments resulting from independent technical review have been resolved.

Date: 17 Feb 2020

Marcia Galloway - Project Manager

Date: 17 Feb 2020

Dave Albers, P.E. - Program Manager

As noted above, all concerns resulting from independent technical review of the project have been considered.

Neil Brown - Independent Technical Review Team Leader/Quality Control Manager

Date: 17 Feb 2020

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

cfs	cubic feet per second
cm	centimeter
COPC	chemical of potential concern
CSM	conceptual site model
DDT	dichlorodiphenyltrichloroethane
DNAPL	dense non-aqueous phase liquid
E & E	Ecology and Environment Inc., member of WSP
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GIS	Geographic Information System
GLLA	Great Lakes Legacy Act
IQR	interquartile range
LiDAR	Light detection and ranging
µg/L	micrograms per liter
µm	micrometers
mg/kg	milligrams per kilogram
mm	millimeter
NCEI	National Centers for Environmental Information
ng/L	nanograms per liter
NYSDEC	New York State Department of Environmental Conservation
OU3	Operable Unit 3
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RI	remedial investigation
SEDA	Sediment Erosion and Deposition Assessment
SVOC	semivolatile organic compound
TAL	target analyte list
TDS	Total Dissolved Solids
TR	total range
TSS	Total Suspended Solids
USGS	United States Geological Survey
VDM	VanDeMark Chemical Inc.
VOC	volatile organic compound
WSP	WSP Canada, Inc.
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

The Eighteen Mile Creek Superfund Site is in Niagara County, New York, on the south side of Lake Ontario. The Eighteen Mile Creek site extends from Lockport, New York, to Lake Ontario. The creek discharges northward into Lake Ontario at Olcott, New York. Ecology and Environment Inc., member of WSP (E & E) is conducting a remedial investigation (RI)/feasibility study (FS) of the Eighteen Mile Creek Superfund Site for Operable Unit 3 (OU3). E & E retained WSP Canada, Inc. (WSP) through WSP USA, Inc., to develop a conceptual site model (CSM) for sediment transport as part of their RI/FS of the Eighteen Mile Creek Superfund Site for OU3. The objectives of this study are to:

1. Develop a CSM for sediment transport in OU3;
2. Identify the data requirements/gaps for assessing the sediment transport processes identified in the CSM as relevant in OU3; and
3. Provide an optional task to develop a numerical modeling framework for OU3.

This report addresses the development of a CSM for sediment transport in OU3. The data gap analysis and development of a numerical modeling framework for OU3 will be completed following the completion of the CSM for sediment transport and submitted under separate cover.

The OU1/OU2 Remedial Design (immediately upstream of OU3) will include demolition (i.e., removal) of the Clinton Street and Williams Street dams. While the scope of this study is limited to OU3, it is recognized that the proposed remediation design for OU1/OU2 will change the flow in Eighteen Mile Creek. In later project phases, when numerical simulation of OU3 with the two upstream dams in place will be required, E & E will coordinate with the project team(s) investigating OU1/OU2 to develop appropriate boundary conditions and input data for sediment modeling in OU3.

1.1 OBJECTIVE OF THE CONCEPTUAL SITE MODEL FOR SEDIMENT TRANSPORT

The CSM for OU3 forms the basis for evaluating sediment transport and how it relates to contaminant transport. The CSM is a written and illustrative representation of the physical, chemical, and biological processes that control the transport, migration, and actual/potential impacts of contamination (in soils, air, groundwater, surface water and/or sediments) on human and/or ecological receptors. The CSM specifies the key sediment transport processes affecting the site and gives special attention to the processes affecting contaminant transport. The activities associated with the development of a CSM include the following:

- Identification of potential contaminants;
- Identification and characterization of the potential source(s) of contaminants;
- Delineation of potential migration pathways through environmental media;
- Establishment of background areas of contaminants for each contaminated media (natural, other anthropogenic, source dependent);
- Identification and characterization of potential environmental receptors; and
- Determination of the limits of the study area or system boundary.

The CSM for sediment transport will not be included in the RI or risk assessment. The information developed in these reports will be used to develop the sediment transport model. The CSM for sediment transport processes will be used to support the FS and evaluation of alternatives. The CSM for sediment transport will be revised to incorporate available data and interpretation of the results as part of the modeling work plan.

1.2 SITE-SPECIFIC INFORMATION AND GUIDELINES

The following documents containing site-specific data were reviewed as part of this study:

- *Data Gap Analysis, Eighteen Mile Creek Superfund Site Operable Unit 3, City of Lockport, Niagara County, New York* (E & E 2017).
- *Phase I Data Evaluation Report, Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study, Niagara County, New York* (E & E 2019a).
- *Project-Specific Quality Assurance Project Plan for the Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study, Niagara County, New York;* Revision 3 and Addendum for Phase IIb (E & E 2019b).
- Eighteen Mile Creek Sediment Study, Summary of August 17-20 and November 3, 1998 Results (New York State Department of Environmental Conservation [NYSDEC] 2001; Focus on radio dating cores).
- Eighteen Mile Creek Water Level Data and Turbidity Data from May 2018 to August 2019 at the following four locations:
    - FM01 – Upstream of Ewings Road;
    - FM02 – Upstream of Jacques Road;
    - FM03 – Upstream of Stone Road; and
    - FM04 – Near Lockport Wastewater Treatment Plant (WWTP).
- U.S. Geological Survey (USGS) Eighteen Mile Creek Flow Data at Burt Dam (Site Number: 04219768) from August 2011 to September 2019; and
- Geographic information system (GIS) data containing the Eighteen Mile Creek bathymetry, creek reach shapefiles, topography, etc.

The CSM was developed as per the following guidelines:

- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. Environmental Protection Agency [EPA] 1988); and
- *Technical Guidelines on Performing a Sediment Erosion and Deposition Assessment (SEDA) at Superfund Sites* (U.S. Army Corps of Engineers, Engineer Research and Development Center [USACE ERDC] 2014).

The following physical and chemical data are available from previous investigations:

- Sediment chemistry and sediment particle size data along the entire creek from 1998 through 2004;
- Surface water chemical data in Olcott Harbor, downstream of Burt/Newfane dams and between the East Branch/Newfane Dam from 2002 through 2016;
- Bathymetry information extending 7,000 feet upstream (south) of Burt Dam;
- Sediment thickness data from Burt Dam upstream to Harwood Street, Lockport;
- Geotechnical data (grain size, bulk density, and moisture content) from Olcott Harbor and some pools downstream of Burt Dam;
- USGS flow gage data from 2011 to 2018 and stage data from 2016 collected 150 feet downstream of Burt Dam; and
- Floodplain extent for a 100-year flood for the Eighteen Mile Creek.

Additional physical and chemical data are being collected as part of the current RI/FS for OU3. Relevant data include the following:

- Subcontracted survey activities:
    - Bathymetric survey of certain creek sections,
    - Light detection and ranging (LiDAR) aerial topographic survey of the creek and shoreline area, and
    - Survey of flow monitoring stations.
- Phase I activities:
    - Sampling/analysis of surface water throughout the creek,
    - Sampling/analysis of creek bank floodplain soil,

    - Sampling/analysis of creek bank floodplain soil and surface water from reference/background area, and
    - Installation of flow monitoring stations.

- Phase II activities:
    - Sampling/analysis of select surface water locations under high flow conditions,
    - Sampling/analysis of sediment and sediment toxicity, and
    - Sampling/analysis of additional floodplains.

2 CONCEPTUAL SITE MODEL

2.1 SITE OVERVIEW

The Eighteen Mile Creek watershed is located along the southern shore of Lake Ontario in Niagara County, New York. Eighteen Mile Creek flows generally to the north and discharges into Lake Ontario, through Olcott Harbor, approximately 18 miles east of the Niagara River. The watershed has a drainage area of approximately 90 square miles and includes Eighteen Mile Creek; two main tributaries — the East Branch of Eighteen Mile Creek, and Gulf Creek; and several minor tributaries (see Figure 1). In addition, much of the flow in the Main Branch of Eighteen Mile Creek comes from water diverted from the Erie Canal.

The Main Branch of Eighteen Mile Creek originates southeast of the city of Lockport, in the vicinity of Keck and Chestnut Ridge Roads, on the south side of the Niagara Escarpment. It flows northwest through the city and is diverted underground, where the creek flows northward underground below the canal approximately 2,000 feet to a point near Clinton Street where it resurfaces. It continues generally north, descending approximately 240 feet over the Niagara Escarpment and flows north through the town of Newfane before draining into Lake Ontario at Olcott Harbor.

Gulf Creek originates southwest of the city of Lockport, near Hinman and Campbell Boulevard, and travels northeast and over the Niagara Escarpment before converging with the Main Branch of Eighteen Mile Creek just north of the Lockport WWTP. The East Branch of Eighteen Mile Creek enters the main channel just north of Ridge Road and contributes significant flow to the main channel.

Two additional tributaries join Eighteen Mile Creek from the west. The first originates in the town of Cambria near Blackman and Upper Mountain Roads and flows generally northeast to its confluence with Eighteen Mile Creek near Purdy Road in the town of Lockport, approximately 3 miles north of the canal. This tributary was once known as Sherman Creek. The second originates in the town of Wilson near Beebe Road and flows northeast to its confluence with Eighteen Mile Creek near Ide Road in the town of Newfane.

Several dams were constructed across Eighteen Mile Creek near Newfane, two of which remain today in OU3: Newfane Dam and Burt Dam. Newfane Dam, located in OU3 near the end of McKee Street and Ewings Road, is 14 feet high and creates a 25-acre impoundment area. It is primarily non-functional and is not currently maintained. The dam controls water flow to some extent and retains water and sediment behind it (see Photo 1). There is an older wooden structure behind the current dam. New York State classifies the dam as an intermediate hazard that does not warrant removal. The dam is privately owned, and the owner is not compliant with New York State dam regulations (Galloway 2019). There are no current plans to remove the dam. Removal of the dam will not be evaluated further.

Photo 1 - Newfane Dam Condition September 2017

Burt Dam is in OU3 approximately 3 miles downstream of Newfane Dam and creates a 95-acre impoundment within the Eighteen Mile Creek gorge. The impoundment extends approximately 2 miles upstream of the dam and is up to 35 feet deep in some parts. The dam was recently upgraded to operate up to a 600-kilowatt capacity. Additional structures were identified as part of the Phase Ia Literature Review and Archeological Sensitivity Assessment including several bridge abutments and a concrete remnant of a dam near the former Lockport Felt Company in Newfane (see Photo 2) (Hartgen 2018).

Photo 2 – Dam remnant near the former Lockport Felt Company

Excess water from the Erie Canal is diverted to Eighteen Mile Creek Operational water discharges from the Erie Canal into the East and West Branches of Eighteen Mile Creek are estimated to be approximately 50 cubic feet per second (cfs) to support maintain a flow of 400 cfs at Burt Dam.

A portion of the Eighteen Mile Creek 1.5 miles downstream of Burt Dam is designated by NYSDEC as Significant Coastal Fish and Wild Life Habitat, and the creek's estimated 65 acres of emerging and submerged vegetation comprise one of the largest coastal wetlands along the southwestern shore of Lake Ontario.

The EPA has divided the Eighteen Mile Creek Superfund site into four separate operable units: OU1, OU2, OU3, and OU4. OU3 is defined as the sediments contaminated by OU1/OU2. OU3 will address contamination in the creek north of Lockport to its discharge into Lake Ontario. The study area north of the creek corridor extends from Harwood Road to the creek's discharge into Lake Ontario and includes numerous contaminated depositional areas. Several industrial facilities and inactive hazardous waste sites are located along or in the vicinity of Eighteen Mile Creek within OU3, including the City of Lockport WWTP, VanDeMark Chemical Inc. (VDM), and the Old Upper Mountain Road Landfill site on Gulf Creek.

2.2 DELINEATION OF EIGHTEEN MILE CREEK OU3

The Eighteen Mile Creek OU3 was divided into seven sub-reaches based on the physical characteristics of the creek observed during previous investigations (E & E 2017). These creek sub-reaches were used to develop the CSM for sediment transport based on the hydrologic and hydraulic regime, channel bathymetry conditions, fluvial geomorphology, location of hydraulic structures, sediment characteristics and anthropogenic activities. The delineated sediment reaches are:

- Sediment Reach 1 (SR1) – Lake Ontario to Burt Dam
- Sediment Reach 2 (SR2) – Burt Dam to the confluence of the creek with the upstream extent of the Burt Dam Impoundment (Burt Dam Impoundment Area)
- Sediment Reach 3 (SR3) – Confluence of the creek with the Burt Dam Impoundment Area to just north of Ide Road
- Sediment Reach 4 (SR4) – Just north of Ide Road to Newfane Dam
- Sediment Reach 5 (SR5) – Newfane Dam to Dale Road (Newfane Dam Impoundment Area)
- Sediment Reach 6 (SR6) – Dale Road to East Branch of Eighteen Mile Creek
- Sediment Reach 7 (SR7) – East Branch of Eighteen Mile Creek to Base of the Niagara Escarpment
- Sediment Reaches 8 and 9 (SR8 and SR9) – Base of the Niagara Escarpment to Downstream of OU1/OU2

Figure 1 shows the extent of delineated sediment reaches within OU3. Table 2.1 shows the comparison of sediment reaches and river reaches used in E & E's study (2017) indicating that SR2 and SR3 and SR8, SR9 and SR10 will be considered the same for purposes of the sediment transport.

Table 2-1 Comparison of Sediment Reaches and River Reaches used in E & E's Study

SEDIMENT TRANSPORT REACHES FOR MODEL	RIVER REACHES USED IN E & E'S STUDY
Sediment Reach 1	Reach 1
Sediment Reaches 2/3	Reach 2
Sediment Reaches 2/3	Reach 3
Sediment Reach 4	Reach 4
Sediment Reach 5	Reach 5
Sediment Reach 6	Reach 6
Sediment Reach 7	Reach 7
OU1/OU2	Reaches 8, 9 and 10

Source: E & E 2017

2.3 HYDROLOGIC AND HYDRAULIC REGIME

Flow conditions in the Eighteen Mile Creek determine hydraulic conditions of the waterbody (e.g., currents and water levels) and sediment transport processes including erosion and deposition in OU3. The hydrologic and hydraulic conditions within OU3 are summarized in the following subsections based on available data and information. A detailed evaluation will be included in the data gap analysis.

2.3.1 HYDROLOGIC REGIME

Climatic factors are important for defining the hydrologic conditions in the Eighteen Mile Creek watershed (referred to as "watershed" hereafter) because precipitation and temperature significantly affect basin runoff characteristics and stream flows. The climate in the watershed is influenced by its proximity to Lake Erie and Lake Ontario. The lakes act as heat sinks, which can delay spring and lead to a mild summer. Similarly, the warm lake waters in fall extend the frost-free period later in the season, particularly in areas close to the lakes. Usually during November and December, the watershed experiences lake effect snowstorms. These storms are caused by air that has been warmed and charged with moisture as it passes over Lake Erie and Lake Ontario. This moisture is then deposited over land in the form of heavy snowfall. These storms are variable year to year and tend to decrease as the ice cover on the lake increases. In general, the watershed experiences warm summers and fairly long and cold winters.

Climate data from the National Centers for Environmental Information (NCEI) is available for the Niagara Falls International Airport, New York, from 1981 to 2010. Evaluation of the results indicate that precipitation levels tend to be relatively stable throughout the year, with no distinct periods of heavy precipitation or drought. Average monthly precipitation in Niagara County ranges from 2.2 to 3.4 inches. Average yearly snowfall is approximately 76.1 inches (NCEI 2020). Prevailing airflow is from the south and southwest. With the exception of an occasional heavy lake-effect snowstorm, severe and damaging storms are not a serious hazard in the area. Average daily maximum temperatures in Niagara County range from 32.1°F in January to 81.1°F in July. The first freeze typically occurs in mid-October and the last freeze occurs in early May. The exact dates may vary depending on elevation and proximity to Lake Erie or Lake Ontario (E & E 2004).

Water levels in Eighteen Mile Creek are monitored via level loggers at four locations in OU3. The details of the water level monitoring station locations are provided in Table 2.2. Manual water level and velocity measurements were collected seasonally at the four water level monitoring locations. Flow data will be used to develop a rating curve for each water level monitoring station. The rating curves will be used to estimate the creek flow data using the recorded water level. The level logger data for the four monitoring stations has not been processed as of this report's publication and will be included in the data gap analysis.

Table 2-2 Water Level Monitoring Station Details

NAME	LOCATION	COORDINATES		PERIOD OF RECORD
		LATITUDE (DEG)	LONGITUDE (DEG)	
FM1	SR4, downstream of Newfane Dam	43.28	-78.71	May 2018 – December 2019
FM2	SR5	43.24	-78.70	May 2018 – December 2019
FM3	SR6, upstream of Stone Road	43.19	-78.71	May 2018 – December 2019
FM4	SR6, near Lockport WWTP	43.18	-78.70	May 2018 – December 2019

The USGS has operated a water level gage in Eighteen Mile Creek downstream of the Burt Dam since August 2011. The mean annual flow at the USGS gage location is summarized in Table 2.3. The mean annual flow is 142.2 cfs downstream of Burt Dam and peak flows range from 984 cfs in 2015 to 2,190 cfs in 2017. Figure 2 illustrates minimum, mean, and maximum monthly flows downstream of Burt Dam. Stream flows peak in April or May due to spring freshet and then gradually decrease until August or September. The stream flows at the USGS water gage are regulated by the Burt Dam operation and/or outlet structures. Similar analysis of the flows in Reaches 2 through 7 will be evaluated in the data gap analysis report based on the processed water level data from flow monitoring stations 1 through 4.

Table 2-3 Mean Annual Flow and Peak Flow Downstream of Burt Dam

YEAR	MEAN ANNUAL FLOW (CFS)	PEAK FLOW (CFS)
2012	145.3	1,220
2013	183.9	1,550
2014	162.0	2,050
2015	115.2	984
2016	110.2	1,420
2017	142.3	2,190
2018	138.1	1,950
Average	**142.2**	**-**

Lumia et al. (2006) presented techniques for estimating the magnitude and frequency of flood discharges on rural, unregulated streams in six hydrologic regions of New York, excluding Long Island. The hydrologic region boundaries were delineated based on physiographic and geologic characteristics of New York. Hydrologic regions refer to areas in which streamflow-gaging stations indicate a similarity of peak-discharge response that differs from the peak-discharge response in adjacent regions. Peak-discharge-frequency data and basin characteristics from 388 streamflow-gaging stations in New York and adjacent states were used to develop multiple linear regression equations for flood discharges with recurrence intervals ranging from 1.25 to 500 years. The Eighteen Mile Creek watershed falls under Hydrologic Region 6 (see Figure 3). The basin characteristics used to predict flood discharges for Region 6 are drainage area, basin storage, mean annual runoff, drainage basin elevation, and ratio of basin slope to channel slope. Table 2.4 provides predicted peak flows for each sediment reach using the StreamStats Web tool and the above-mentioned approach (USGS 2019). Figure 4 illustrates the flow-duration curves for sediment reaches. Based on Table 2.4, reaches downstream of SR6 are heavily influenced by the East Branch of Eighteen

Mile Creek. The drainage area for SR7 is 23.9 square miles, while SR6 is 75.9 square miles; the increase in drainage area is substantially due to the confluence of the East Branch of Eighteen Mile Creek in SR6.

The USGS approach did not consider flow attenuation as a result of man-made storage areas such as dams. Dams have major impacts on river hydrologic regime through changes in the timing, magnitude, and frequency of low and high flow; ultimately producing a hydrologic regime differing from the pre-impoundment natural flow regime. Therefore, the hydrologic regime for Sediment Reaches 1, 2, 3, and 4 presented in Table 2.4 and Figure 4 represents the pre-impoundment hydrologic regime. Hydrologic modeling needs to be conducted to predict the post-impoundment hydrologic regime in these reaches using reservoir-routing techniques considering the Newfane and Burt Dam reservoir stage-storage data, dam outlet structures characteristics, dam operating rules, and the diversion of flow from the Erie Canal into main channel of the Eighteen Mile Creek and East Branch of Eighteen Mile Creek.

Table 2-4 Flood Discharges – Sediment Reaches

HYDROLOGIC PARAMETERS		SEDIMENT REACHES					
	SR7	SR6	SR5	SR4	SR3	SR2	SR1
Drainage Area (square miles)	23.9	75.9	76.3	82.9	84.1	84.6	86.9
1.25-Year Peak Flood (cfs)	399	862	856	900	906	899	912
1.5-Year Peak Flood (cfs)	475	999	993	1,040	1,050	1,040	1,060
2-Year Peak Flood (cfs)	568	1,170	1,160	1,220	1,230	1,220	1,240
5-Year Peak Flood (cfs)	800	1,570	1,570	1,660	1,670	1,660	1,690
10-Year Peak Flood (cfs)	954	1,840	1,840	1,950	1,960	1,950	1,980
25-Year Peak Flood (cfs)	1,150	2,180	2,170	2,310	2,330	2,310	2,360
50-Year Peak Flood (cfs)	1,290	2,420	2,410	2,570	2,590	2,570	2,630
100-Year Peak Flood (cfs)	1,430	2,650	2,650	2,820	2,850	2,820	2,890
200-Year Peak Flood (cfs)	1,580	2,910	2,900	3,100	3,130	3,100	3,180
500-Year Peak Flood (cfs)	1,760	3,210	3,210	3,430	3,460	3,440	3,520

SUMMARY

The Eighteen Mile Creek hydrologic regime in OU3 is affected by presence of the Newfane and Burt Dams and the diverted flow from the Erie Canal. The flows downstream of SR7 is heavily influenced by flow from the East Branch of Eighteen Mile Creek (see Figure 4). The sediment reach hydrologic conditions primarily depend on:

- SR8/9 – diverted flows from the Erie Canal;
- SR7 –flows from OU1/OU2, the Erie Canal, WWTP and Gulf Creek;
- SR6 – flows from SR7, the East Branch of Eighteen Mile Creek including diverted flows from Erie Canal;
- SR5 – flows from SR6 and Newfane Dam operational conditions;
- SR4 – Newfane Dam operational conditions and Ide Road;
- SR3 – Newfane Dam operational conditions and confluence of Burt Dam Impoundment Area;
- SR2 – flows from SR3 and Burt Dam operational conditions; and
- SR1 – Burt Dam operational conditions and Lake Ontario water level.

The hydrologic conditions in the Eighteen Mile Creek OU3 vary greatly throughout the year, therefore, sediment transport processes will similarly vary.

2.3.2 HYDRAULIC REGIME

The hydraulic regime of a watercourse is defined using flow depth and width, flow velocity, and water surface profile. The hydraulic regime depends on flow rates, river channel slope, channel and floodplain shape, channel and floodplain roughness, hydraulic structures present in the watercourse, and boundary conditions (e.g., upstream flow rates, downstream water levels, tributary flows, and hydraulic structures). The sediment transport processes are influenced by the hydraulic regime of the watercourse in addition to sediment properties. The hydraulic regime of the Eighteen Mile Creek OU3 is quite variable over the course of a year and between years depending on flow rates, operation of hydraulic structures, and boundary conditions.

The hydraulic regime in the Eighteen Mile Creek OU3 is complex due to the presence of bridges, culverts, dams, and dam operational conditions. Therefore, hydrodynamic modeling is required to predict the hydraulic conditions in the Eighteen Mile Creek OU3. The following sections describe conditions that affect the hydraulic regime in Eighteen Mile Creek.

2.3.2.1 HYDRAULIC STRUCTURES

Hydraulic structures alter hydraulic conditions of the waterbody both upstream and downstream of hydraulic structures. For example, dams generally reduce the flow rates and sediment transport rates downstream of the dam. The sediment usually deposits upstream of dams since currents are reduced, while sediment will usually be eroded downstream of dams as sediment transport is reduced from the upstream reaches.

There are several marine and fluvial hydraulic structures in Eighteen Mile Creek OU3 that alter the hydraulic regime of the creek. Table 2.5 provides the hydraulic structures in each sediment reach and a general description potential effects on the hydraulic regime.

Table 2-5 Hydraulic Structures in OU3

SEDIMENT REACHES	HYDRAULIC STRUCTURES[1]	POTENTIAL IMPACTS[2]
SR1	• Marina infrastructure: o Dockwall o Docks o Boat launches • West Lake Road Bridge • Bridge downstream of Burt Dam	• Operation of vessels in SR1 would create vessel-generated waves and produce additional currents due to the wakes. • The presence of bridges, with piers in the riverbed, represent an alteration of the natural geometry of the river cross-section and would induce significant obstacles to river flow. The effects on the hydraulic regime are generally local, but can be considerable. The major effect is an increase of water surface elevation upstream of the bridge (backwater effect) above the normal water surface profile that would occur without the bridge. The backwater effect would slow down the flow velocities and could increase sedimentation upstream of the bridges. • The contraction of the channel cross-section at the bridge location would increase the flow velocities and cause local scour, and the sediments removed from this location would usually be deposited immediately downstream. • Localized scour at the bridge piers.
SR2	• Burt Dam • Wilson Burt Road Bridge	• The presence of a dam in the river would attenuate the downstream flow rates and trap incoming sediments. • The downstream effects would change sedimentation/erosion balance in the river channel.

SEDIMENT REACHES	HYDRAULIC STRUCTURES[1]	POTENTIAL IMPACTS[2]
SR3	• No hydraulic structures	• None.
SR4	• Ewings Road • Ide Road Culvert • Remnants of dam	• The presence of bridges, with piers in the riverbed, represents an alteration of the natural geometry of the river cross-section and can induce significant obstacles to river flow. The effects on the hydraulic regime are generally local, but can be considerable. The major effect is an increase of water surface elevation upstream of the bridge (backwater effect) above normal water surface profile that would occur without the bridge. The backwater effect would decrease the flow velocities and could increase the sedimentation upstream of bridges. • The contraction of the channel's cross-section at the bridge location would increase the flow velocities and cause local scour, and the sediments removed from this location would be deposited in the immediate downstream. • Localized scour at the bridge piers. • The potential effects of culverts on erosion and sedimentation at upstream and downstream of culvert are similar to that of bridges. • Changes in flow around in-stream structures.
SR5	• Newfane Dam	• Refer to potential impacts for SR2 in this table.
SR6	• Jacques Road Bridge	• Refer to potential impacts for SR4 in this table.
SR7	• Ewings Road Bridge • Ridge Road Bridge • Stone Road Bridge • Plank Road Bridge • Somerset Railway Bridge	• Refer to potential impacts for SR4 in this table.
SR8/9 and OU1/OU2	• Clinton Street Dam • Water Street Dam	• Structures will be evaluated as part of the OU1/OU2 model and may be removed as part of the remediation.

Notes:

[1] No detailed information is currently available for the hydraulic structures located within the Eighteen Mile Creek OU3. A future survey may be needed to incorporate these structures in the model.

[2] No site-specific information is available on erosion and sedimentation in the vicinity of the hydraulic structures except for the Burt and Newfane Dam Impoundment Areas. The potential impacts on erosion and sedimentation due to the presence of bridges and culverts are general.

The Newfane and Burt Dams trap most sediment transported from upstream areas. The sediment trapping efficiencies of these dams depend on the stage-storage characteristics of the dams, dam outlet characteristics and/or operating conditions, and incoming sediment characteristics. Some of this information such as dam characteristics and sediment characteristics data is currently available while other information will either be collected in the field or modeled. Table 2.6 provides details for Burt and Newfane Dams obtained from New York State Inventory of Dams website.

Table 2-6 Burt and Newfane Dam Details

DETAILS	BURT DAM	NEWFANE DAM
Federal ID Number	NY00745	NY10226
Type of Construction	CN – Concrete Gravity	CB – Buttress
Purpose	Hydroelectric	Other
Dam Length (feet)	328	270
Dam Height (feet)	55	14
Spillway Width (feet)	75	0
Maximum Discharge (cubic feet per second)	6,116	1,400
Maximum Storage (acre-feet)	2,447	25
Reservoir Surface Area (acres)	95	25
Drainage Area (square miles)	77.4	75

Source: NYSDEC 2019.

2.3.3 BOUNDARY CONDITIONS

Boundary conditions that will affect hydraulic conditions include:

- Diversion of flow from Erie Canal and other flows into OU1/OU2;
- Flows into SR7 from the OU1/OU2 reach, including diversion from Erie Canal;
- Gulf Creek, Lockport WWTP outfall, and three Unnamed Creek tributary discharges to SR7;
- East Branch of Eighteen Mile Creek and eight Unnamed Creek tributary discharges to SR6;
- Unnamed Creek tributary discharges to SR4; and
- Lake Ontario Water Levels at Olcott.

East Branch of Eighteen Mile Creek and Unnamed Creek tributaries flood discharges are available from the StreamStats Web tool (USGS) as discussed in Section 2.3.1 and through further evaluation of the flow monitoring data. The Lake Ontario water levels at Olcott will be evaluated in the data gap analysis based on data collected from the Olcott Harbor gage station (#9052076) located near SR1.

SUMMARY

The hydraulic regime in the Eighteen Mile Creek OU3 is complex due to the presence of bridges, culverts, dams, and dam operational conditions. Therefore, hydrodynamic modeling is required to characterize the Eighteen Mile Creek OU3 hydraulic regime. The following bullets describe the hydraulic conditions in each sediment reach based on available information:

- SR7, SR6, SR4, and SR3 – The hydraulic regimes in these reaches are due to open-channel hydraulics, presence of bridges and culverts and depend on channel slope, flow rates, and channel and floodplain roughness.
- SR5 and SR2 – The hydraulic regimes in these reaches are influenced by dams and are similar to lake environments and depend on inflow and outflow rates and impoundment area characteristics.
- SR1 – The hydraulic regime is due to open-channel hydraulics, influenced by dams, culverts, and the Lake Ontario water levels at the mouth of the creek. Sediment transport within the outer basin of Olcott Harbor and through two offshore jetties extending into Lake Ontario will occasionally be influenced by the wind-generated waves.

2.4 SEDIMENT

The basic sediment property information required for sediment transport evaluation is sediment composition, sediment particle size, and wet bulk density. Sediment particle size is required to characterize the critical shear stress required to initiate sediment motion and to estimate sediment settling velocity. Bulk density is a quantitative measure used to assess how consolidated a sediment is. In cohesive sediments, an increase in bulk density generally indicates a higher level of consolidation and, hence, a higher required critical shear stress.

The following bullets provide descriptions of sediment transport processes of cohesive and mixture of cohesive and non-cohesive sediments:

- Mixtures of sand, silt, and clay will generally behave as a sediment with cohesive properties when the clay-silt dominated fraction (< 8 micrometers [μm]) exceeds a critical value, typically given as approximately 10% by volume. For mixtures below this critical clay-silt threshold, the sediment bed will either be weak or non-cohesive and will behave largely as a sand bed and finer sediments will be washed out. Above this critical silt-clay threshold, cohesiveness will dominate the behavior of the sediment bed, which will be subject to a continuous cycle of deposition, consolidation, fluidization, erosion, (potential) flocculation, and deposition.
- The transport and erosion/deposition of cohesive sediments are typically described by a relatively (i.e., in comparison to non-cohesive sediments) large number of empirical and site-specific parameters, including: mineral composition, temperature, biological activity, bulk density, critical shear stresses for erosion and deposition, and (hindered) settling velocity. Non-cohesive sediments are typically parameterized in terms of sediment diameter and density with a well-developed theory to describe the resulting sediment transport and deposition.
- Cohesive sediment transport in quasi-steady-state flow conditions typically takes place as suspended load (wash-load) with a relatively uniform concentration profile. Non-cohesive sediment transport of sand-sized particles will generally take place as both suspended and bed load, whereas gravel will be transported as bed load.
- Fine sediments form cohesive sediment beds when the shear stress at the bed is below the critical value for deposition, which is essentially a proxy for the turbulence level in the flowing water. Initially, the freshly deposited sediment forms a loose layer or a fluid mud layer in high source concentrations. If the bed sediment is undisturbed, the sediment gradually consolidates and the erosion resistance (i.e., critical shear stress for erosion) increases with depth. Erosion occurs when the critical shear stress for erosion of the exposed sediment layer is exceeded. Non-cohesive sediments have a more straightforward erosion and deposition pattern, eroding above a critical shear stress and depositing below it. The physical properties of the resulting non-cohesive sediment bed are largely static, except bed form evolution and winnowing.

.

Eighteen Mile Creek sediment has been characterized using the data collected for various studies within OU3. Sieve analysis and hydrometric tests were conducted to derive sediment particle size distribution. Table 2.7 lists the number of sediment samples collected for geotechnical analysis in each sediment reach within Eighteen Mile Creek OU3.

Table 2-7 Number of Sediment Samples Collected for Geotechnical Analysis within the Sediment Reaches

SEDIMENT REACH	NUMBER OF SEDIMENT SAMPLES
Lake	6
SR1	25
SR2	111
SR3	62

SEDIMENT REACH	NUMBER OF SEDIMENT SAMPLES
SR4	12
SR5	60
SR6	54
SR7	49

Sediment grain size data was obtained from multiple studies using different methodology to classify sediment size. Therefore, the results were characterized based on the standard sediment gradation scale shown in Table 2.8. Summation of sediment class percentages (gravel, very coarse sand, coarse sand, medium sand, fine sand, and fines) resulted in more than 100% for the sediment particle size dataset presented in Table 2.9. Review of the data indicated that percentages greater than 100% corresponded to the medium sand percentages. Therefore, the medium sand data was removed from the dataset for further analysis. Further evaluation of the grain size data will be completed as part of the data gap analysis.

Table 2-8 Sediment Gradation Scale

SEDIMENT CLASS NAME	SIZE RANGE (MM)
Gravel	64 – 2
Very Coarse Sand	2 – 1
Coarse Sand	1 – 0.5
Medium Sand	0.5 – 0.25
Fine Sand	0.25 – 0.125
Very Fine Sand	0.125 – 0.063
Coarse Silt	0.063 – 0.031
Medium Silt	0.031 – 0.016
Fine Silt	0.016 – 0.008
Very Fine Silt	0.008 – 0.004
Coarse Clay	0.004 – 0.002
Medium Clay	0.002 – 0.001
Fine Clay	0.001 – 0.0005
Very Fine Clay	0.0005 – 0.00024

Source: USACE 2014

Note:

Silt and clay particles are represented as total fines in Figures 5 through 12.

Sediment cores retrieved from SR1 contained variable amounts of organic material (higher organic content in the southern part of the reach). Harbor sediment cores are described as organic-rich sediment on top of sand clay with a maximum soft sediment depth over 4 feet. Blacky silt sediments were encountered in the middle part of the reach, and gravel was encountered just downstream of Burt Dam.

Sediment in SR2 and SR5 consisted of varying amounts of decayed organic materials (mostly rootlets, leaves, wood, and other vegetative matter), grading into varying proportions of fine sand, silt and clay, with occasional fine gravel (less than 10%). Sediment color usually ranged from gray to brown or black. Particle size analysis of SR2 sediments identified the presence of primarily silty/clayey sediments, with approximately 20% of sand mixes of silt and/or clay. Particle size distribution of the sediments in SR5 is similar to that in SR2, with predominantly silty/clayey sediments and some sandy mixtures. Gravel (over 10%) was observed at more locations in these reaches. Sediment thickness was observed to be greatest in SR2, followed by SR3 and SR5. The maximum sediment depths observed were 15 feet in SR2, 12 feet in SR3, and 9 feet in SR5.

Sediment in SR4, SR6, and SR7 consisted of varying amounts of decayed organic material (mostly rootlets, leaves, wood, and other vegetative matter), grading into varying proportions of fine sand, silt, and clay, with occasional fine gravel. Sediment color usually ranged from gray to brown. In most cases, stratification was not observed. At some locations, sand or fine gravel was observed without sufficient fine-grained sediment to yield an adequate sample. SR4 is predominantly characterized by silt or clay sediments (more than 90% fines present in the sample). Some sandy sediment mixed with varying amounts of gravel and silt-sized material were also present in SR4, SR6, and SR7. Sediment containing more than 10% gravel was very rare in SR4, but was observed at some locations along SR6 and SR7. The maximum sediment depths observed were 1.8 feet in SR4, 5.6 feet in SR6, and 4.5 feet in SR7.

Figures 5 through 12 present the analysis of sediment composition in the Eighteen Mile Creek reaches in box-whisker plots. Sediment composition show a high variability with minimum and maximum percentage of each sediment composition. The total range (TR) and interquartile range (IQR) in percentages of sediment compositions at sediment reaches are summarized in Table 2.9. The TR reflects the lowest percent and highest percent regardless of outliers (indicated as a data point in Figures 5 through 12). The range showing the minimum and maximum value excluding outliers is shown on Figures 5 through 12 as the full range in the box and whisker plot. The IQR shows roughly the range of the middle 50% of the data and is represented as a blue box in the box and whisker plot in Figures 5 through 12. The sediment results indicate the following:

- The Eighteen Mile Creek sediment primarily consists of sand, silt, and clay;
- Olcott Harbor (downstream of SR1) sediments are dominated by fines. This is expected as flow velocity in this area is low and facilitate the settlement of fine sediment;
- Sediments in SR1 (downstream of Burt Dam) are primarily sands;
- The Burt Dam Impoundment Area (SR2) sediments are dominated by fines. This is expected as flow velocity in this area is low and facilitate the settlement of fine sediment;
- Sediments in SR3 are primarily dominated by fines;
- Sediments in SR4 (downstream of Newfane Dam) are primarily sands;
- The Newfane Dam impoundment area (SR5) sediments are dominated by fines. This is expected as flow velocity in this area is low and facilitate the settlement of fine sediment;
- Sediments in SR6 are primarily dominated by fines
- Sediments in SR7 are primarily dominated by fines; and
- The IQR in percentage of total fines was 88.7 to 90 for the mouth of the creek, 23.5 to 32 for SR1, 91.2 to 99 for SR2 (Burt Dam Impoundment Area), 71.5 to 95 for SR3, 20.2 to 45.5 for SR4, 76 to 95 for SR5 (Newfane Dam Impoundment Area), 69.2 to 85 for SR6, and 34.5 to 70.5 for SR7.

Table 2-9 Summary of Sediment Composition

REACH	GRAVEL		VERY COARSE SAND		COARSE SAND		MEDIUM SAND		FINE SAND		TOTAL FINES	
	TR	IQR	TR	IQR	TR	IQR	TR	IQR	TR	IQR	TR	IQR
Lake	0 – 0.7	0 – 0.33	2.4 – 3.8	2.78 – 3.73	1.2 – 2.2	1.20 – 2.13	0	0	4 – 5.9	4.08 – 5.90	88 – 90	88.7 – 90
SR1	0 – 0.2	0	2 – 40	34 – 38	0.3 – 18	4.25 – 7.65	0	0	22 – 92	26 – 29.5	3.9 – 36	23.5 –-32
SR2	0 – 17	0	0	0	0 – 6.8	0 – 0.58	0.1 – 24	0.3 – 2.03	0.1 – 31	0.6 – 5.90	42 – 100	91.2 –- 99
SR3	0 – 61	0 – 1.6	0 – 1.5	0	0 – 26	0 – 1.23	0.3 – 20	0.9 – 3.25	0.8 – 46	3.58 – 18.2	7.9 -99	71.5 – 95
SR4	3.4 – 33	7.1 – 16	0	0	2.9 – 29	8.65 – 14.7	6.8 – 40	11.2 – 33.5	7.1 – 34	16.2 – 22.5	13 – 64	20.2 – 45.5
SR5	0 – 40	0 – 2.35	0	0	0 – 24	0 – 1.87	0.1 – 39	0.53 – 4.6	0.3 – 20	3.68 – 10	18 – 100	76 – 95
SR6	0 – 13	0 – 2.22	0	0	0 – 7.9	0.4 – 1.62	0.3 – 34	1.2 – 5.85	4.1 – 53	11 – 24	24 -96	69.2 – 85
SR7	0 – 17	0.5 – 2.45	0	0	0.1 – 11	0.6 – 2.45	0.1 - 25	2.45 – 8.65	3.7 – 71	22.5 – 49	16 - 96	34.5 – 70.5

Key:

TR = Total Range

IQR = Interquartile Range

Creek bank floodplain soil samples were collected along 13 transects in five of the seven reaches. Floodplain soil samples were not collected in SR2 and SR3 because the creek banks are generally too high to flood based on evaluation of LiDAR data and 100-year floodplain data. The floodplain sediment composition results are summarized below, and laboratory analytical results are provided in the *Phase I Data Evaluation Report Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study* (E & E 2019a).

Sediment Reach 1 (SR1): The floodplain sediments in SR1 consist of gravels, sands, silt, and clays. The gravel ranges from 38% to 65% except one sampling location that has 7.9%. The silt ranges from 11% to 26% except one sampling location that has 54%.

Sediment Reach 4 (SR4): The floodplain sediments in SR4 consist of gravels, sands, silt, and clays. The silt ranges from 30% to 69% except one sampling location that has 10%.

Sediment Reach 5 (SR5): The floodplain sediments in SR5 consist of gravels, sands, silt, and clays. The silt ranges from 33% to 70% and clays and colloids range from 9% to 18%.

Sediment Reach 6 (SR6): The floodplain sediments in SR6 consist of gravels, sands, silt, and clays. The silt ranges from 31% to 78% and clays and colloids range from 4% to 18%.

Sediment Reach 7 (SR7): The floodplain sediments in SR7 consist of gravels, sands, silt, and clays. The silt ranges from 38% to 75% and clays and colloids range from 8.2% to 20%.

SUMMARY

The Eighteen Mile Creek OU3 channel sediment was characterized as follows:

- Creek Mouth, SR2, and SR5 – primarily cohesive sediments consisting of silt and clay; and
- SR1, SR3, SR4, SR5, SR6, and SR7 – primarily a mixture of cohesive and non-cohesive sediments consisting of fine sand, silt, and clay.

2.5 ANTHROPOGENIC ACTIVITIES

Anthropogenic activities (e.g., dredging, filling, vessel traffic, anchor deployment, watershed land use changes, and construction of hydraulic and shoreline protection structures) removal of existing dams can modify the existing hydrologic and hydraulic regime and sediment transport processes in the Eighteen Mile Creek OU3.

The Eighteen Mile Creek watershed encompasses portions of the towns of Cambria, Lockport (including a portion of the city of Lockport), Royalton, Hartland, Newfane, and Wilson, all of which are in Niagara County. Land use in the watershed consists primarily of cropland and orchards, with residential, commercial, and industrial areas in and around Lockport, Newfane, and Olcott Harbor. The city of Lockport is the most densely populated area within the watershed. Additional land uses are provided in the OU 3 Data Gap Analysis Report (E & E 2017). The sediment reaches will be affected by future land use changes. Changes in land use (e.g., urban development, deforestation, and agriculture) affect runoff conditions, water quality, and sediment loading to waterbodies. Construction of bridges, culverts, and shoreline protection structures could modify the hydraulic conditions locally and, hence, sediment transport processes.

Removal of the dams would release sediments in the impoundment areas to downstream areas. If the Newfane Dam were removed in the future, some, likely coarser sediments within the impoundment area would be released to SR3, SR4, and the rest will be transported to the Burt Dam Impoundment Area. The very fine particles would be transported as suspended sediment to SR1 and Lake Ontario via the Burt Dam outlet. If the Burt Dam were removed, sediments from the impoundment area would be released to SR1 and Lake Ontario.

SR1 contains a harbor and marina. Vessels operating in these areas create wake waves and propeller wash. Wake waves add additional hydraulic forces on the channel bed and bank, which accelerates sediment erosion processes.

Propeller wash creates scour on the channel bed and the deployment of a ship anchor could disturb the bottom sediments and make it easier to erode.

Occasional dredging of the navigation channel at the upstream end of the piers is needed to maintain the navigable depth. Modifications to the navigation channel change existing hydraulic conditions, which then changes sediment transport processes. The USACE recently conducted maintenance dredging in the navigation channel to a depth of 12 feet below low water datum. E & E believes that the sediment removed from the navigational channel originates from Lake Ontario and is transported into the navigational channel by wave action.

2.6 FLUVIAL GEOMORPHIC CONDITIONS

Local and watershed-scale processes are fluvial geomorphic conditions that govern formation and ongoing geomorphological changes in Eighteen Mile Creek. Geomorphological indicators include bar formation, scour zones, accretion or degradation, channel infilling/dredging, and bank erosion. Watershed-scale factors include change in sediment and runoff conditions due to changes in land use. Currently, no information is available on the abovementioned indicators. E & E recommends conducting a field investigation to assess fluvial geomorphic conditions of Eighteen Mile Creek. The investigation will help document the current site conditions that need to be incorporated into the modeling.

3 SOURCE OF CONTAMINATION

3.1 PRIMARY SOURCE

3.1.1 OU1/OU2

Sediment contaminated with polychlorinated biphenyls (PCBs) and metals has been identified along the entire 15-mile length of the main branch of Eighteen Mile Creek, including OU3. Based on existing data, the primary potential sources of contamination to the Eighteen Mile Creek OU3 are the surface waters and sediment from upstream sources, including Eighteen Mile Creek OU1/OU2 and the Erie Canal. The primary chemicals of potential concern (COPCs) in OU1/OU2 are PCBs and metals, primarily lead. Historical studies have found the highest concentrations of PCBs and metals have been discharging to Lake Ontario from Eighteen Mile Creek relative to the other Lake Ontario tributaries. A 1993/1994 NYSDEC study established that manufacturing operations along the New York State Barge Canal were potential sources of metals and PCBs. PCBs were identified at their highest concentrations near Jacques Road, upstream of Burt Dam SR4 (NYSDEC 1996).

Additional potential sources, such as hazardous waste sites and tributaries, do not appear to be significant except for the potential Old Upper Mountain Road site's contribution to contaminated sediments in Gulf Creek. The EPA is addressing cleanup at Eighteen Mile Creek OU1/OU2, while NYSDEC is addressing cleanup at the Old Upper Mountain Road site.

3.1.2 ERIE CANAL

Waters from the Erie Canal are diverted into Eighteen Mile Creek through gates in Lockport and the East Branch of Eighteen Mile Creek through gates at the waste weir at Maybees, 0.13 miles west of Bolton Road (HAER 2009). Spill discharge calculations from the New York State Canal Corp. developed on November 2, 1999, indicate that discharge from Lockport is 47 cfs and Maybees is 12 cfs. The maintenance of this flow from the canal will need to be considered during the development of model and related remedial alternatives. The earlier studies completed by NYSDEC demonstrated the link between the Erie Canal and a broad list of contaminants transported in water that may have originated as far away as Lake Erie and the Niagara River, and migrated to Eighteen Mile Creek via the Erie Canal (E & E 2017). Subsequent studies completed as part of the NYSDEC 2009 supplemental RI report concluded that canal sediments do not appear to be a significant contributor of PCBs or metals to Eighteen Mile Creek in the project area and the likelihood of recontamination of the creek by the canal is small (E & E 2009a, b). Therefore, the Erie Canal will not be considered as a source of contamination in the CSM but will be considered as contributor to the base flow.

3.2 OTHER POTENTIAL SOURCES

3.2.1 UPPER MOUNTAIN ROAD AND GULF CREEK

The Old Upper Mountain Road site was reportedly operated as a municipal dump by the city of Lockport from 1921 to the 1950s. The site includes 7 acres of former municipal dump area, a ravine, and Gulf Creek. A site investigation conducted at the Old Upper Mountain Road site in 2007 revealed that consequential amounts of hazardous wastes were present at the site. The investigation report suggested that these hazardous wastes had adversely impacted surface water and sediment in Gulf Creek adjacent to the site. The site was divided into three OUs: OU1 - approximately 6 acres of landfill wastes; OU2 - surface water and sediment within Gulf Creek; and OU3 - approximately 1 acre of landfill wastes.

The findings related to impacts on Eighteen Mile Creek within OU3 include:

- Analytical results of surface water samples collected from downstream locations in Gulf Creek reported low levels of volatile organic compounds (VOCs). In addition, only iron was detected at concentrations above soil cleanup guidance values for Class D waters within Gulf Creek.
- Nine Target Analyte List (TAL) metals were identified at concentrations above their respective severe effect levels in the sediment of Gulf Creek; the most prevalent metals detected were lead and zinc. TAL metals impacts were observed throughout Gulf Creek sediment, including sediment samples collected at the farthest reaches of Gulf Creek.
- The TAL metals reported in sediment samples are similar to TAL metals observed within the on-site fill material (OU1 and OU3), and likely migrate to the sediments of Gulf Creek via erosional runoff and groundwater transport pathways (EA Engineering 2011).

Sediment samples collected in Gulf Creek had average lead, other COPC metals, and PAH concentrations that were equivalent to average concentrations in SR7 sediments. PCBs were detected at less than 1 mg/kg in one sample (CH2M Hill et al. 2015). The results indicate the Gulf Creek sediments could be a potential source of contamination to Eighteen Mile Creek within OU3 but the contamination is being addressed by NYSDEC under a separate action. The contamination in Gulf Creek will be factored into the model if a remedial action is not anticipated at the site in the near future.

3.2.2 VANDEMARK CHEMICAL INC.

VDM is a custom chemical batch manufacturer of phosgene and phosgene derivatives located just downstream of OU2 on the east bank of the creek. VDM completed interim corrective measures and remedial activities at the plant site in 2012 to remove coal tar and address dense non-aqueous phase liquid (DNAPL) contamination of the groundwater (Golder 2012). VDM identified coal tar residuals and solidified coal tar seeps along the creek bank that historically could have impacted the creek. VDM completed a corrective measures implementation with remediation activities that were conducted from September 6 to November 15, 2012, to address the cleanup and containment of coal tar residuals and DNAPL located in soil and bedrock along a portion of VDM's property adjacent to the north bank of Eighteen Mile Creek and located south of VDM's manufacturing facility in Lockport, New York (Golder 2012). The activities included construction of the DNAPL interception trench on the bank. Additional monitoring activities have been completed to verify that there have been no impacts on the creek (Golder 2015, 2016). Therefore, VDM source contamination will not be incorporated into the CSM.

3.2.3 EAST BRANCH OF EIGHTEEN MILE CREEK

The East Branch of Eighteen Mile Creek, Gulf Creek, and several small unnamed tributaries were sampled as part of the NYSDEC 1998 and EPA Great Lakes Legacy Act (GLLA) 2010 investigations to determine whether major tributaries could be potential sources of contamination to the main channel of Eighteen Mile Creek (CH2M Hill et al. 2015). Sediment samples had lower lead and polycyclic aromatic hydrocarbons (PAHs) concentrations than the main channel, and PCBs were not detected. The results indicate that East Branch sediments are not a potential source of contamination to Eighteen Mile Creek's main channel within OU3. Therefore, the East Branch of Eighteen Mile Creek source contamination will not be incorporated into the CSM.

3.2.4 CITY OF LOCKPORT WASTEWATER TREATMENT PLANT (WWTP)

The City of Lockport WWTP is the only site within Eighteen Mile Creek OU3 that has an active State Pollutant Discharge Elimination System permit. The primary outfall for the WWTP is located at the upstream limit of OU3. The permit includes a monitoring program for various physical properties (e.g., temperature), biological variables (e.g., dissolved oxygen), and the following: metals, nutrients, and VOC/semivolatile organic compounds (SVOCs): mercury, lead, chromium, copper, lead, nickel, zinc, nitrogen, selenium, phosphorus, bromodichloromethane, dibromochloromethane, chloroform, trichloroethylene, and bis(2-ethylhexyl)phthalate. No monitoring is performed for organic COPCs. EPA Aquatic Life Criteria is available for metals, all of which have effluent limits at or below the criteria, except selenium, for which the effluent limit is a maximum daily concentration (4.6 micrograms per liter [μg/L]) and the criteria is a 30-day exposure limit (3.1 μg/L) (EPA 2016). There have been no exceedances of these limits reported by NYSDEC, indicating that this site is not a potential source of contamination to Eighteen Mile Creek within OU3 and will not be included in the CSM.

SUMMARY

The primary sources of contaminations for the Eighteen Mile Creek OU3 are surface waters and sediment from Eighteen Mile Creek OU1/OU2.

- Other potential sources of contaminations for the Eighteen Mile Creek OU3 have been evaluated and not considered to be significant and will not be incorporated into the CSM.

4 CONTAMINATED MEDIA

As part of previous investigations, as presented in the Data Gap report, samples of all media were collected and analyzed in OU3 and the OU1/OU2 source area. PCBs and metals (particularly lead) were identified as the primary COPCs based on historical studies. Mercury, PAHs, pesticides (i.e., dichlorodiphenyltrichloroethane [DDT] metabolites), and dioxins/furans also were considered as COPCs.

4.1 GROUNDWATER

Groundwater is not expected to be a potential source of PCBs, PAHs, lead, and other COPCs to the Eighteen Mile Creek within OU3 based on understanding of site, land use in watershed, and groundwater sample results in the OU2 (E & E 2017). Evaluation of groundwater discharges and potential groundwater contaminant sources within Eighteen Mile Creek OU2 is ongoing. The results of the evaluation will be incorporated in the model.

SUMMARY

Groundwater is not expected to be a potential source of contaminants to the Eighteen Mile Creek OU3. An evaluation is currently ongoing, and the results will be incorporated in the model.

4.2 SURFACE WATER

Water samples were collected and analyzed to characterize surface water quality. EPA's tributary study has confirmed that the Eighteen Mile Creek has had the highest PCB concentrations in surface water relative to other major tributaries in Lake Ontario in New York State (EPA 2011). In 2008, PCB concentrations in Eighteen Mile Creek surface water were more than 40 times greater than observed in other Lake Ontario tributaries and two-to-three orders of magnitude higher than observed in any other New York State tributary in 2009 to 2010.

A tributary study completed by the EPA and NYSDEC from 2002 to 2012 shows no trends and little variation in PCB concentrations over the 10-year period. The results indicate there is an ongoing source of PCB concentrations in the surface water that impacts Lake Ontario more than other tributaries. Data for surface water is from one location in SR1 in Olcott Harbor. NYSDEC continued monitoring from a second location in SR6 at Jacques Road, which was later moved to a location in SR4 near Ide Road. PCB concentrations in SR1 ranged from 19 to 93 nanograms per liter (ng/L, parts per trillion) for samples collected between 2002 and 2012. Data from 2011 and 2012 show that the dissolved PCB concentration accounts for approximately 70% of the total PCBs concentration at Olcott Harbor. Mercury and pesticides also were consistently detected in the samples, but the pesticide monitoring was suspended in 2005 because the concentrations were at low levels. In SR6, the total PCB congener concentrations are higher than in SR1, with an average of 89.3 ng/L in SR6 versus an average of 39.6 ng/L in SR1. All concentrations exceed the EPA Aquatic Life Criteria of 14 ng/L for PCBs (EPA 2016).

Twenty-two surface water samples were samples were collected in Eighteen Mile Creek during May/June 2018 (Phase IA) and October/November 2018 (Phase IB). The Phase IA sampling was conducted in spring 2018 to represent high-flow conditions and the Phase IB sampling was conducted in fall 2018 to represent low-flow conditions.

PCB Aroclors were not detected in Phase IA and Phase IB samples. Total and dissolved PCB congeners were detected in all samples collected for the Phase IA and Phase IB sampling events. The concentrations in the total portions are over 10 times greater than the dissolved portions. Total PCB congener concentrations in SR7 range from 46 ng/L near Lockport to 89 ng/L just upstream of East Branch of Eighteen Mile Creek. PCB congener concentrations gradually decreased from 89 ng/L in SR7 to 11 ng/L in SR1 (Olcott Harbor) in spring 2018. PCB concentrations in the East Branch were 0.07 ng/L in spring 2018. The decrease in concentrations downstream of East Branch in spring 2018 may be due to dilution of PCB concentrations by additional flow contributed by the East

Branch. In fall 2018, PCB concentrations were higher than in the spring downstream of East Branch of Eighteen Mile Creek, but lower than in the spring upstream of East Branch of Eighteen Mile Creek. Additional evaluation of the results relative to flow will be completed once the flow monitoring data is processed and submitted under a separate cover in March 2020.

For the Phase IA sampling event, SVOCs consisting primarily of PAHs were detected in eight samples representing five reaches (SR1, SR2, SR3, SR7, and SR9) in OU3. For Phase IB sampling event, SVOCs (typically PAH compounds such as fluoranthene and phenanthrene) were detected in five samples representing two reaches (SR6 and SR7). PAH total concentrations were generally below detected levels. The highest reportable total PAH concentration was 0.12 µg/L near Lockport in the spring. The total PAH concentrations in SR7 during the high-flow event increased five times to 0.65 µg/L.

Various metals and dissolved metals were reported as detected in all samples collected for the Phase IA and Phase IB sampling programs. Mercury was detected below the quantification limit in three samples collected for total metals in May 2018 (Phase IA). In the Phase IB (November 2018) sampling program, mercury was detected in 11 total metals samples and nine dissolved portion samples. Lead and copper concentrations were more consistent along the creek. Lead was detected in the total samples but not in the dissolved sample. Lead concentrations in the total portion were generally low, ranging between 2.8 and < 1 µg/L, increasing within SR7 ten-fold to 26 µg/L (total fraction) during the high-flow event in November 2018. Copper concentrations are generally similar in the dissolved and total portions. Copper concentrations were generally low, ranging between 7.4 µg/L and < 1.7 µg/L. Similar to lead concentrations, the concentration of copper increased in SR6 during the high-flow event in November; however, the increase was less dramatic with a recorded concentration of 14 µg/L. The results suggest that copper is primarily in the dissolved phase. Lead and copper concentrations in the East Branch were not detectable.

Total Dissolved Solids (TDS) ranged from 460 mg/L to 670 mg/L for the Phase IA sampling event and from 274 mg/L to 414 mg/L for the Phase IB sampling event. Total Suspended Solids (TSS) ranged 10 mg/L to 21 mg/L for the Phase IA sampling event and from 1.0 mg/L to 10.9 mg/L for the Phase IB sampling event. Results for data collection efforts in 2019 will be evaluated as part of the data gap analysis.

Results show that higher concentrations were observed in SR6 in samples collected on November 2, 2018, after a large rainfall event. Turbidity levels on that date were between 44 and 59 NTU, approximately 20 times higher than previous readings.

The details of this sampling study are provided in the *Phase I Data Evaluation Report, Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study* (E & E 2019a).

SUMMARY

The water column serves as a medium to transport and disperse the contaminants throughout the Eighteen Mile Creek OU3. The following conclusions are based on water sampling analytical results:

- The contaminants are present in both dissolved and suspended phases with no consistent trend present among the metals concentrations for the ratio of dissolved to suspended phases.
- The contaminant concentrations are higher in the suspended phase than dissolved phase. This phenomenon does not correspond to the TDS and TSS concentrations. The TDS concentrations were much higher than the TSS concentrations.
- Copper concentrations are low and found primarily in the dissolved phase.
- PCB congener concentrations decrease along the creek from SR6.
- Lead and copper concentrations were more consistent along the creek.
- Higher contaminant concentrations were recorded during the high-flow events as expected.
- PAH detection areas are in the vicinity of populated areas.

4.3 SEDIMENTS

The sediment in the creek bed has been sampled and analyzed extensively throughout most of OU3. Early sediment studies conducted by NYSDEC confirmed the presence of high levels of metals and PCBs and identified DDT metabolites, dioxins/furans, and PAHs in SR1 and the impoundments behind Burt Dam (SR2) and Newfane Dam (SR5) (NYSDEC 1998). The investigation also detected high concentrations of contaminants immediately upstream of Burt and Newfane Dams and in upstream sediments close to the Erie Canal. The cesium dating results from the sediment core samples taken upstream of Burt Dam concluded that the highest concentrations of contaminants were in subsurface sediments at depths of 70 to 80 centimeters dating from the early 1950s to mid-1960s (NYSDEC 2001). These studies identified upstream areas in the city of Lockport and Erie Canal as potential sources of contamination.

A PCB trackdown study conducted in 2006 indicated that most of the sediment in Eighteen Mile Creek within OU3 is contaminated with PCBs, and only the underlying soils in the creek bed at depths up to 2.7 feet are free of PCB contamination (E & E 2007). The EPA GLLA RI sampling program targeted sampling of depositional zones throughout creek bed in SR6 and SR7 (CH2M Hill et al. 2015). The results from this study indicated high variability of the PCB concentrations in SR7. Previously identified high PCB concentration locations were later found to have lower PCB concentrations and new high PCB concentrations were identified at new locations, confirming the high variability of the PCB concentrations in the sediment and potential for sediment movement.

COPCs were detected in sediments of Eighteen Mile Creek through its entire length from the Erie Canal to Lake Ontario. Summary statistics for COPCs in sediment, including the average and maximum detected results by reach, is provided in E & E's Data Gap Analysis for OU3 (E & E 2017).

COPC metals show a similar average and maximum concentration pattern of contamination by reach. The average concentrations of COPC metals are lower immediately below the creek corridor site (SR7) and increase to SR5 in the depositional area behind Newfane Dam. The average concentrations for COPC metals except mercury are the highest in SR2 behind Burt Dam, decreasing to background levels in SR1 downstream of Burt Dam. The maximum concentrations follow the same general pattern of contamination. High concentrations of lead and other metals in subsurface sediments in SR2 result in higher average concentrations behind the Burt Dam. Radio carbon-dated sediment cores taken from the Burt Dam depositional pool indicate that there was a significant potential historical metals source from the early 1950s to the mid-1960s. The average and maximum concentrations also show an increase in SR4 behind Newfane Dam, but subsurface concentrations of metals in these cores are generally lower than SR2 (CH2M Hill et al. 2015).

PCBs and PAHs show similar average and maximum concentration patterns of contamination by reach. PCB average and maximum concentrations are relatively higher in reaches immediately downstream of the creek corridor site in SR7 and then decrease to levels below 1 milligrams per kilogram (mg/kg) in SR1. PCB concentrations do not increase in the SR5 depositional area behind Newfane Dam. PCB average and maximum concentrations increase slightly in SR2 upstream end. The data suggest (as expected) that where the creek meets the impoundment waters behind Burt Dam there is a significant area of sediment deposition caused by the decreased flow rates. However, the PCB concentration profiles, with depth, indicate a significant amount of mixing in this area. In the deeper sediments of SR2 closer to Burt Dam, a much more distinct change in PCB concentration. Depth and maximum concentrations at depth indicate a potential historical source coinciding with deposition in the late 1960s to the mid-1970s.

In general, PAH concentrations decrease toward Lake Ontario. However, PAH average and maximum concentrations increase in SR4 and SR5, which are located in more populated areas and may be attributed to urban runoff. The findings from the EPA GLLA RI suggest that PAH contamination is ubiquitous throughout the watershed and is related to common anthropogenic sources (CH2M Hill et al. 2015). PAHs do not appear to be an appropriate indicator of PCB contamination from potential sources believed to be in the creek corridor site (OU2). Lower concentrations and more uniform distribution of the mercury and DDT metabolites also indicate anthropogenic sources not directly related to the contaminants originating in creek corridor site (OU2).

In 1998, NYSDEC collected two sediment cores in the depositional pools immediately upstream of the Burt Dam (SR2) and Newfane Dam (SR5). The cores were radiometrically dated to establish a chronology of deposition and associated contamination at a site (NYSDEC 2001). Radio-dating results show the maximum copper (2,450 parts per million) and lead (4,490 parts per million) concentrations in the Burt Dam depositional pool occur in sediments deposited sometime between the middle 1950s and early 1960s (70 to 80 centimeter [cm] subsample). Radio dating results from the core collected at upstream of Newfane Dam indicate the 20 to 24 cm depth corresponds to the 1963 to 1964 period. The reliability and usability of this data will be evaluated further as part of the data gap analysis.

Sediment data resulting from NYSDEC's 1994 sampling event showed higher contaminant concentrations in the surficial samples downstream of the Burt Dam as compared to surficial samples upstream of the dam. The highest contaminant concentrations upstream of the Burt Dam were recorded in deep core samples, not in the surficial sediments.

SUMMARY

The sediment column serves as a source and sink for the contaminants and act as medium to transport and disperse the contaminants throughout the Eighteen Mile Creek OU3. The sediment contaminant concentrations are variable in time and space and represent a dynamic balance of various sources and sinks to the sediment column. The following conclusions are based on sediment sampling analytical results:

- Most of the sediment in Eighteen Mile Creek within OU3 is contaminated with PCBs, and only the underlying soils in the creek bed are free of PCB contamination.
- The average concentrations for COPC metals except mercury decreases to background levels in SR1, below Burt Dam.
- The average concentrations for COPC metals except mercury are the highest in SR2 behind Burt Dam.
- The average and maximum concentrations also show an increase in SR5 behind Newfane Dam, but subsurface concentrations of metals are generally lower than SR2.
- PCB concentrations in SR6 have high variability in time and space.
- The average concentrations of COPC metals are lower immediately downstream of the creek corridor site (SR7) and increases to SR5 in the depositional area upstream of Newfane Dam.
- Radio carbon-dated sediment cores taken from the Burt Dam depositional pool indicate that there was a significant potential historical metals source from the early 1950s to the mid-1960s.

4.4 SOILS

The soils in the creek bank and floodplains have been sampled extensively throughout most of Eighteen Mile Creek within OU3. The results show that large areas have the potential to transport contamination during flood events. Floodplain samples were not collected from SR2 and SR3 as the creek banks are generally too high to flood.

One hundred eighteen (118) floodplain soil samples were collected during May and June 2018 (Phase IA) at 59 locations at two depths. The details of this sampling study are provided in the *Phase I Data Evaluation Report Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study* (E & E 2019a). PCB Aroclors were detected at varying levels in 71 OU3 floodplain samples. SVOCs consisting of primarily PAH compounds were detected in all OU3 samples. Metals including mercury were detected in all OU3 samples, and PCB congeners were analyzed in approximately 20% of the samples and were detected in all samples. However, the PCB congeners were detected at levels well below the PQL of the PCB Aroclors for all samples collected in SR1.

The results from the floodplain sampling indicate the following:

- The potential impacts from flooding of contaminated sediment would not be a concern for SR1 as the PCBs were not detected in most of the floodplain samples and the concentrations of other COPCs were low;
- The floodplain areas in SR4 are flat and prone to flooding and the results show detections of PCBs, PAHs, and lead in the floodplain samples indicating that flooding has deposited creek contaminants in floodplain areas. The magnitude or extent of the potential impacts from flooding of contaminated sediments are unknown and additional floodplain sampling was conducted as part of the Phase II activities;
- The floodplain areas in SR5 are flat and prone to flooding and the results show detections of PCBs, PAH, and lead in the floodplain samples indicating that flooding has deposited creek contaminants in floodplain areas. The magnitude or extent of the potential impacts from flooding of contaminated sediments are unknown and additional floodplain sampling was conducted as part of the Phase II activities;
- The floodplain areas in SR6 are flat and prone to flooding and the results show detections of PCBs and lead in the floodplain samples indicating that flooding has deposited creek contaminants in floodplain areas. The magnitude or extent of the potential impacts from flooding of contaminated sediments are unknown and additional floodplain sampling was conducted as part of the Phase II activities; and
- The floodplain areas in SR7 are flat and prone to flooding and the results show detections of PCBs, PAHs, and lead in the floodplain samples indicating that flooding has deposited creek contaminants in floodplain areas. The magnitude or extent of the potential impacts from flooding of contaminated sediments are unknown and additional floodplain sampling was conducted as part of the Phase II activities.

Irrigated soil samples were also collected during the Phase IA sampling event at nine irrigated field locations and two ditch locations. PCB Aroclors were not detected in the irrigated field samples. Total PCB congeners were reported at low part per trillion levels (below background concentrations) in a portion of the all samples that were analyzed for PCB congeners.

The details of this sampling study are provided in the *Phase I Data Evaluation Report Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study* (E & E 2019a). Results of additional floodplain soils collected as part of Phase II will be evaluated once they are reviewed and approved.

SUMMARY

Flooding has deposited creek contaminants in the floodplain of the Eighteen Mile Creek OU3 except in reaches SR1, SR2, and SR3.

5 SEDIMENT TRANSPORT

The key sediment transport processes relevant to the Eighteen Mile Creek are sediment erosion, sediment bedload transport, suspended sediment transport, and sediment deposition. Sediment erosion is defined as the net movement of sediments from the sediment bed to the water column. Sediment bedload transport occurs when sediment particles roll or bounce along the sediment bed. This generally occurs within a few grain diameters distance from the bed. Bedload is a typical mode of transport for heavier sand size and larger particles. Bedload material moves slower than the surrounding fluid. During suspended sediment transport, sediment particles are suspended in the water column by turbulence and carried with the flow of water. Suspended load is the typical mode of transport for fine-grained sediments. Suspended load generally moves at the same velocity as the surrounding fluid. Sediment deposition is characterized as the net movement of sediments from the water column to the sediment bed.

Particle size and velocity gradients are key factors in sediment transport within OU3. Once sediments are suspended, the fate of sediments depends on many factors, including the size of the particles and their settling velocity. Heavier particles tend to settle quickly into the creek bed, while finer particles that remain suspended are transported downstream.

The sediment transport process descriptions for each sediment reach are based on available information. No historic bathymetry data are available to identify the sediment deposition and erosion zones or sediment deposition and erosion rates on a large scale. However, erosional and depositional zones have been characterized locally based on sediment samples and the hydraulic regime. Additionally, it is assumed that the impoundments of the Burt and Newfane Dams represent depositional zones. This assumption is supported by sediment coring and radiocarbon dating behind the dams, showing a progressive deposition of material in the tested sections of the impoundments.

Sediment Reach 1 (SR1):   SR1 extends from Burt Dam to the mouth of the Eighteen Mile Creek at Lake Ontario. This reach extends through shallow areas of the creek channel; and deepens and flows into Olcott Harbor. Olcott Harbor has two parallel foot piers at the entrance with a 12-foot-deep and 140-foot-wide federally maintained navigational channel. The hydraulic regime in SR1 primarily depends on flow rates from Burt Dam (Burt Dam operational conditions) and Lake Ontario water levels including storm surges and waves as well as vessel-generated wake waves. Burt Dam acts as a sediment trap and the sediment load coming to SR1 from upstream will be minimal. Therefore, it is expected that Eighteen Mile Creek downstream of Burt Dam may erode, or has historically eroded, just downstream of the Burt Dam due to the lack of upstream sediment supply and, very locally, due the hydrodynamic influence of the dam's spillway. Sediment sampling downstream of Burt Dam indicates that sediment primarily consists of gravel, implying that just downstream of Burt Dam is an erosional zone where the more typical fine-grained materials present throughout Eighteen Mile Creek have been selectively eroded leading to armoring of the stream bed.

The flow velocities near the mouth of the Eighteen Mile Creek will be lower than that of upstream part of SR1. It is expected that sediment transported from the upstream deposits near the lake mouth. Sediment sampling at the lake mouth indicated that approximately 90% of the sediments are fines indicating this area is a depositional zone. During the flood conditions, it is expected that the peak flow in the SR1 will be greatly attenuated by the Burt Dam and sediment regime will be similar to normal flow conditions.

During storm events/storm surge, the fine sediments in the mouth of Eighteen Mile Creek will be resuspended and transported into the SR1. The transported sediment will either settle in the SR1 or transported back to Lake Ontario depending on the hydraulic conditions

It is also expected that vessel wakes and propeller wash would erode localized areas in the SR1.

Historical dredging volumes in the Olcott Harbor is provided in Table 5.1. The dredging volumes indicate that approximately 760 cubic yards per year deposited in the navigation channel during the 13-year period from 1985 to 1997. Approximately 400 cubic yards per year deposited during the 18-year period between 1997 to 2014. Historical dredging volume indicates that annual deposition rates in navigational channel ranged from 400 to 760 cubic yards.

Table 5-1 Historical Dredging Volumes – Olcott Harbor

Year	Dredging Volume (cubic yards)
1985	5,315
1997	9,874
2014	7,322

Sediment Reach 2 (SR2): SR2 is the Burt Dam Impoundment Area. The hydraulic regime in SR2 depends on Newfane Dam and Burt Dam operating conditions. Burt Dam acts as a sediment trap and, therefore, SR2 is primarily a depositional zone. It is expected that larger sediment particles will deposit in the upstream section of the SR2 and finer sediment particle size will deposit near the dam. Measurements of sediment thickness along transects at the upstream end of the impoundment averaged about 13 feet. Large sediment deposition areas have formed where the swiftly moving creek flows into the impoundment area and flow velocities drop quickly. The sediment input to SR2 includes sediments carried from upstream reaches, and sediments from overland flows and other potential point sources, such as stormwater outfalls. The sediment sinks will include sediments leaving SR2 through discharges to SR1 and sediment deposition in the creek channel of SR2. Sediment sampling for SR2 indicates that sediment primarily consists of fines. Higher contaminant concentrations in the surficial samples downstream of Burt Dam were recorded during the 1994 NYSDEC sampling event. The highest contaminant concentrations upstream of the Burt Dam were recorded upstream in the deeper core samples, not in the surficial sediments. The cesium dating results performed on the sediment core samples taken upstream of Burt Dam indicated maximum copper and lead concentrations occurred in sediments deposited between the middle 1950's and early 1960's (70 to 80 cm sample). Recent trace metal concentrations, as measured in the surface sediments, are considerably lower than the buried, peak concentrations. Peak trace metals concentrations observed further upstream in the Burt Dam depositional pool were generally found closer to the surface (28 to 52 cm).

These results confirm that the Burt Dam is a depositional zone with higher depositional rates close to the dam and with lower depositional rates at the upstream end of SR2 due shallow and fast-moving water.

The sediment trapping efficiency of Burt Dam depends on impoundment residence time, impoundment area depth, and dam operating conditions. The estimated residence is 520 hours based on a dam maximum storage volume of 6,116 acre-feet and an average outflow rate of 142 cfs. The average outflow rate from Burt Dam is assumed as the USGS water gage measures flow rates downstream of the Burt Dam. The 520-hour residence time likely rarely occurs as the dam is expected to generally operate under normal storage conditions and only occasionally reach its maximum storage volume. The normal storage area of the Burt Dam, and hence a more typical residency time estimate, is not available as of this report's publication. Fine silt particles (0.01 millimeters [mm]) would take about 2 hours to fall through 1 foot of water and fine clay particles (0.001 mm) would take about 175 hours to fall through 1 foot of water. It would take about 70 hours to settle a fine silt particle to the maximum Burt Dam depth of 35 feet and 255 days for a fine clay particle to settle under calm conditions. Therefore, most of the suspended sediments transported into the Burt Dam are expected to settle into the reservoir bed, except for the clay particles. The clay particles in the water column would be transported down to SR1 through the dam outlet. To confirm this, a sediment plume is shown at Olcott Harbor in June 2013 (see Photo 3).

Source: U.S. Geological Survey, June 6, 2013

Photo 3 – Sediment Plume at Olcott Harbor

A breach of Burt Dam would transport sediments in the impoundment area to SR1. The amount of sediment transported downstream would depend on dam breach characteristics and flow conditions during the breach.

The Burt Dam Impoundment Area may experience wind-generated waves from south winds. Depending on the water depth and wave properties (i.e., height, period, steepness, and breaking), wave motion may resuspend previously deposited sediments, making them available for transport by currents of otherwise insufficient velocity to trigger sediment transport.

Sediment Reach 3 (SR3): SR3 extends from the Burt Dam impoundment inlet to just north of Ide Road. This reach was flooded after installation of Burt Dam. The flow conditions in SR3 are determined by Newfane Dam operating conditions and the culvert located at Ide Road. This reach has surrounding marsh and forested wetland areas that were historically flooded. The sediment sources to SR3 will include discharge from SR4, overland flows and erosion occurring in the SR3 channel. The sediment sinks will include sediment leaving SR3 through discharge to SR2 and sediment deposition in the SR3 channel. Large sediment deposition areas have formed where the swiftly moving upstream creek flows into the impoundment area and the flow velocities drop quickly. The sediment sampling results indicate that sediment primarily consist of fine and sand. This reach is a depositional zone as incoming water slows down while entering the Burt Dam Impoundment Area.

Sediment Reach 4 (SR4): SR4 is the portion of creek between just north of Ide Road and the Newfane Dam. The flow conditions in the SR4 are determined by Newfane Dam operating conditions and the culvert located at Ide Road. In this reach, the creek is relatively swift moving and includes comparatively few sediment depositional areas of shallower depths. The sediment sources to SR4 will include discharge from Newfane Dam and three Unnamed Creek tributaries, overland flows, and erosion in the SR4 channel. The sediment sinks will include sediments leaving SR4 through discharge to SR3 and sediment deposition in the SR4 creek channel. The sources and sinks will vary according to the flow conditions, occurrence of runoff events, and Newfane Dam operating conditions. The Newfane Dam operates as a sediment trap and reduces the sediment load downstream. Therefore, it is expected that the Eighteen Mile Creek channel downstream of the Newfane Dam may erode, or has historically eroded, due the lack of upstream sediment supply. The culvert at Ide Road would create backwater conditions just upstream of the culvert and may facilitate sediment deposition in the upstream channel especially during flood conditions. The sediment sampling results indicate that sediment consists of gravel, sand, and fines in varying proportions. SR4 has a depositional zone just upstream of Ide Road and erosional zones just downstream of Newfane Dam.

Sediment Reach 5 (SR5): SR5 is the Newfane Dam Impoundment Area and includes deep-water areas with sediment several feet thick. The Newfane Dam acts as a sediment trap and SR5 is primarily a depositional zone. Sediment sources to SR5 include sediment discharged from SR6, and sediments from overland flow. The sediment sinks will include sediments leaving SR5 through discharges to SR4 and potential sediment deposition in the SR5 channel. Sediments in the bed primarily consist of fines (silt and clay and colloids) as per sediment sampling results for SR5. Radio dating of a sediment core from the Newfane Dam Impoundment Area indicated that peak cesium-137 concentrations occurred in a 20 to 24 cm section corresponding to the middle 1960s.

Similar to Burt Dam, the sediment trapping efficiency of Newfane Dam depends on impoundment residence time, impoundment area depth, and dam operating conditions. No outflow rates from the Newfane Dam are available to estimate the residence time of sediment in the Newfane Dam Impoundment Area. The maximum storage area of Newfane Dam is much smaller than that of the Burt Dam and the residence time of sediments in Newfane Dam would be less than that of Burt Dam. Therefore, it is expected that the most fines in the suspended sediments leave the Newfane Dam and would deposit in the Burt Dam Impoundment Area.

A breach of Newfane Dam would transport the sediments in the impoundment area to the downstream reaches. The amount of sediment transported to the downstream would depend on dam breach characteristics and flow conditions during the breach.

The Newfane Dam Impoundment Area may experience wind-generated waves from southeast winds. Wave motion acts as an agitator that can resuspend sediments and make them available for sediment transport by currents.

Sediment Reach 6 (SR6): SR6 extends from upstream of the Newfane Dam depositional pool to the East Branch of Eighteen Mile Creek. This reach is characterized by relatively shallow (<1 foot) sediment deposition areas, and higher flow velocities. The hydraulic regime of SR6 is highly influenced by the flows from the East Branch of Eighteen Mile Creek, channel and floodplain bathymetry, and the Jacques Road bridge. The sediment sources to

SR6 include sediment from SR7, the East Branch of Eighteen Mile Creek, four Unnamed Creek tributaries, overland flow, and potential channel erosion within SR6. Several outfalls from the Newfane area and agricultural drainage areas may also contribute sediments and contaminants to this reach. The significant flow from the East Branch of Eighteen Mile Creek increases flow velocity in the reach and reduces the potential for sediment deposition. Sinks will include sediment leaving SR6 through discharges to SR5 and potential sediment deposition in the SR6 channel. The EPA GLLA RI sampling program identified several depositional zones in SR6 (CH2M Hill et al. 2015). Sediment sampling results from the creek bed indicated deposits of gravel, sand, and fines in varying proportions, which indicates a mixed regime of erosion and deposition.

Sediment Reach 7 (SR7): SR7 extends from the bottom of the Niagara Escarpment to the East Branch of Eighteen Mile Creek. The reach is characterized as large stretches of slowly moving water with high sediment deposition. The hydraulic regime in SR7 depends on the flows from Eighteen Mile Creek OU2, discharges from the Lockport WWTP outfall, discharges from Gulf Creek, discharges from three Unnamed Creeks, discharge from the East Branch of Eighteen Mile Creek, channel and floodplain bathymetry, and five bridges within the SR7. Similar to SR6, the EPA GLLA RI sampling program identified several depositional zones in SR7 (CH2M Hill et al. 2015). Sediments in the SR7 are characterized as primarily sand and fines consisting of clay and silt. Sediment sources to SR7 include Gulf Creek, three Unnamed Creeks, and overland flow.

A schematic of the processes that influence sediment transport in the water column and the sediment bed of the Eighteen Mile Creek OU3 is shown in Figure 13. Local advection and dispersion in the water column control the distribution of sediment particles throughout OU3. Advection moves the sediments according to the local water velocity while dispersion spreads sediments based on concentration gradients. Sediments are typically classified as cohesive or non- cohesive as discussed in Section 2.5. Each sediment class is subject to different sediment transport processes. Creek flows will result in variable shear stresses at the sediment bed that, depending upon erodibility, may lead to erosion.

Figure 14 shows the CSM for sediment transport and describes the interaction between sediment reaches and sediment source areas. Potential sediment source areas are shown on Figure 14 as limited data are available to assess all of the sediment reaches. Some sediment sources (e.g., point sources and non-point sources) will be absent or less significant within the sediment reach.

Sediment Reach 8/9 and OU1/OU2: SR8/9 extends from the Eighteen Mile Creek OU2 to the bottom of the Niagara Escarpment and receives flow primarily from OU1/OU2. The reaches cover the creek that cascades down the steep gradient of the Niagara Escarpment that separates OU2 from OU3. There is minimal sediment deposition in this reach due to high water velocity. These reaches will be considered as the connection to a separate model being prepared for OU1/OU2. OU1/OU2 will be influenced by diversion from the Erie Canal as well as remedial activities to remove hydraulic structures such as Clinton Street Dam.

SUMMARY

The Eighteen Mile Creek OU3 sediments are primarily fines (clay and silt) with sand. The sediment transport processes in the Eighteen Mile Creek are:

- Resuspension of fine sediments in the water column;
- Suspended fine sediments transported downstream;
- Settlement of suspended sediments in ambient conditions; and
- Movement of sand as bed load and settlement.

The Newfane and Burt Dam impoundment areas are identified as primarily depositional zones and sediment depositional characteristics will depend on the residence time in these impoundment areas. The residence time depends on the storage area of the impoundment area and inflow/outflow rates. The Burt Dam residence time is estimated as 520 hours based on the maximum storage area and average outflow rates. The USGS gage flow rates were used to estimate the residence time. It is expected that the actual residence time would be less than 520 hours as the normal storage volume is smaller than the maximum storage volume. It is expected that the sediments including fine sediments transported to Burt Dam from the upstream reaches would be deposited in the impoundment area. Larger sediments are expected to settle at the upstream end of the impoundment area and finer sediments are expected to settle near the dam.

Sediment depositional areas were identified in shallower areas of the Eighteen Mile Creek within OU3, with higher concentrations of PCBs and lead. The results from subsequent confirmatory samples have been inconsistent. This suggests that distribution of PCB and lead contamination in sediments varies significantly and conditions change over time. Deposition in the shallow water depth area also is caused by the significant amount of woody debris obstructing the water flow throughout these portions of the Eighteen Mile Creek within OU3.

The Eighteen Mile Creek bed will likely be eroded during high flow events except the Newfane and Burt Dam impoundment areas and the sediments may settle in the eroded areas during the low-flow conditions.

Sediment deposition onto the banks and adjacent floodplain due to flooding is not well-documented but limited sampling of the historical creek channels and wetlands indicate limited impacts based on the low concentrations of contamination.

Anthropogenic activities discussed in Section 2.5 are expected to modify the sediment transport processes in the Eighteen Mile Creek OU3.

6 CONCLUSIONS

The CSM for sediment transport in Eighteen Mile Creek OU3 is based on the review of hydrologic, water quality, sediment quality, and sediment particle size data. This data describes the fate and transport of contaminants in OU3 and the nature and extent of contamination. The quality and amount of data are sufficient to identify the sediment transport processes that occur within the Eighteen Mile Creek and to develop a preliminary CSM for OU3.

Additional data is required to refine the CSM and conduct the hydrodynamic and sediment transport modeling. A data gap memo will be prepared and will identify the data gaps that currently exist in the data that will be needed to assess the sediment transport processes for the site. The data considered will include, but not limited to, Eighteen Mile Creek bathymetry, hydraulic structures, flow statistics, sediment properties, dam operating curves, impact of climate change in flow rates, sediment loading and contaminant concentrations. The data gap memo and development of a numerical modeling framework for OU3 will be submitted separately.

BIBLIOGRAPHY

CH2M Hill, Ecology and Environment, Inc., Environmental Design International, Inc., and Teska Associates, Inc. 2015. *Remedial Investigation Report, Eighteenmile Creek Area of Concern, Niagara County, NY*, prepared for USEPA GLNPO and USEPA Region 2.

EA Engineering P.C. and EA Science and Technology (EA Engineering). 2011. *Final Remedial Investigation Report Old Upper Mountain Road (932112) Lockport, New York, Site Number 932029, Town of Lockport, Niagara County*. Prepared for NYSDEC Region 9.

Ecology and Environment, Inc. (E & E). 2004. *Eighteen Mile Creek Comprehensive Watershed Management Plan Concept Document, Eighteenmile Creek Restoration Project*, Niagara County, New York, Prepared for Niagara County Department of Economic Development.

____________. 2007. *Final Report for the Eighteenmile Creek PCB Source Trackdown Project*. Niagara County, New York.

__________. 2009a. Final Supplemental Remedial Investigation Report for the Eighteenmile Creek Corridor Site (Site No. 932121), City of Lockport, New York. Prepared for the New York State Department of Environmental Conservation.

__________. 2009b. Final Additional Investigation Addendum to the Supplemental Remedial Investigation Report for the Eighteenmile Creek Corridor Site (Site No. 932121), City of Lockport, New York. Prepared for the New York State Department of Environmental Conservation.

__________. 2017. *Data Gap Analysis Eighteen Mile Creek Superfund Site Operable Unit 3 City of Lockport, Niagara County, New York*, Prepared for United States Environmental Protection Agency and U.S. Army Corps of Engineers.

____________. 2019a. *Phase I Evaluation Report Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study Niagara County, New York*, Prepared for United States Environmental Protection Agency and U.S. Army Corps of Engineers.

____________. 2019b. *Project-Specific Quality Assurance Project Plan for the Eighteen Mile Creek Superfund Site Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study Niagara County, New York*, Revision 3 (July 2019) and Addendum (November 2019). Prepared for United States Environmental Protection Agency and U.S. Army Corps of Engineers.

*Phase I*Federal Emergency Management Agency (FEMA). 2019. Flood Insurance Study (Vol. 1 of 3), Niagara County, New York.

Galloway, Marcia. 2019. Personal Communication. Project Manager, Ecology and Environment, Inc., Lancaster, New York. Email “Re. Newfane Dam,” December 19, 2019, discussion with Alon Dominitz, Dam Safety Section Chief, New York.

Golder Associates, Inc. (Golder). 2012. SNPE – VanDeMark Chemical Interim Corrective Measures Closeout Report, January 2012.

__________. 2013. SNPE-VanDeMark Chemical, Creek Bank Corrective Measures Implementation Construction Closeout Report, February 2013.

__________. 2015. 2014 Annual Monitoring/Inspection Report, SNPE- VDM Creek Bank Corrective Actions, VanDeMark Chemical Inc. – Lockport, New York, Order on Consent: R9-20080205-5. February 2015.

__________. 2016. 2015 Annual Monitoring/Inspection Report, April 2016

Hartgen Archeological Associates, Inc. (Hartgen). 2015. Phase IA Literature Review and Archeological Sensitivity Assessment, Eighteen Mile Creek Superfund Site Remedial Investigation / Feasibility Study, Operable Unit 2 (OU2), Mill Street, William Street, Olcott Street, and Clinton Street, City of Lockport, Niagara County, NY, February 2015.

Historic American Engineering Record (HAER). 2009. The New York State Barge Canal, Waste Weir (Maybees), 0.13 miles west of Bolton Road, Royalton Center, Niagara County, NY. HAER No. NY-506.

Lumia, Richard, D.A. Freehafer, and M.J. Smith. 2006. *Magnitude and Frequency of Floods in New York: U.S. Geological Survey Scientific Investigations Report 2006-5112*.

National Oceanic and Atmospheric Administration (NOAA) Tides & Currents. Online Database for Lake Levels, Tides and Currents. Accessed in October 2019.

National Centers for Environmental Information (NCEI). 2020. "Normals Monthly Station Details" Niagara Falls International Airport, NY US. Data generated on February 2, 2020. Accessed online at: https://www.ncdc.noaa.gov/cdo-web/datasets/NORMAL_MLY/stations/GHCND:USC00305840/detail. Accessed on February 2, 2020.

New York State Department of Environmental Conservation (NYSDEC). 1996. *Trackdown of Chemical Contaminants to Lake Ontario from New York State Tributaries*.

__________. 1998. Eighteenmile Creek and Olcott Harbor Sediment Study, Niagara County, New York

__________. 2001. *Final Report, Eighteen Mile Creek Sediment Study*. Summary of August 17-20 and November 3, 1998 Results.

__________. 2019. New York State Inventory of Dams. NYSDEC Division of Water. Dam Safety Section. Vector digital data. Published on November, 25, 2009. Albany, New York.Accessed online at: http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1130. Accessed on October 23, 2019.

U.S. Army Corps of Engineers, Engineer Research and Development Center (USACE ERDC). 2014. *Technical Guidelines on Performing a Sediment Erosion and Deposition Assessment (SEDA) at Superfund Sites*.

U.S. Environmental Protection Agency (USEPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.*

__________. 2011. Field Data Report, Lake Ontario Tributaries 2009-2010. USEPA Monitoring and Assessment Branch.

__________. 2016. *National Recommended Water Quality Criteria - Aquatic*

Life Criteria Table. Available online at https://www.epa.gov/wqc/national-recommended-water-quality-criteriaaquatic- life-criteria-table, accessed December 2016.

United States Geological Survey (USGS). 2019. StreamStats Online Tool. Accessed online at: https://streamstats.usgs.gov/ss/. Accessed in October 2019.

__________. 2019. USGS National Water Information System Online Database for Stream Flows. Accessed online at: https://waterdata.usgs.gov/nwis. Accessed in October 2019.

APPENDIX

A FIGURES

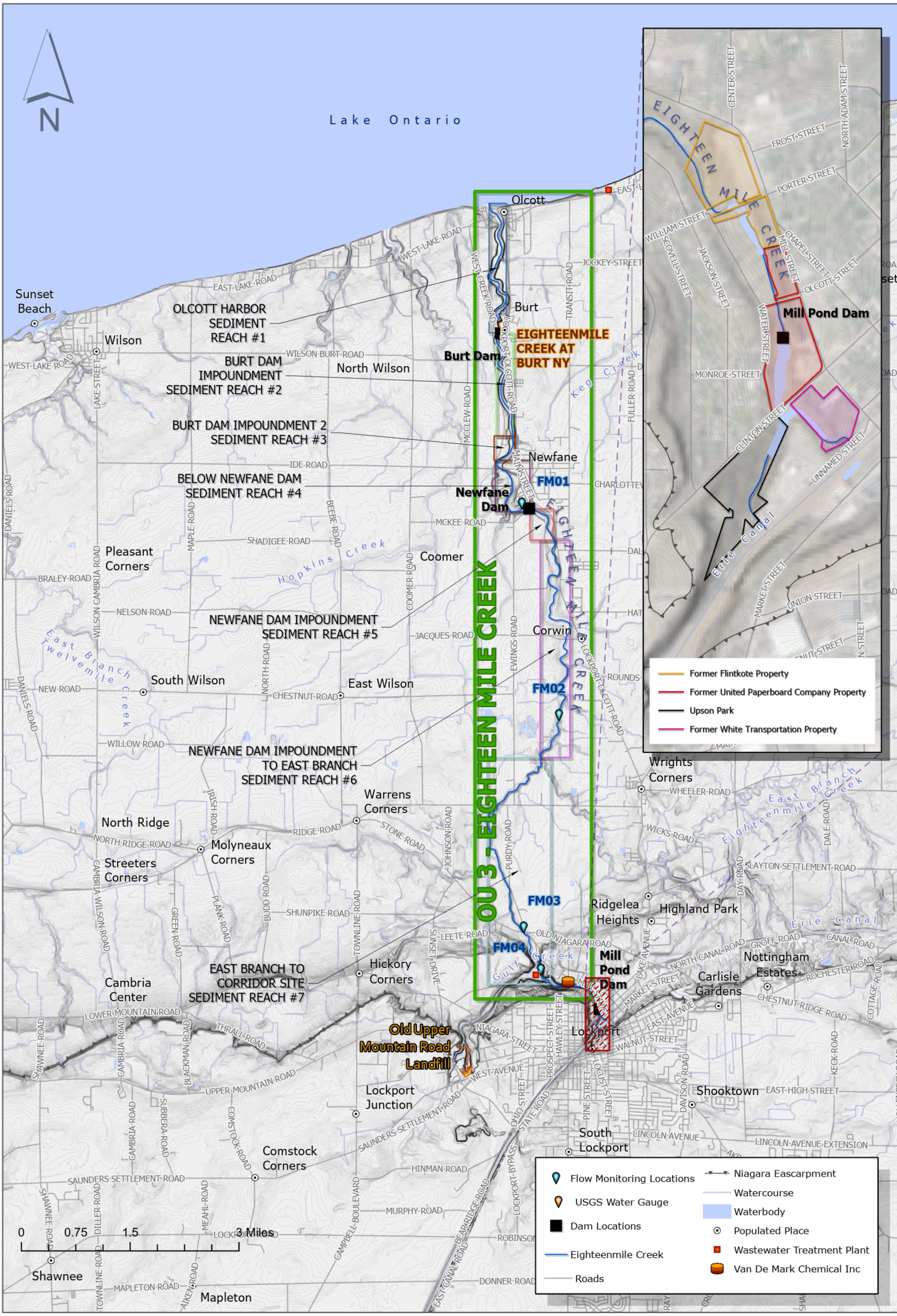

FIGURE 1 -
EIGHTEEN MIILE CREEK OU3 SEDIMENT REACHES

APPENDIX

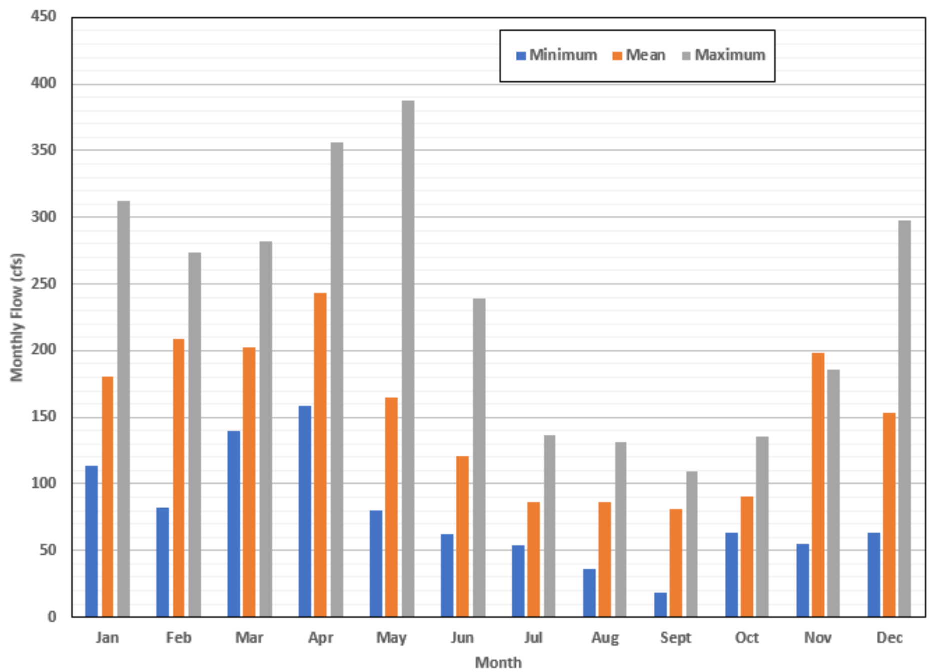

Figure 2: **Monthly Flows Downstream of Burt Dam**

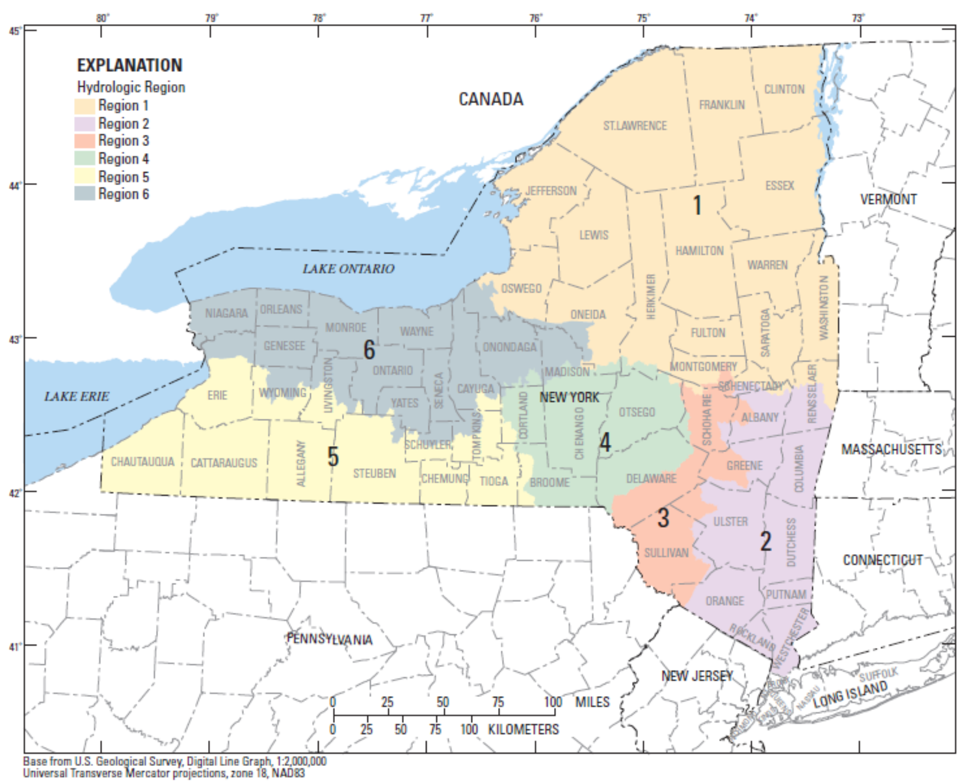

Figure 3: **Six Hydrologic Regions of New York**

APPENDIX

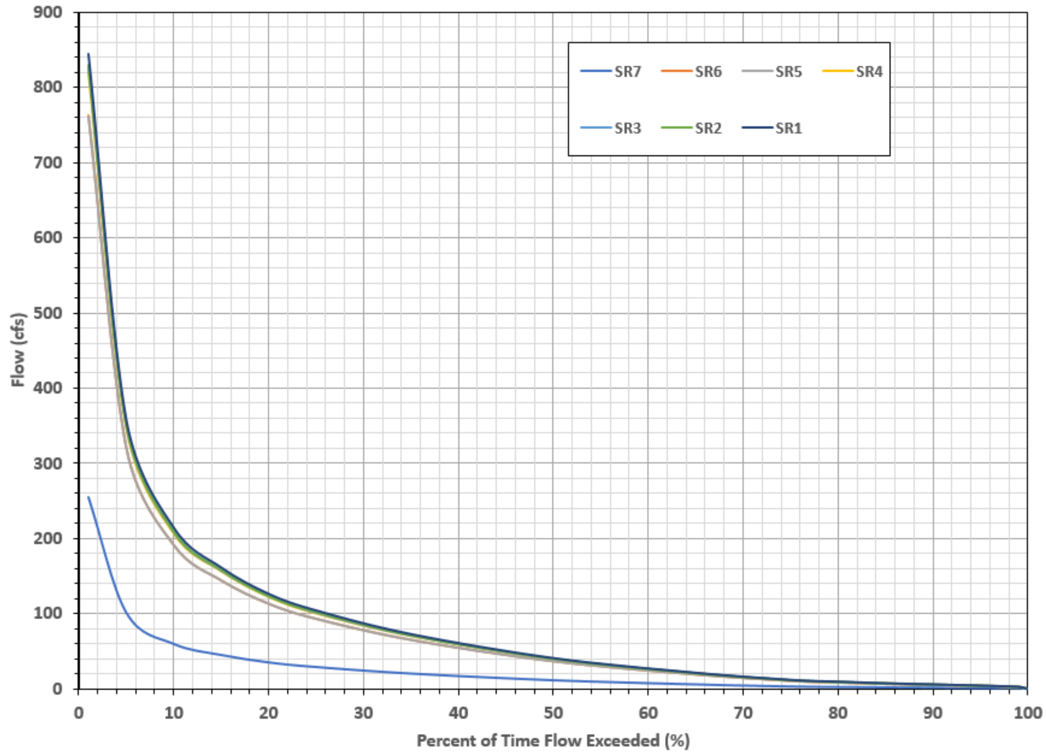

Figure 4: Flow-Duration Curves for Sediment Reaches

APPENDIX

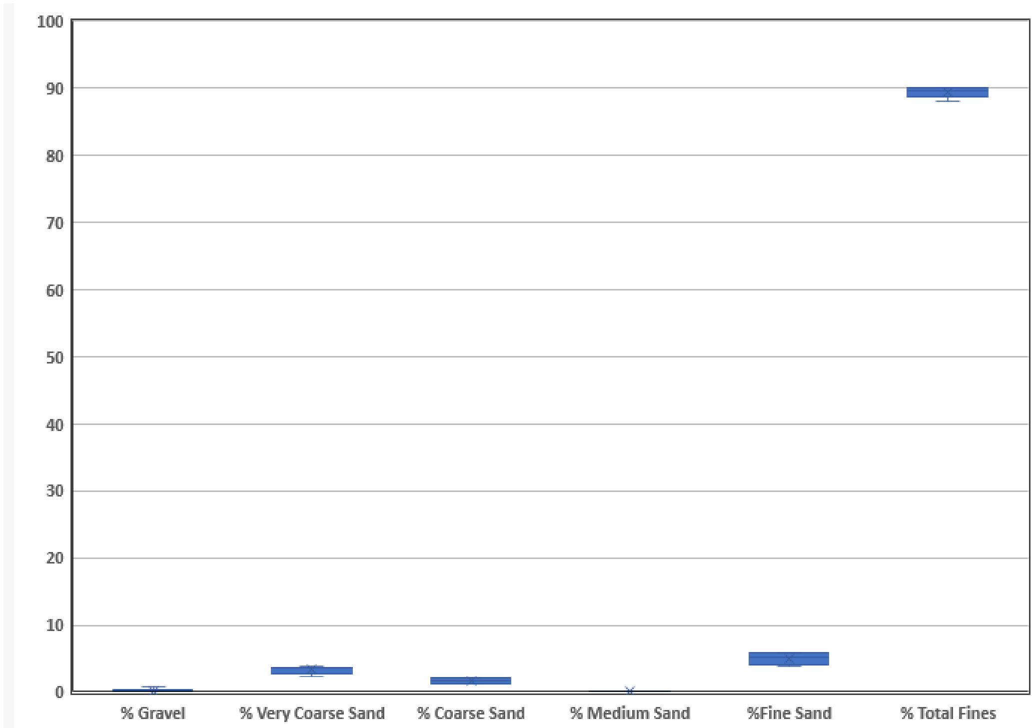

Figure 5: **Sediment Details – Lake Ontario**

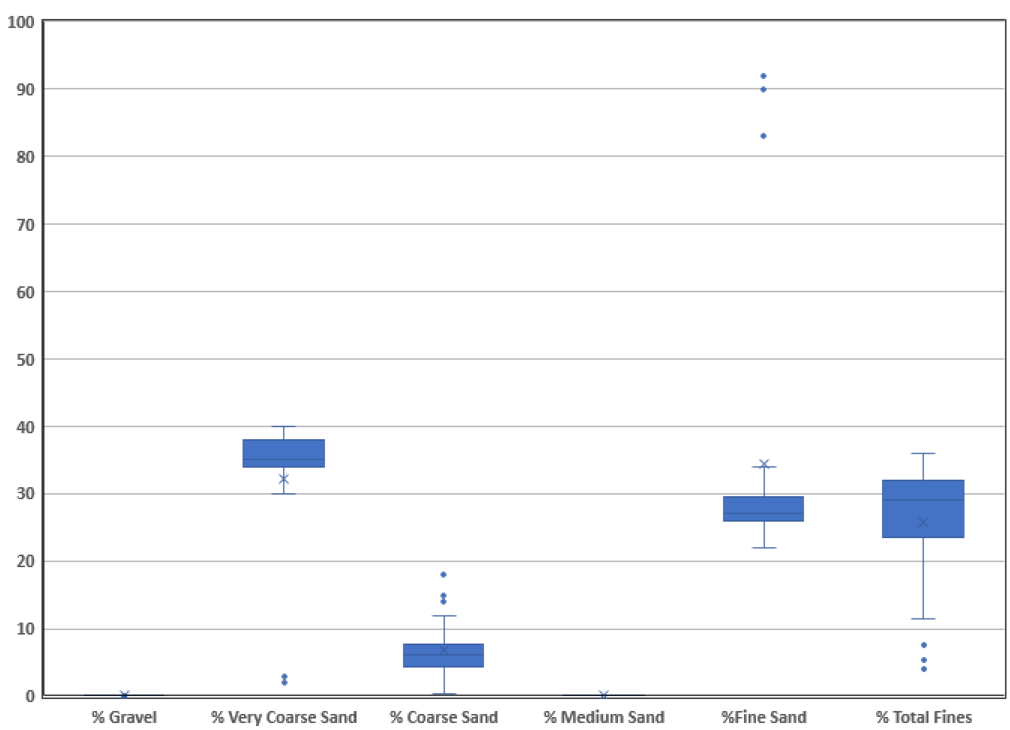

Figure 6: **Sediment Details – SR 1**

APPENDIX

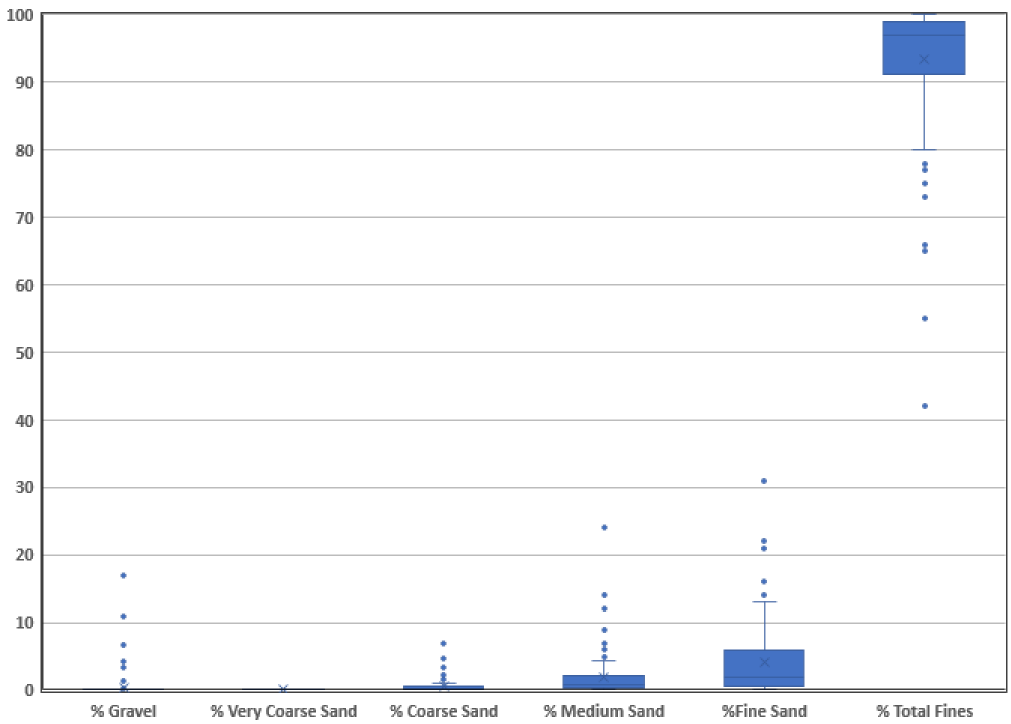

Figure 7: **Sediment Details – SR 2 (Impoundment Area)**

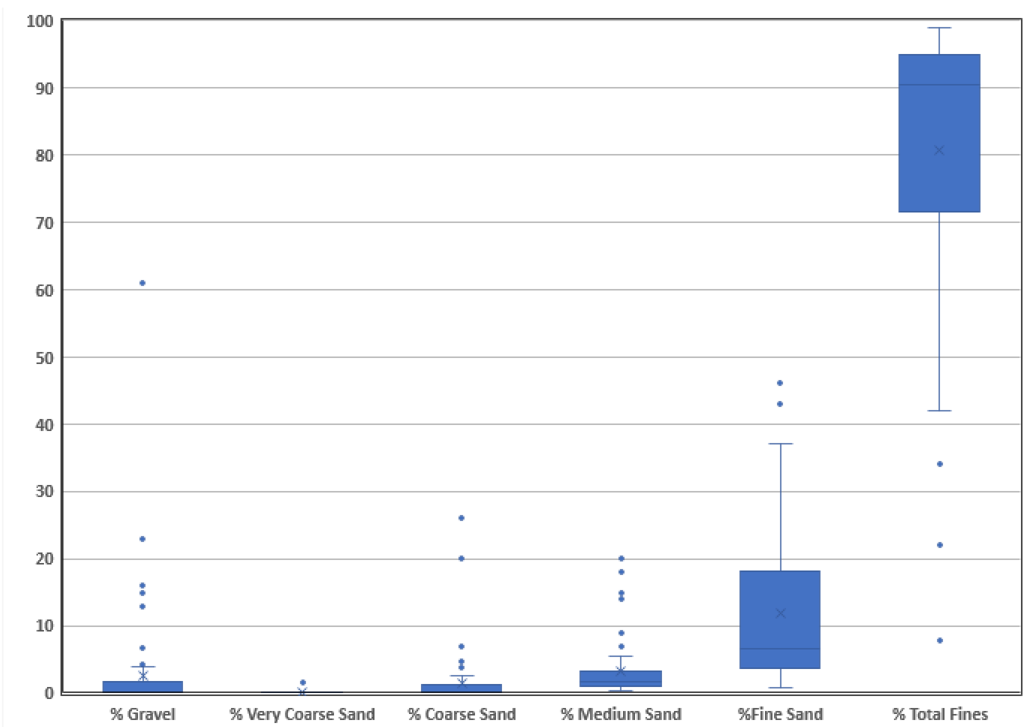

Figure 8: **Sediment Details – SR 3**

APPENDIX

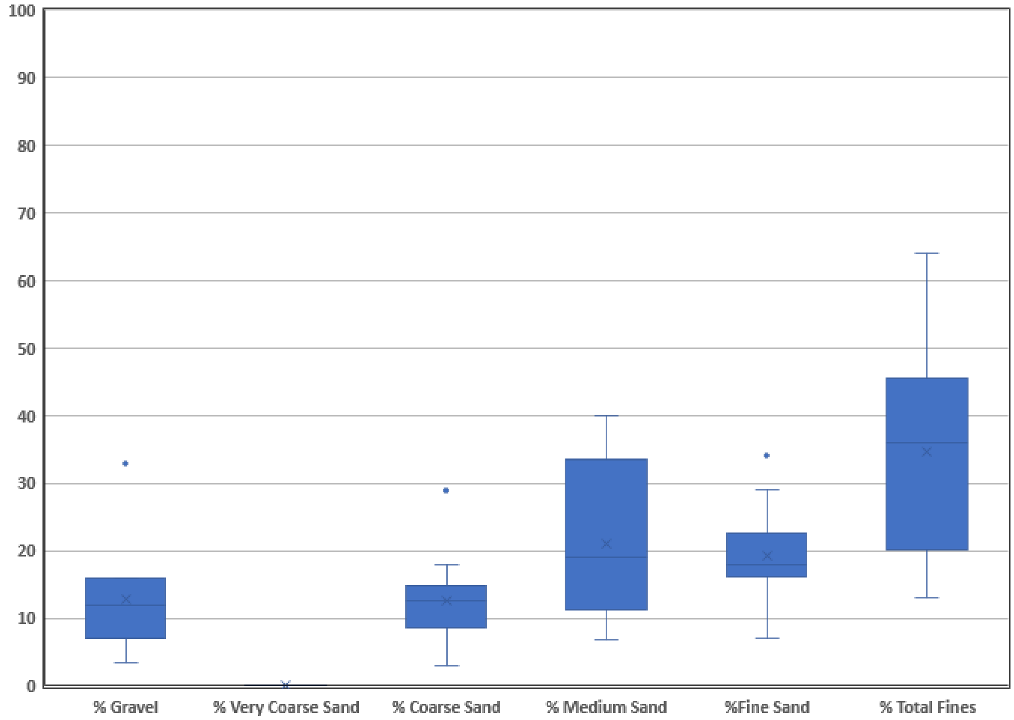

Figure 9: **Sediment Details – SR 4**

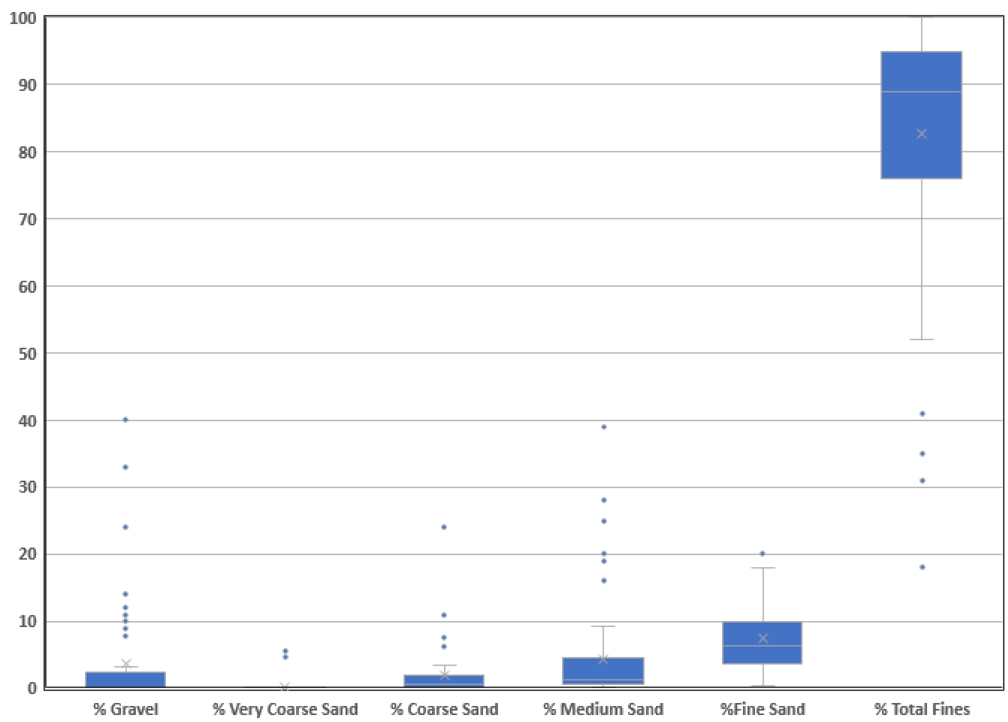

Figure 10: **Sediment Details – SR 5**

APPENDIX

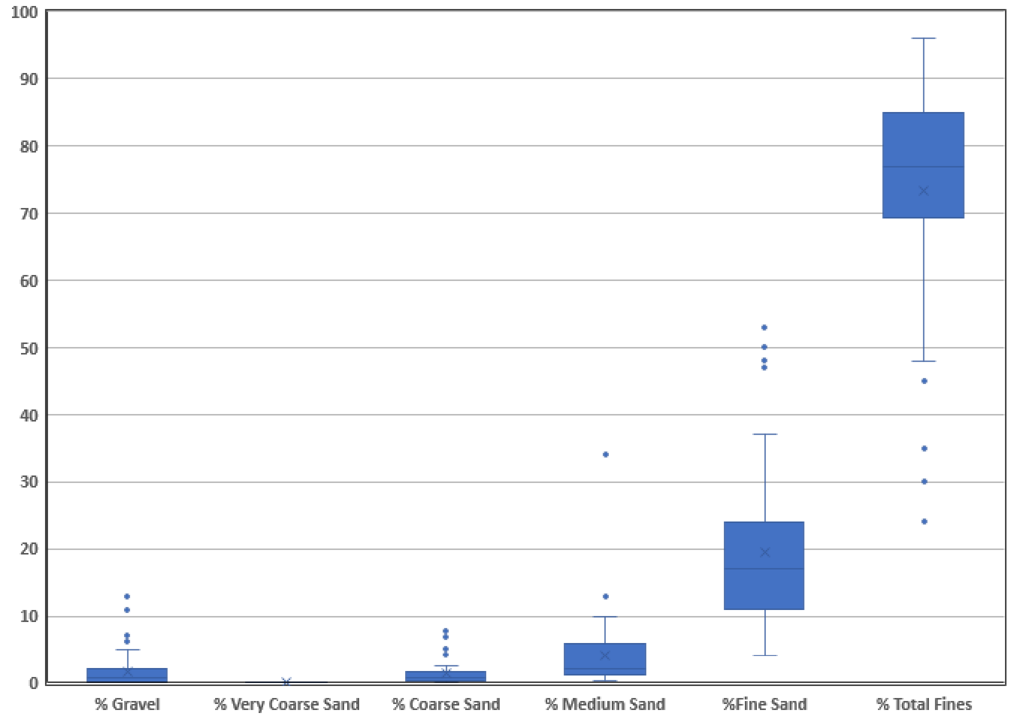

Figure 11: Sediment Details – SR 6

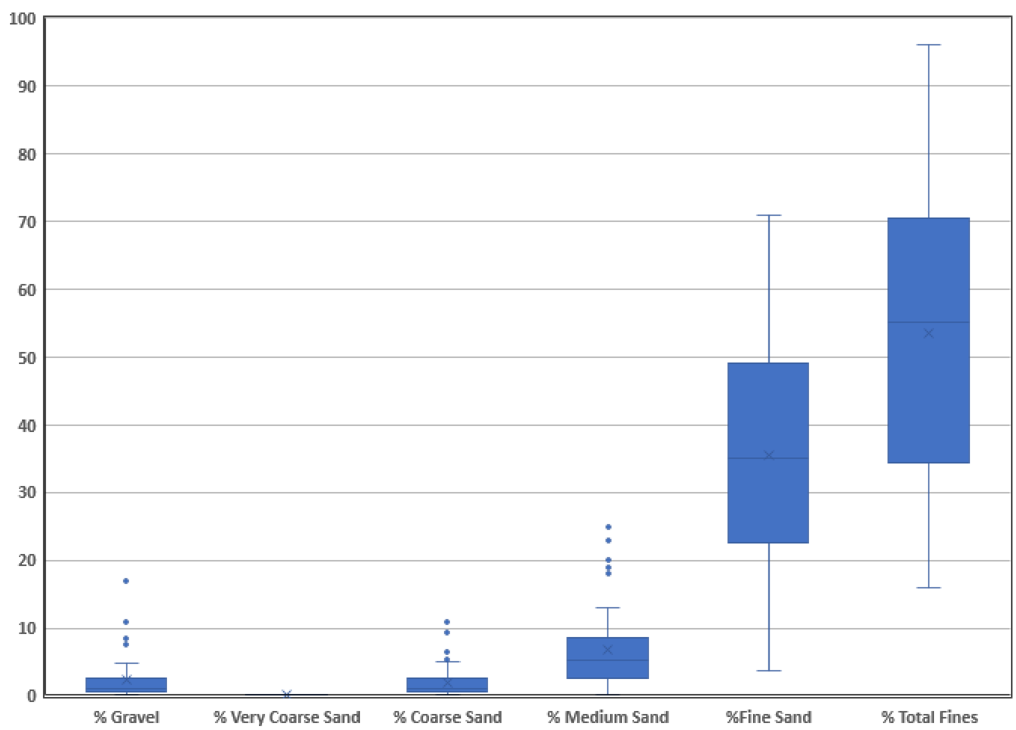

Figure 12: Sediment Details – SR 7

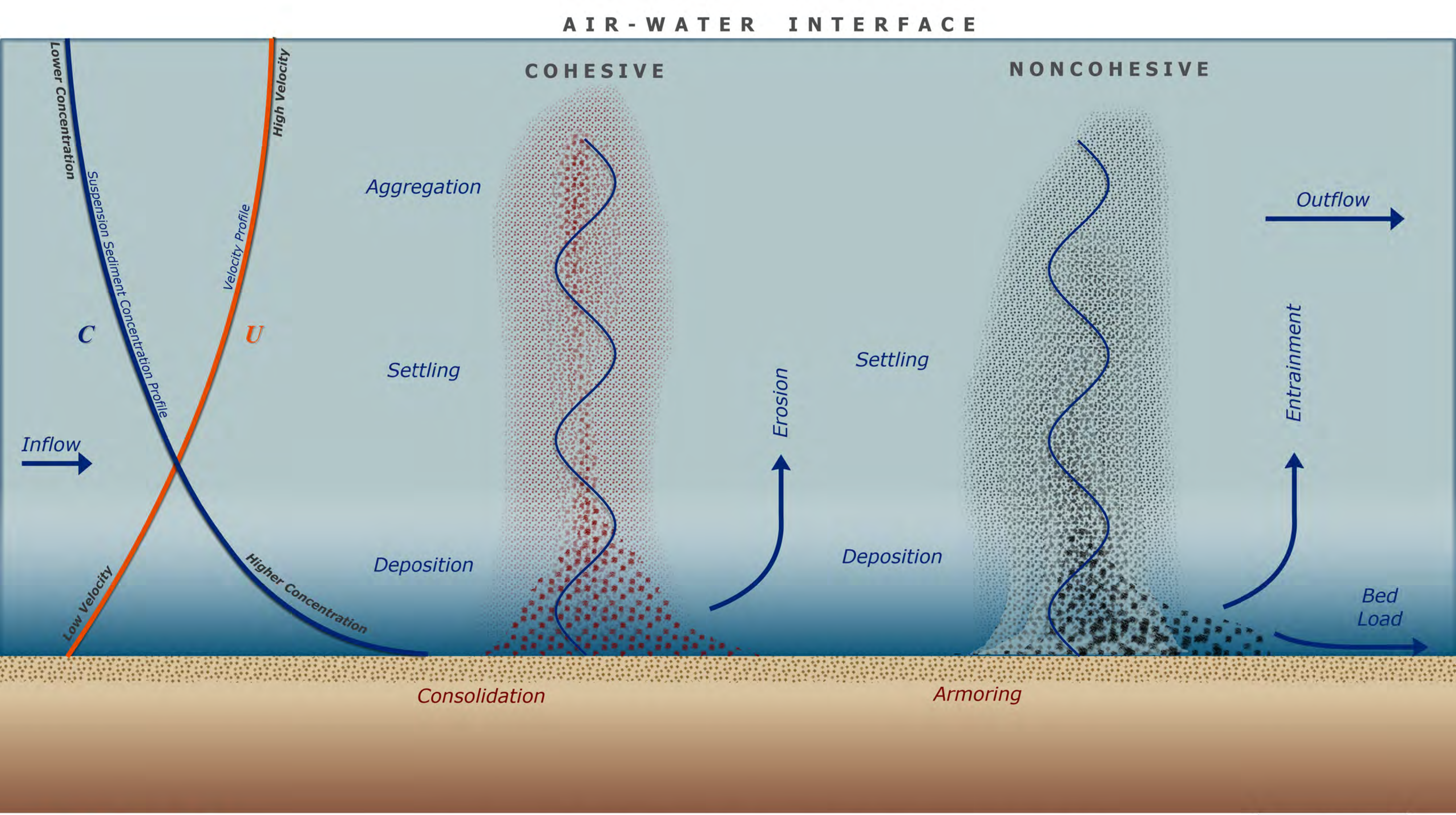

FIGURE 13 - SCHEMATIC OF SEDIMENT TRANSPORT PROCESS

EIGHTEEN MILE CREEK PROJECT

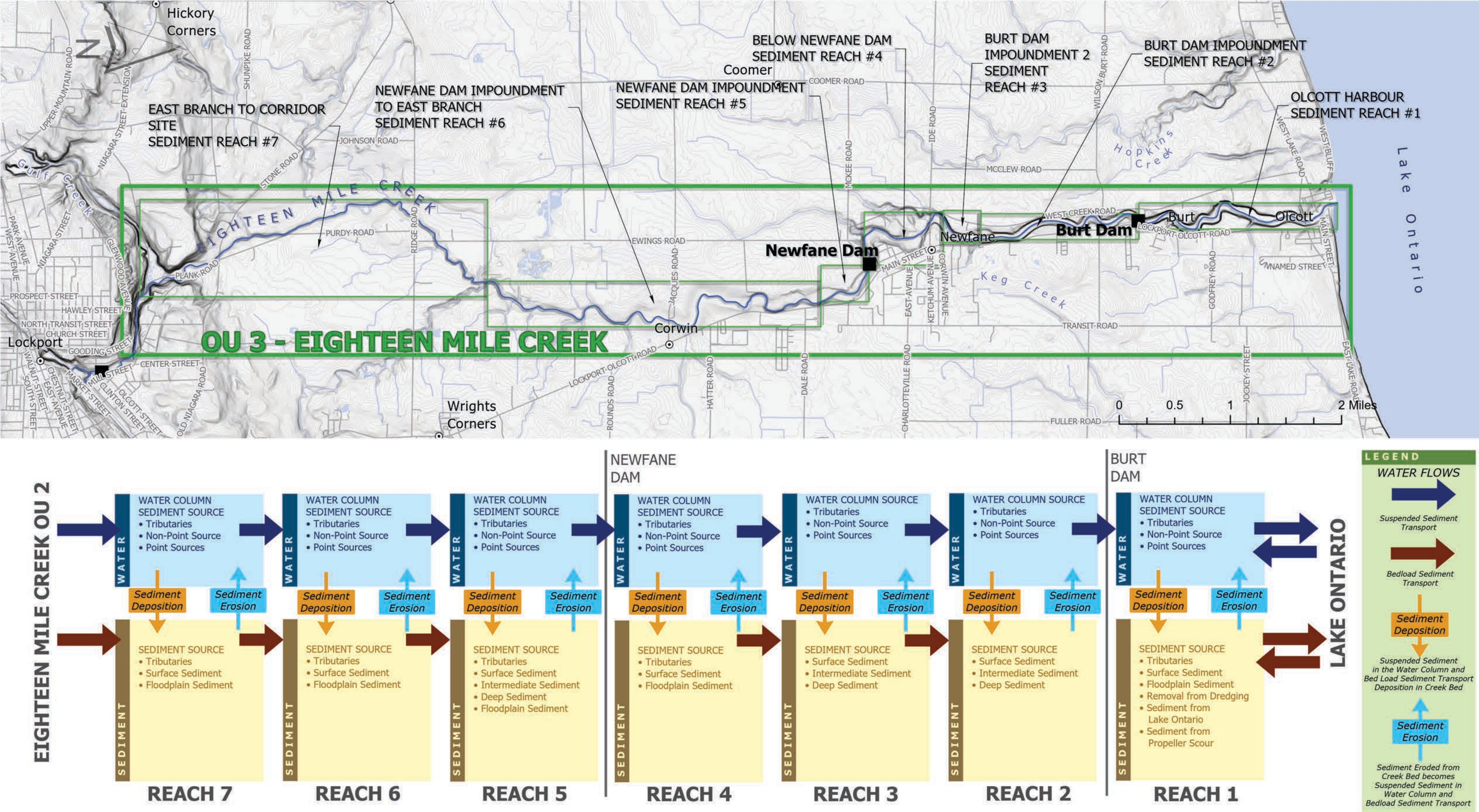

FIGURE 14 - CONCEPTUAL SITE MODEL FOR SEDIMENT TRANSPORT

EIGHTEEN MILE CREEK PROJECT

Note:
1. Point source is defined as sediment that enters the creek from a confined plane (e.g. discharge pipes, tributary, drainage ditches & storm water outfalls).
2. Non-point source is defined as sediment that enters the creek from a wide area (e.g. land runoff, eroding creek bed & bank)