NIAGARA POWER PROJECT

RELICENSING

EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

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EXECUTIVE SUMMARY

STUDY PURPOSE

The Niagara Power Project in Lewiston, Niagara County, New York, is one of the largest non-federal hydroelectric facilities in North America. In 1957, a 50-year license for operation of the Project was issued by the Federal Power Commission (now the Federal Energy Regulatory Commission, or FERC) to the Power Authority of the State of New York (now the New York Power Authority, or NYPA). The Project first produced electricity in 1961. The operating license for the Project expires in August 2007 and NYPA has begun the relicensing process. As part of the relicensing process, NYPA investigated the potential effects of water level and flow (when used in this report the term "flow" means velocity) fluctuations on aquatic and terrestrial habitat. The Investigation Area includes U.S. waters of the mainstem upper Niagara River and mainstem lower Niagara River and portions of its tributaries, and associated riparian habitats. For this report, the upper Niagara River is defined as that part of the United States portion of the Niagara River from the Peace Bridge downstream to the Niagara Power Project intakes. The lower Niagara River is defined as the United States portion of the Niagara River from the tailrace of the Niagara Power Project downstream to Lake Ontario. U.S. waters and riparian zones extending from the Project water intakes in the upper river to the tailrace in the lower river are being examined in a separate study and are not discussed in this report. Stantec Consulting Services, Inc. conducted all fieldwork, preliminary data analysis, wrote habitat descriptions for this report, and provided technical assistance in determining the potential effects of water level and flow fluctuations on aquatic and terrestrial habitats. Gomez and Sullivan Engineers, P.C. and E/PRO Engineering & Environmental Consulting, LLC completed the final analysis of potential effects on habitats and species that use these habitats. URS Corporation produced all maps and figures for this report.

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STUDY PARAMETERS

Water Level and Flow Fluctuations

Water level and flow fluctuations in both the upper and lower Niagara River are caused by a number of factors. Natural factors include flow surges from Lake Erie, wind, ice conditions, and regional and long-term precipitation patterns that affect lake levels, while manmade factors include boat wakes, regulation of Niagara Falls flows per the 1950 Niagara River Water Diversion Treaty, operation of hydroelectric power plants on the Canadian side of the river, and operation of the Niagara Power Project. The influence of these factors on water levels is interrelated and dynamic. Because the water level in the Niagara River at any location at any time is a complex function of natural and manmade factors, distinguishing the exact amount of water level fluctuation attributable to each factor is difficult. In the upper river, the fluctuations were assessed using monthly minimum and maximum water level data from permanent water level gauges for a typical, wet and dry year. All "significant" storm events were removed from the dataset. For the lower river, monthly minimum and maximum water levels from temporary gauges in 2002 were used. For the Lewiston Reservoir, monthly minimum and maximum water levels from 1991-2002 were used. Even the efforts to remove water level data recorded during significant storm events could not isolate the effects of NYPA and OPG operations on water levels and flow in the upper Niagara River as there are other influencing factors, such as localized environmental conditions on Lake Erie and smaller wind events that were included in the analysis. Because water level fluctuations are influenced by a number of factors, the approach used for this investigation provides a resource conservative of the potential effects due to NYPA and OPG operations (i.e., resource conservative means that this analysis is likely to overestimate rather than underestimate the effect of NYPA and OPG power operations on habitat in the investigation area).

Habitat Characterization

The aquatic habitats in the upper and lower Niagara River, Lewiston Reservoir and the terrestrial habitats near these areas were delineated and classified using a combination of aerial photography,

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existing literature, and field surveys. Key habitat features that were mapped included water depth zones, the location and relative extent of areas with little or no current, dominant substrates, the location of submerged aquatic vegetation (SAV) and emergent aquatic vegetation (EAV), and the location of documented large wetland areas. In 2002, field data collection was completed along 24 representative transects in the upper and lower river and Lewiston Reservoir. In addition, three cross-sectional transects per tributary (a total of nine) were established in Tonawanda, Cayuga, and Ellicott Creeks. Elevation control was established at each transect and site-specific aquatic and terrestrial habitat data were collected. The resulting habitat information was used in assessing habitat availability and distribution in relation to fluctuating water levels.

Habitats were described by their attributes (e.g., depths, vegetation type, substrate, velocity). Water level fluctuations in the Niagara River and Lewiston Reservoir were analyzed using water elevation data from 10 permanent gauges in the upper river, four temporary gauges in the lower river, and one permanent gauge in the Lewiston Reservoir. The potential effect of water level and flow fluctuations on aquatic and terrestrial habitat and the habitat used by representative species was assessed in the upper and lower Niagara River and Lewiston Reservoir. The was accomplished using (1) minimum and maximum water elevations superimposed on the habitat that exists in a given area to identify the habitat types located in the zone of fluctuation and (2) information in existing scientific literature to make qualitative determinations regarding the potential effect on habitats and representative focus species.

Focus Species

The potential effects of these water level and flow fluctuations on aquatic and terrestrial habitats and the habitat of representative (focus) species were assessed by examining the timing and magnitude of the fluctuations in relation to the habitats that exist in a given area and how and when these habitats are utilized by these species. A total of 37 species (19 fish, 15 wildlife, and three macroinvertebrates) were selected by NYPA, USFWS, and NYSDEC. These were chosen because they are of particular interest (i.e., lake sturgeon), represent the majority of all species that use the various habitats in the investigation area for specific life-stages (i.e., spawning and nesting, overwintering, foraging, etc.), and sufficient literature exists on the habitat requirements for these species. These species were used as analysis tools

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for determining the potential effects of water and flow fluctuations on aquatic and terrestrial habitats in the investigation area. Although the potential effects discussed in this report are focused on the life stage of the 37 representative species, these species are meant to represent similar grouping of species that use habitats influenced by water level and flow fluctuations for similar life stages.

FINDINGS AND CONCLUSIONS

Aquatic and Terrestrial Habitat

Upper Niagara River

In the upper river, water depths affected by water level fluctuations were determined to be within the 0-2-foot zone, and a small component (the first 0.5 feet) of the 2-6-foot depth zones, with the difference in monthly maximum and minimum water elevations being <2 feet for most months and years. Most areas that were not sheltered from wind or wave action had little or no submerged aquatic vegetation (SAV) in the 0-2-foot depth zone, and SAV was common in 2-20 feet of water, much of it forming dense beds. Areas that were particularly exposed to southwest winds had little or no vegetation between 0 and 4 feet deep. Sheltered areas often had SAV and EAV (emergent aquatic vegetation) in the 0-2-foot zone. This is similar to a survey conducted in 1955, which found SAV in water generally 1.5 – 5.5 feet deep, and in water <1.5 feet deep in sheltered areas; however it was not indicated what the water surface elevation was during the 1955 survey. A survey conducted in 1928 also found SAV and EAV in the same locations as in 1955 and 2002 (although SAV occurred at depths up to ~20 feet in 2002). The same species were dominant in all years. The potential effect of water level fluctuations in the 0-2-foot depth zone is on SAV and EAV distribution. It is possible that in some areas of the river, water level fluctuations have created conditions for SAV and EAV such that their distribution shifts landward in wet years and towards the center of the channel of the river in dry years. An indirect effect of these fluctuations is on where wind and wave action may be focused, which has the potential to affect SAV and EAV establishment in nearshore areas. Water level fluctuations potentially affect the extent of areas of

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little or no velocity in the upper and lower rivers, causing slight decreases in extent as water levels fall and slight increases in extent as water levels rise.

Long-term (e.g., seasonal, yearly) water level fluctuations in the upper river and Grand Island tributaries could result in changes in coastal wetland habitat structure, distribution, and species composition over time. Many coastal wetlands are dynamic ecosystems that require water level fluctuations and both high and low water levels to maintain habitats and the diversity of plant and animal species. These long-term fluctuations have varying sources, magnitudes, frequencies, timing, and duration, each with different effects on wetlands, and are important to the maintenance of coastal wetlands. Short-term (daily) fluctuations resulting from American and Canadian hydroelectric operations likely have a limited direct effect on coastal wetlands because these fluctuations are cyclical, with generally consistent extent and frequency; enabling wetland vegetation to become adapted. The portion of Buckhorn Marsh that is located between the two weirs is not affected by water level fluctuations and water levels between these water level control structures are relatively stable.

Regulation of water levels that result in dampening of fluctuations can affect coastal wetlands. Where water-level regulation has significantly reduced the occurrence of extreme high and low water levels, disruption of the natural fluctuation cycle favors species intolerant of water-depth change and associated stresses, and/or excludes species requiring periodic exposure of fertile substrates, potentially leading to a reduction of species diversity. For example, the dominance of cattails in many Lake Ontario marshes suggests a trend toward reduced species diversity following a reduction in the amplitude of natural water level fluctuations.

Seasonal and daily fluctuations in water levels may influence the portion of the nearshore zone affected by waves by exposing a wider area of this zone to wave action than if there were no fluctuations. Energy associated with waves may be an important factor affecting the local extent of EAV in nearshore habitats, physically uprooting and removing EAV and creating bands of coarser substrates in exposed nearshore habitats.

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Lower Niagara River

In the lower river, monthly differences between maximum and minimum elevations are similar to those of the upper river. Water depths affected by water level fluctuations were determined to be within the 0-2-foot and a small component (approximately the first 0.5 feet) of the 2-6-foot depth zones. In the lower river, water level fluctuations affect depth to a greater extent than width, as the river's sides are very steep. The distribution of SAV in the nearshore area of the lower river may be affected in the same manner as in the upper river, although the nearshore area in the lower river where SAV could become established is much narrower than in the upper river. A 1928 survey of the lower river found that SAV was uniformly distributed in the nearshore area at depths of 3-13 feet, which is similar to that found in 2002 (although SAV occurred at depths up to ~20 feet in 2002). No wetlands and very little EAV were identified in the lower river. Water level fluctuations potentially affect the extent of areas of little or no velocity in the upper and lower rivers, causing slight decreases in extent as water levels fall and slight increases in extent as water levels rise.

Coastal wetland habitats do not occur in the lower river because of the relatively steep slopes leading down to the water, the lack of shallow water areas with flat bathymetry, coarse substrates, and fast water flows. These combined factors are not conducive to the development of large, fringe riverine wetlands, and these habitats likely have never existed in the lower river to any great extent.

Lewiston Reservoir

The sides of the Lewiston Reservoir are large boulder riprap, which is unsuitable substrate for the establishment of SAV. Most of the bottom of the reservoir contains substrate suitable for SAV establishment, but extensive SAV establishment is likely precluded by water level fluctuations.

The steep, riprapped interior walls of Lewiston Reservoir, combined with the extreme weekly water level fluctuations, are not conducive to the development of coastal wetland habitats and none occur there.

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Fish and Macroinvertebrate Focus Species

Upper and Lower Niagara River

Water level and flow fluctuations have the potential to affect the spawning, egg, and larval habitat used by lake sturgeon, lake trout, muskellunge, largemouth bass, smallmouth bass, walleye, yellow perch, bluntnose minnow, northern pike, and crayfish (in both the upper and lower Niagara River), brown bullhead, greater redhorse, burrowing mayfly nymphs and eggs, and giant floater mussels (in the upper Niagara River only), and Chinook salmon and rainbow smelt (in the lower Niagara River only). Potential effects resulting from the loss of use of shallow water habitats are somewhat mitigated by the fact that suitable habitat exists at greater depths and affords opportunities for these species' lifestages at depths that are not affected by water level fluctuations. Northern pike are documented to spawn in shallow (<1.2 feet deep) water on SAV and EAV, but are also documented to spawn over SAV in water up to 16 feet deep. SAV is common throughout the upper river and along the shorelines of the lower river in water up to ~20 feet deep, and may provide suitable spawning, egg and larval habitat at depths that are not affected by water level fluctuations. EAV is nearly absent from the lower Niagara River; therefore, northern pike in the lower river may spawn only over SAV, which is generally below the depth affected by water level fluctuations.

Water level and flow fluctuations in the upper and lower Niagara River also have the potential to affect the spawning, egg and larval habitat used by white sucker. Of the aquatic focus species, white sucker have the narrowest range of reported spawning depths (0.2 – 1 foot), a range of depths that are fully encompassed by the water level fluctuations in the upper and lower river

The spawning, egg, and larval habitat of emerald shiner are not affected by water level and flow fluctuations in the upper and lower Niagara River, as emerald shiner are pelagic and their spawning, egg and larval habitat is in mid-water. In addition, water level fluctuations in the lower Niagara River do not affect burrowing mayfly nymphs and eggs, and giant floater mussels.

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Lewiston Reservoir

The large boulder riprap sides of the Lewiston Reservoir are not suitable substrate for the spawning of smallmouth bass, rock bass, and yellow perch. The substrate of the bottom of the reservoir (primarily clay, mud, muck and silt) is not suitable for smallmouth bass and rock bass spawning. Although the substrate of the bottom of the reservoir is suitable for yellow perch spawning, at the time the fieldwork was conducted for this investigation there was little SAV and submerged brush, the preferred habitat for yellow perch spawning. Similar to the upper and lower river, the spawning, egg, and larval habitat of emerald shiner are not affected by water level fluctuations in Lewiston Reservoir because emerald shiner are pelagic and their spawning, egg and larval habitat is in mid-water.

Wildlife Focus Species

Upper and Lower River

The representative wildlife species that potentially lay eggs and hibernate in suitable habitat in areas influenced by water level fluctuations in the upper river and its tributaries include the green frog, northern leopard frog, common mudpuppy, common snapping turtle, and midland painted turtle. In the lower river these species include the common mudpuppy, green frog, common snapping turtle, and midland painted turtle. Any potential effects are somewhat mitigated by the presence of suitable habitat in the upper and lower rivers for these species' lifestages at depths that are not influenced by water level fluctuations.

Some of the suitable nesting habitat of the Virginia rail, American coot, and spotted sandpiper is located in areas influenced by water level fluctuations in the upper river and its tributaries. However, water and shorebirds are known to adapt to water level changes by employing various nest building strategies and/or by laying multiple clutches of eggs during the nesting season. A similar situation exists in the lower river for the nesting lifestage of the spotted sandpiper.

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There is muskrat habitat (for all lifestages) in the upper river that is influenced by water level fluctuations. However, sufficient food sources exist in the upper river and there is suitable water depth for muskrat below the zone that is influenced by fluctuating water levels. In addition, literature also indicates that muskrats can build high and low level (elevation) dens and access tunnels in river banks to accommodate fluctuating water levels. There appears to be suitable habitat available for the muskrat in areas not influenced by water level fluctuations (i.e., between the weirs at Buckhorn Marsh, some of the marsh associated with Burnt Ship Creek west of Interstate 190). The presence of a muskrat den on Grass Island in the Chippawa-Grass Island Pool east of Woods Creek suggests that water level fluctuations in the upper river may be within tolerances for this species.

Water level fluctuations can have an overall positive effect on the foraging opportunities of wildlife focus species that feed in nearshore habitats of the upper (and its tributaries) and lower rivers. Temporal shifting of the water depth zones can increase foraging opportunities for these species by increasing the amount of area available for foraging when the water is low. Conversely, foraging opportunities can be diminished when water levels are high.

According to literature and review of field data collected in 2002, all other wildlife focus species' lifestages are mobile or are more likely to occur outside of areas influenced by water level fluctuations during immobile lifestages.

Lewiston Reservoir

Preferred substrates and hibernacula for the common snapping turtle are absent from Lewiston Reservoir and suitable nesting habitat is found outside the zone of water level fluctuations, and great blue heron, canvasback, and greater scaup do not nest in the reservoir. Foraging opportunities for the great blue heron and spotted sandpiper would likely be enhanced during low water levels in the reservoir because of the increased availability of forage area and easier access to prey. Conversely, the foraging efficiency of canvasback is potentially indirectly affected by water level fluctuations because the extreme weekly fluctuations in Lewiston Reservoir preclude the development of extensive SAV beds. The effects

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on the foraging efficiency of greater scaup are expected to be minimal because this species forages in a wide range of water depths (similar to those found in the reservoir). During the time that this species typically occurs on the reservoir to any significant extent (fall and winter), water depths in most areas of the reservoir are at least 10 feet or greater.

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ABBREVIATIONS

Agencies

FERC	Federal Energy Regulatory Commission
INBC	International Niagara Board of Control
NYNHP	New York Natural Heritage Program
NYSOPRHP	New York State Office of Parks, Recreation and Historic Preservation
NYSCD	New York State Conservation Department
NYSDEC	New York State Department of Environmental Conservation
NYPA	New York Power Authority
OPG	Ontario Power Generation
USFWS	United States Fish and Wildlife Service

Units of Measure

C	Celsius, Centigrade
cfs	cubic feet per second
cm	centimeter
EST	Eastern Standard Time

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F	Fahrenheit
fps	feet per second
ft	feet
IGLD 1985	International Great Lakes Datum 1985
in	inch
m	meter
mi	mile
mm	millimeter
MW	Megawatt
USLSD	U.S. Lake Survey Datum 1935

Environmental

EAV	emergent aquatic vegetation
HSI	habitat suitability index
IBA	Important Bird Area
SAV	submerged aquatic vegetation

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1.0 INTRODUCTION

The New York Power Authority (NYPA) is engaged in the relicensing of the Niagara Power Project (Project) in the Town of Lewiston, Niagara County, New York. The present operating license of the plant expires in August 2007. In preparation for the relicensing of the Project, NYPA is developing information related to the ecological, engineering, recreational, cultural, and socioeconomic aspects of the Project. As part of this information-gathering effort, aquatic and terrestrial habitats were mapped and characterized in relation to documented water levels so that the potential effects of water level and flow fluctuations on these habitats and associated species could be qualitatively evaluated.

The scope and design of this investigation was prepared by the Niagara Power Project Relicensing Team, which consists of technical and relicensing staff from NYPA; URS Corporation (URS); Gomez and Sullivan Engineers, P.C.; E/PRO Engineering and Environmental Consulting, LLC; and Aquatic Science Associates, Inc. Stantec Consulting Services, Inc. conducted all fieldwork, preliminary data analysis, wrote habitat descriptions for the report, and provided technical assistance in determining the potential effects of water level and flow fluctuations on aquatic and terrestrial habitats. Gomez and Sullivan Engineers, P.C. and E/PRO Engineering & Environmental Consulting, LLC completed the final analysis of potential effects on habitats and species that use these habitats. URS Corporation produced all maps and figures for this report.

The 1,880-MW (firm capacity) Niagara Power Project is one of the largest non-federal hydroelectric facilities in North America. The Project was licensed to the newly created Power Authority of the State of New York (now the New York Power Authority) in 1957. Construction of the Project began in 1958, and first electricity was produced in 1961.

The Project has several components. Twin intakes are located approximately 2.6 miles above Niagara Falls. Water entering these intakes is routed around the Falls via two large low-head conduits to a 1.8-billion-gallon forebay, lying on an east-west axis about 4 miles downstream of the Falls. The forebay is located on the east bank of the Niagara River. At the west end of the forebay, between the

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forebay itself and the river, is the Robert Moses Niagara Power Plant, NYPA's main generating plant at Niagara. This plant has 13 turbines that generate electricity from water stored in the forebay. Head is approximately 300 feet. At the east end of the forebay is the Lewiston Pump Generating Plant. Under non-peak-usage conditions (i.e., at night and on weekends), water is pumped from the forebay via the plant's 12 pumps into the 22-billion-gallon Lewiston Reservoir, which lies east of the plant. During peak usage conditions (i.e., daytime Monday through Friday), the pumps are reversed for use as generators, and water is allowed to flow back through the plant, producing electricity. The forebay therefore serves as headwater for the Robert Moses plant and tailwater from the Lewiston Plant. South of the forebay is a switchyard, which serves as the electrical interface between the Project and its service area.

Approximately 3,600 acres of lands and waters are owned by NYPA in the Village and Town of Lewiston, City of Niagara Falls, and Town of Niagara. The NYPA-owned lands are managed by NYPA in association with the generation and transmission of electricity at the Niagara Power Project.

1.1 Physical Description of the Niagara River

The Niagara River, which flows from Lake Erie to Lake Ontario, forms a portion of the boundary between the State of New York and the Province of Ontario. The river drains four of the five Great Lakes, a drainage area of approximately 263,700 square miles. The difference in surface elevations between the two lakes is about 326 feet, half of this occurring at Niagara Falls.

The upper Niagara River extends about 22 miles from Lake Erie to the Cascades Rapids, which begin 0.6 miles upstream of the Horseshoe Falls (Canadian side of river). From Lake Erie to Strawberry Island, a distance of approximately 5 miles, the channel width is greatest at the river's head (9,000 feet) and least at Squaw Island, just downstream of the Peace Bridge (1,500 feet). Average channel velocities are approximately 5 to 9 feet per second (fps) in the vicinity of the Peace Bridge. Between Squaw and Strawberry Islands, the river width is approximately 2,000 feet, with average channel velocities on the order of 4 to 5 fps.

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At Grand Island, just downstream of Strawberry Island, the river divides into the west channel, known as the Canadian or Chippawa Channel, and the east channel, known as the American or Tonawanda Channel. The Chippawa Channel, approximately 11 miles long, varies in width from 2,000 to 4,000 feet. Average channel velocity is 2-3 fps. The Chippawa Channel carries approximately 58% of total river flow. The 15-mile-long Tonawanda Channel varies in width from 1,500 to 2,000 feet upstream of Tonawanda Island. Downstream of this island the channel varies in width from 1,500 to 4,000 feet, with average channel velocities of 2-3 fps. At the downstream end of Grand Island (i.e., the north end), the channels unite to form the 3 mile-long Chippawa-Grass Island Pool, at the lower end of which is the International Niagara Control Structure. This linear structure, with 18 sluice gates for control of flow over Niagara Falls, extends perpendicularly from the Canadian shoreline to the approximate midpoint of the river. The Falls is located about 4,500 feet downstream of the International Niagara Control Structure. The fall (i.e., change in elevation) from Lake Erie to the Chippawa-Grass Island Pool is approximately 9 feet. The lower Niagara River emerges from the gorge at Lewiston, New York, subsequently dropping another 5 feet to Lake Ontario, and widening to 2,000 feet. The lower Niagara River is navigable from the mouth at Lake Ontario to just upstream of the Niagara Power Project tailrace by conventional watercraft, and upstream to the Whirlpool by specialized watercraft.

1.2 Investigation Area

For this report, the upper Niagara River is defined as that part of the United States portion of the Niagara River from the Peace Bridge downstream to the Niagara Power Project intakes. The lower Niagara River is defined as that part of the United States portion of the Niagara River from the tailrace of the Niagara Power Project downstream to Lake Ontario (Figure 1.3-1). The Investigation Area includes U.S. waters of the mainstem upper Niagara River and mainstem lower Niagara River and portions of its tributaries, and associated riparian habitats. Excluded from this is the area between the upper and lower Niagara River as defined above. This area is the subject of a separate report. Discussions in this report focus primarily on the upper Niagara River (including Twomile Creek and several upper Niagara River tributaries on Grand Island) and three mainstem tributaries of the upper river (Tonawanda Creek, Ellicott Creek, and Cayuga Creek), the lower Niagara River, and Lewiston Reservoir.

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1.3 Objectives and Tasks

The objectives of this investigation were to:

1. Assess the potential effects of water level and flow fluctuations on aquatic and terrestrial habitats in the investigation area.
2. Describe the outcomes of Objective 1 on specific life stages of representative aquatic and terrestrial focus species that utilize potentially affected habitats.

The tasks used to address the objectives were:

1. Delineate and classify aquatic and terrestrial habitats in the investigation area.
2. Characterize aquatic and terrestrial habitats in the investigation area along representative transects.
3. Describe the potential effects of water level and flow fluctuations on aquatic and terrestrial habitats of the Niagara River, selected tributaries of the river, and Lewiston Reservoir.
4. Identify representative aquatic and terrestrial species of interest.
5. Describe how the representative aquatic species use their habitats.
6. Describe how representative terrestrial species use their habitats.
7. Identify species and lifestages that may be affected by water level and flow fluctuations.

Habitat mapping across the investigation area provided a general overview of habitat within the upper Niagara River, lower Niagara River, and Lewiston Reservoir. Detailed habitat characterization along representative transects described the distribution of specific habitat features and provided the basis for evaluations of the potential effects of water level fluctuation on nearshore habitat and associated species. Qualitative assessments were made primarily using cross-sectional views of representative

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transects to evaluate relationships between habitats (and associated fish and wildlife) and water level fluctuation patterns documented in the investigation area. Plan view habitat maps were also consulted to assess habitat availability and distribution.

Water level and flow data from 1991 to 2002 were analyzed by URS et al. (2005a) to characterize fluctuations and to identify the relative influence of natural and anthropogenic causal factors. Results of those analyses were used to identify the potential effects of water level and flow fluctuations on aquatic and terrestrial resources.

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This material is contained in:
Volume 2
Section: Effect of Water Level and Flow Fluctuations on Aquatic and Terrestrial Habitat

FIGURE 1.3-1

INVESTIGATION AREA

[NIP – General Location Maps]

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2.0 WATER LEVEL AND FLOW FLUCTUATIONS

Data on Niagara River and Lewiston Reservoir water level and flow fluctuations are integral to assessing the potential effects of those fluctuations on habitats and species. This section describes the regulations governing water levels and flow, the results of the water level and flow fluctuation analyses completed in support of NYPA's relicensing of the Project as they pertain to the subject of this habitat report, and the average Niagara River water velocities.

2.1 Treaty and Regulations Governing Water Levels and Flow

In 1950, the United States and Canada signed the Niagara River Water Diversion Treaty, the purpose of which was to preserve the beauty of Niagara Falls by guaranteeing adequate flow over the Falls, at the same time ensuring the fair use of remaining water for power generation. Article IV of the treaty provides that no less than 100,000 cubic feet per second (cfs) must be released over Niagara Falls from 8 a.m. to 10 p.m. EST beginning April 1 and ending September 15 each year, and from 8 a.m. to 8 p.m. EST beginning September 16 and ending October 31 each year (i.e., the tourist season). It also provides that no less than 50,000 cfs must be released over Niagara Falls at any other time. Article V provides that all water in excess of the mandated flows over Niagara Falls may be diverted for power purposes.

The 1993 Directive of the International Niagara Board of Control (INBC) requires that the International Niagara Control Structure be operated to ensure an operational long-term average pool level of El. 562.75 feet (IGLD 1985 El. 561.55). All elevations in this report are referenced to U.S. Lake Survey Datum 1935 (USLSD). Values for other pertinent datums, such as International Great Lakes Datum 1985 (IGLD 1985), are listed in parentheses. The Directive also establishes certain tolerances for the pool's water level as measured at the Material Dock gauge (located on the Canadian side of the river approximately 3 miles upstream of Niagara Falls), permitting up to 1.5 feet fluctuation between daily maximum and minimum levels. This daily allowable fluctuation must occur within a normal 3-foot range between El. 561.24 to 564.22 feet (IGLD 1985 El. 560.04 to 563.02), as shown in Figure 2.1-1. Under

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extreme conditions (e.g., high flow, low flow, ice), the allowable range of Chippawa-Grass Island Pool water level fluctuation is extended to 4 feet. The Directive establishes the absolute permissible low level in the pool at El. 560.75 feet (IGLD 1985 El. 559.55) and the absolute permissible high water level at El. 564.75 feet (IGLD 1985 El. 563.55).

2.2 Water Level Fluctuation Analyses

As part of the relicensing process for the Niagara Power Project, URS characterized the fluctuation that occurs within the upper Niagara River, lower Niagara River, and Lewiston Reservoir from 1991 through 2002. Data were collected from 16 permanent water level gauges in the upper and lower river and Lake Ontario (URS et al. 2005a) and from four temporary water level gauges in the lower river downstream of the Robert Moses tailrace in late October to early November 2001 and during the period June through November 2002. The locations of these gauges are shown in Figure 2.2-1. Water levels were also monitored in 2002 in and around Buckhorn Marsh on the northern end of Grand Island (see Section 2.2.1.2).

The URS characterization included a description of: 1) the magnitude, frequency and spatial extent of water level and flow fluctuations in the Niagara River associated with water diversions for power generation at the Niagara Power Project and the Sir Adam Beck Project and 2) the magnitude and frequency of water level fluctuations in Lewiston Reservoir associated with power generation at the Project. It was known at the investigation's outset that water level and flow fluctuations in both the upper and lower Niagara River are caused by a number of factors. Natural factors include flow surges from Lake Erie, wind, ice conditions, and regional and long-term precipitation patterns that affect lake levels, while manmade factors include boat wakes, regulation of Niagara Falls flows for scenic purposes, operation of power plants on the Canadian side of the river, and operation of the Niagara Power Project. The influence of these factors on water levels is interrelated and dynamic. Because the water level in the Niagara River at any location at any time is a complex function of natural and manmade factors, distinguishing the exact amount of water level fluctuation attributable to each factor is difficult. The URS et al. (2005a) report also differentiates the effects of significant wind events (defined as those that caused changes in flow at Fort Erie on the order of 25,000 to 50,000 cfs per day or a change in water level at Fort

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Erie greater than 2 feet per day) that induced water level fluctuations through a combination of gauge data analysis and empirical calculation of surface wave height and wind setup (see Section 2.2.1.4).

Data were analyzed in various ways to produce a picture of daily fluctuation in the upper and lower river and to establish the upstream extent of such fluctuation in the upper river. The results are summarized in the following sections. Complete details are available in the water level study report (URS et al. 2005a).

2.2.1 Upper Niagara River

Water level fluctuation in the upper Niagara River from all causes, including power production by both U.S. and Canadian plants and natural factors, normally amounts to less than 1.5 feet per day as measured at Material Dock, the official monitoring gauge (Table 2.2.1-1). A daily water level fluctuation of 1.5 feet is allowed by the 1993 Directive of the INBC. The portion of upper-river water level changes attributable to power production is the result of varying withdrawals of water by the Power Entities, namely, NYPA and Ontario Power Generation (OPG). It was found that regulation of the Chippawa-Grass Island Pool water levels has a more pronounced effect during the tourist than the non-tourist period. The reason for this is that during daylight hours in the tourist season, NYPA and OPG are required to pass more water over Niagara Falls for scenic purposes, making less of the natural flow in the river available for hydropower generation. This requires NYPA and OPG to use more water from storage in the Chippawa-Grass Island Pool during the tourist season to meet energy demand.

Lake Erie water levels and natural conditions, such as wind-generated flow surges and ice, influence water levels in the upper Niagara River, especially during the non-tourist season. Graphs of hourly water level and flow data, duration-distribution analysis of daily fluctuations, and an analysis of the days with the greatest daily fluctuation by URS et al. (2005a) bear this out.

The elevation of Lake Erie also fluctuates on a short-term basis. Lake Erie is a long, narrow, and relatively shallow lake with its major axis aligned with the prevailing southwesterly winds. The head of

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the Niagara River lies at the downwind end of the lake near Buffalo, New York. Strong southwest winds can greatly increase the lake water level at Buffalo, increasing river flow at the same time. This increase in water level is called wind set-up, and represents a wind-induced tilting of the lake, called a seiche.

Regulation of Chippawa-Grass Island Pool water levels and river storage diminishes the effect of flow surges from Lake Erie. During extreme events, water level increases at Fort Erie have reached as high as 10 feet, but the dampening effect along the river has led to a rise in Chippawa-Grass Island Pool surface levels of only one foot. Wind-generated surface waves may contribute to water level fluctuations in the Chippawa-Grass Island Pool, while wind set-up is more of an influence at Fort Erie (URS et al. 2005a).

To demonstrate the relative contributions to water level fluctuations made by various natural and man-induced factors in the upper reaches compared to the lower reaches of the upper Niagara River, URS et al. (2005a) prepared two cross-sectional views of the upper river (one at Frenchman's Creek and one at Material Dock) comparing these factors. These drawings are included as Figures 2.2.1-1 and 2.2.1-2, respectively. While the ranges for the 5/95% exceedance levels (i.e., water levels occurring greater than 5% but less than 95% of the time) are comparable between the two gauges, the ranges for maximum and minimum are much greater at Frenchman's Creek (located in the upper reaches of the upper river near Lake Erie) compared to Material Dock (located in the lower reaches near the NYPA intakes). The amplitudes of surface waves are similar between the two locations, but the amplitudes of potential storm surge event/wind set-up are dramatically different. A storm surge on Lake Erie can cause a change in water level at Frenchman's Creek of greater than 5 feet but can be less than the allowable 1.5 feet fluctuation at Material Dock.

2.2.1.1 Upper Niagara River Tributaries

Water level fluctuations on the upper Niagara River influence water levels in tributaries to the mainstem. To determine the extent of this influence, an analysis was performed by URS et al. (2005b) using "standard step backwater" hydraulic computations as described by the U.S. Army Corps of

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Engineers (USACE 2002). The results illustrating the extent of the influence of the upper Niagara River mainstem influence on tributary water levels are mapped in Figure 2.2.1.1-1. The habitat analysis for Tonawanda, Cayuga and Ellicott Creeks was conducted to the upstream extent of the model data that was available. The potential habitat effects associated with water level fluctuations in the mainstem Niagara extend some unknown distance upstream from these boundaries. The extent of the affected area in these three tributaries and the effect it has on the conclusions of this report will be the subject of a future investigation.

2.2.1.2 Buckhorn Marsh and Grass Island

Due to the interest in evaluating water level fluctuation effects on fish and wildlife resources in Buckhorn Marsh and at Grass Island, URS monitored water levels in those areas in 2002. Buckhorn Marsh is a large wetland complex associated with Burnt Ship Creek and Woods Creek, near the northern tip of Grand Island. Most of the portion of the marsh east of Interstate-190 is enclosed by two weirs. The stoplog crest elevation of the west weir is (USLSD 1935) 564.86 feet and that of the east weir is 564.23 feet (Anderson 1995). The portion of the marsh west of Interstate-190 includes no water level control structures. Grass Island is a vegetated shoal located in the Tonawanda Channel of the upper river near the mouth of Woods Creek.

Six temporary monitoring gauges were installed by URS in Buckhorn Marsh and Grass Island in late March 2002 and were monitored through mid-November 2002. One gauge was placed in the undiked portion of the marsh west of Interstate-190 (gauge SD-01), two within the diked portion of the marsh east of Interstate-190 (gauges SD-02 and SD-03), one in Woods Creek near its mouth (gauge SD-04), one in Burnt Ship Creek near its mouth (gauge SD-05, and one within the deep emergent marsh that forms Grass Island (gauge SD-06). The locations of these gauges are shown in Figure 2.2.1.2-1. Water level graphs for gauges SD-01, SD-02, and SD-05 (i.e., the undiked portion of the marsh west of Interstate-190 and the western end of the diked area) are included in URS et al. 2005a and those for gauges SD-03, SD-04, and SD-06 (i.e., the eastern undiked portion of the marsh bordering Woods Creek, Grass Island, and the eastern end of the diked area) are in URS et al. 2005a. These areas were graphed and discussed

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separately so that water level fluctuations in the diked portion of the marsh could be described in relation to the undiked areas immediately to the west and east.

For the west side of Buckhorn Marsh, monthly water levels during the March through November 2002 monitoring period mirrored each other at gauge SD-01 (undiked section of Burnt Ship Creek) and gauge SD-05 (near mouth of Burnt Ship Creek), where daily fluctuation patterns were evident (URS et al. 2005a). Water levels in Burnt Ship Creek at SD-01 and SD-05 display very similar fluctuation patterns throughout 2002. Water levels at SD-01 fluctuate daily usually around 0.2-0.3 feet per day during the tourist season of 2002. This fluctuation can be attributed to the daily water level fluctuations in the Chippawa-Grass Island Pool. The daily fluctuations were not evident during the first three weeks of November 2002, which corresponds to non-tourist season. The data from these two gauges are useful in categorizing water level fluctuations, however the data should not be relied upon when analyzing absolute water level elevations due to anomalies described in URS et al. 2005a.

Water levels at SD-02 display a pattern largely independent of the water levels observed at SD-01, as this gauge is upstream of the west weir. Water levels in the diked portion of Burnt Ship Creek (gauge SD-02) appear independent of water levels in the Niagara River as the water levels at SD-02 stayed at a consistently higher elevation and varied considerably less throughout the sampling season. However, from March 28 – April 16, 2002, the water level at SD-02 did fluctuate above the west weir, however after April 16, the water level appears to have stabilized. The cause of the fluctuations at SD-02 prior to April 16, 2002 is unknown, and these patterns were not observed at SD-03, which was located in the marsh above the east weir. The difference between water levels at SD-02 and SD-01 was greatest in the spring (March through mid-June) when the water level was typically about 1.0 foot higher in the diked portion of the marsh. As the year progressed to September and October, the water level differences decreased to about 0.5 feet.

The water level patterns on the east side of Buckhorn Marsh during the 2002 monitoring period followed a generally similar pattern to those presented above, although with more dramatic fluctuations outside the diked portion of the marsh. Woods Creek (gauge SD-04) and Grass Island (gauge SD-06), which are subjected to Niagara River water level fluctuations, exhibited daily fluctuations of

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approximately 1.5 feet throughout the monitoring period (URS et al. 2005a). The water level in the diked portion of the marsh (gauge SD-03) did not exhibit daily fluctuations and was somewhat higher than Woods Creek and Grass Island from April to June and October to November. However, unlike the west side of the marsh, the summer and early fall water levels outside the control structures were higher, by as much as 0.5 feet (URS et al. 2005a). Water levels within the diked portion of the marsh fluctuated much less than in Woods Creek or at Grass Island.

In summary, the two weirs impounding Buckhorn Marsh hold the water level fairly constant in the diked portion of the marsh while, downstream of the weirs, the water level in the undiked portion of the marsh and associated tributaries generally tends to follow the fluctuation patterns present in the river (URS et al. 2005a).

2.2.1.3 Annual Duration Analysis Curves

URS et al. (2005a) prepared annual duration analysis curves using 1991-2002 data from permanent gauges. Water level data from the ten gauges relevant to this habitat investigation are summarized in Table 2.2.1.3-1. Duration analysis curves show the percentage of time in the period of record that a value of any given magnitude has been equaled or exceeded. The median value represents the 50th percentile point. The extreme ends of the distribution curves (high and low percentiles) represent infrequent, large, or small fluctuations due to all factors represented in the data set (URS et al. 2005a). Maximum, 5% exceedance, median (50% exceedance), 95% exceedance, and minimum water elevations were plotted in conjunction with a variety of habitat data collected in the field along transects (see Section 3.2) to illustrate habitat occurrence relative to fluctuating water levels.

2.2.1.4 Monthly Non-Storm Water Elevation and Flow Analyses for Upper Niagara River

The 1991-2002 gauge data for the upper river were further analyzed by removing data recorded during “significant” storm events and then identifying maximum and minimum water elevations for each month during typical, wet, and dry years. These analyses provided an opportunity to evaluate potential

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effects of water level and flow fluctuations on habitats during any month of the year. The procedures used to complete these analyses and the results are described below.

In terms of river flow conditions, 1995 was a comparatively "typical" year, 1997 was a "wet" year, and 2001 was a "dry" year. Of the 12 years (1991 - 2002) of data that were analyzed in the water level and flow fluctuation report (URS et al. 2005a), the average river flow at Fort Erie was 212,723 cfs. In 1995, the average hourly flow in the Niagara River at Fort Erie was approximately 212,668 cfs. In 1997, the average hourly flow was approximately 243,000 cfs, and for 2001 the value was approximately 186,000 cfs.

In order to determine the effect of combined Canadian and NYPA hydroelectric operations on Niagara River water levels, significant wind events were identified and sorted from the data. Storm events were selected by analyzing wind data at Buffalo Niagara International Airport for 1995, 1997, and 2001 and corroborating those data with flow conditions observed at the Fort Erie gauge. Identification of the "significant" storm events to exclude was based on engineering judgment of the wind's effect on water level and stream flow. Significant wind events were defined as those that caused changes in flow on the order of 25,000 to 50,000 cfs per day or a change in water level at Fort Erie greater than 2 feet per day. The water level data were then analyzed without the significant storm events to determine the effect of Canadian and NYPA hydroelectric operations and other less significant factors. This approach to determine the effects of power operations on water levels in the upper Niagara River was considered conservative, as it is not possible to separate other factors that contribute to changes in water levels such as small wind effects, boat waves and local environmental conditions.

It is important to note that it is not possible to completely isolate the effects of power operations on water levels in the upper Niagara River, as there is usually some wind activity on Lake Erie. The analysis completed by URS et al. (2005a) was a conservative estimate of the effect due to NYPA and OPG power operations. Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3 were created to show the monthly maximum and minimum water elevations, as well as differences between those elevations, during "non-significant storm" periods at several gauges in the upper Niagara River for 1995, 1997 and 2001, respectively. Information from these tables was used to characterize water level fluctuation at different

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locations in the upper Niagara River. These fluctuations are due to a combination of smaller natural events in the river and Lake Erie as well as NYPA and OPG power generation (URS et al. 2005a).

At the Material Dock gauge, differences between maximum and minimum water elevations for non-storm events during non-tourist season months (November - March) were mostly <2.0 feet in 1995, 1997, and 2001. The only exception occurred in March 1995 when the difference was 2.03 feet (Table 2.2.1.4-1). During tourist season months (April - October), differences between maximum and minimum elevations at the Material Dock gauge during non-storm events frequently exceeded 2.0 feet in 1995 (typical year) and 1997 (wet year), with the differences ranging between 2.17 feet in April 1997 to 2.59 feet in October 1997 (Table 2.2.1.4-2). During the tourist season, water level fluctuations due to regulation of the Chippawa-Grass Island Pool for power generation were generally less in 1997 (high flow year) compared to 1995 (typical year) due to the availability of more water in the river (URS et al. 2005a). In 2001 (dry year), differences between maximum and minimum elevations for non-storm events never exceeded 2.0 feet at the Material Dock gauge (Table 2.2.1.4-3).

At the Frenchman's Creek gauge, differences between maximum and minimum elevations for non-storm events were almost always <2.0 feet during both non-tourist season and tourist season months. The only exceptions occurred in January 1995 (Table 2.2.1.4-1) and January 1997 (Table 2.2.1.4-2), when the differences were 2.17 feet and 2.00 feet, respectively.

At the gauges in the middle reaches of the upper river (i.e., LaSalle, Black Creek, Tonawanda Island, and Huntley Station), differences between maximum and minimum elevations for non-storm events during non-tourist season months (November - March) were mostly <2.0 feet in 1995, 1997, and 2001. The only exceptions occurred in January and February 1995 (Table 2.2.1.4-1) and January 1997 (Table 2.2.1.4-2) when the differences ranged between 2.08 feet and 2.56 feet. During tourist season months (April - October), differences between maximum and minimum elevations at the middle river gauges during non-storm events also were mostly <2.0 feet in 1995 (typical year) and 1997 (wet year), with the differences ranging between 2.02 feet at the LaSalle gauge in May 1995 to 2.66 feet at the Tonawanda Island gauge in April 1995 (Table 2.2.1.4-1). In 2001 (dry year), differences between

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maximum and minimum elevations for non-storm events never exceeded 2.0 feet at the middle river gauges (Table 2.2.1.4-3).

2.2.2 Lower Niagara River

Water level fluctuations in the lower river, measured immediately below the Robert Moses Power Plant tailrace, are much less than those observed above the Robert Moses tailrace (URS et al. 2005a). The average daily water level fluctuation during the 2002 tourist season at the gauge SG-01A, located 1.4 miles downstream of the Robert Moses tailrace, was approximately 1.5 feet. The daily fluctuations decrease progressively at the temporary gauges located further downstream. At the most downstream temporary gauge SG-04A, the average daily fluctuation during the tourist season was 0.6 feet. From the data collected, it appears that manmade regulation for Treaty flows and Canadian and U.S. hydroelectric generation have an effect on water levels and flows in the lower Niagara River to its mouth at Lake Ontario (URS et al. 2005a).

The average water levels in the lower Niagara River downstream of the Robert Moses tailrace have a seasonal cycle related to the water level of Lake Ontario. Lake Ontario water levels are unrelated to Niagara River hydropower operations. Water levels downstream of the Robert Moses tailrace fluctuate less during the non-tourist season because the Falls flow is constant and because generation flows at the Niagara Power Project and OPG's Sir Adam Beck Project fluctuate less (URS et al. 2005a).

Gauge data from the 2002 monitoring period showed that the lower river temporary water level gauge readings from near Artpark (gauges SG-01A, SG-01B, and SG-01C) and Lewiston Landing (gauge SG-02A) had similar patterns throughout the monitoring period (URS et al. 2005a). The most upstream location (Artpark) showed slightly higher water levels than the Lewiston Landing site, but the differences were generally less than a foot. There was a gradual decline in the water levels from June to November, with more than a 3-foot drop over that period, which is related to the seasonal declines in water levels in Lake Ontario. Daily fluctuations at both gauges were typically about 1.0-1.3 feet (URS et al. 2005a).

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The gauges near Joseph Davis State Park (gauge SG-03A) and Fort Niagara (gauge SG-04A) had synchronous readings during the monitoring period. The daily fluctuations were noticeably reduced compared to those recorded closer to the Robert Moses tailrace, typically ranging between 0.5 and 0.8 feet (URS et al. 2005a). The gauge readings at Joseph Davis State Park were consistently higher than at Fort Niagara, but by less than one foot. The water levels declined at these two locations as the season progressed, similar to the Artpark and Lewiston Landing gauges, with readings over 3.0 feet lower by the end of the monitoring period.

Table 2.2.2-1 shows lower-river maximum and minimum monthly elevations (over a portion of 2002) in the context of maximum and minimum monthly elevations at Port Weller (Lake Ontario) over the period 1991-2002 and 2002, and in the Lewiston Reservoir over the period 1991-2002.

2.2.3 Lewiston Reservoir

Water levels in the Lewiston Reservoir fluctuate in response to daily demand for energy and Niagara River flow. All fluctuations are attributable to Project operations, although water level fluctuations are always greater during the tourist season, as the Project's nighttime share of river water is stored for use during peak demand periods.

Operation of the Niagara Power Project can result in water level fluctuations in the Lewiston Reservoir of 3-18 feet per day, and approximately 11-36 feet per week depending on the season and river flows. Weekly drawdowns are typically greater (21-36 feet) during the tourist season than the non-tourist season (11-30 feet), when NYPA's allocated share of water for power generation is reduced during daytime hours to provide higher scenic Falls flow (URS et al. 2005a).

Table 2.2.2-1 shows maximum and minimum monthly elevations of the Lewiston Reservoir over the period 1991-2002.

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2.2.4 Flow Fluctuation

Flow duration curves for tourist and non-tourist seasons were developed for the Fort Erie gauge. Flows are usually higher during the tourist season, with the exception of severe winter storms causing high flow events during the non-tourist season. Flows in the tourist season range between 190,000 to 245,000 cfs in the upper Niagara River at Fort Erie (URS et al. 2005a).

2.2.5 Water Velocities of the Niagara River

Estimates of average river channel velocities were made for the upper Niagara River between Fort Erie and the NYPA intakes and for the lower Niagara River between NYPA/OPG's Project tailraces and Lake Ontario. Since both stream reaches are subject to backwater effects (see Section 1.3 in URS et al. 2005a), the stage-discharge relationship at any given location varies for different downstream water levels. A range of average channel velocities was, therefore, calculated for a low and high downstream water level condition. The average stream velocity was determined at each cross-section for a range of flows corresponding to the 10% and 90% exceedance intervals for a high and low water level. Table 2.2.5-1 shows the range in average river velocities. Locations of the gauges in the table are in Figure 2.2-1.

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TABLE 2.2.1-1

DAILY MEDIAN WATER LEVEL FLUCTUATIONS FOR THE PERIOD 1991-2002

Gauge	Tourist Season (Ft., USLSD 1935)	Non-Tourist Season (Ft., USLSD 1935)
Fort Erie	0.62	0.82
Frenchman's Creek	0.54	0.49
Huntley	0.49	0.45
Black Creek	0.61	0.44
Tonawanda Island	0.55	0.43
LaSalle	1.21	0.45
Slater's Point	1.42	0.45
NYPA Intake	1.47	0.46
Material Dock	1.31	0.45

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TABLE 2.2.1.3-1

WATER ELEVATIONS AT SELECTED GAUGES BASED ON DURATION ANALYSES OF 1991-2002 DATA

Gauge	Water Elevation (Ft., USLSD 1935) Equaled or Exceeded Max.	5%	50% (Median)	95%	Min.	Δ max/min	Δ 5%/95%
Fort Erie	581.79	574.46	572.78	571.16	568.67	13.12	3.30
Frenchman's Creek	570.33	567.67	566.62	565.60	563.92	6.41	2.07
Black Creek	568.76	566.24	565.40	564.52	563.17	5.59	1.72
Huntley	570.71	567.54	566.39	565.45	564.00	6.71	2.09
Tonawanda Island	569.23	566.65	565.82	564.92	563.37	5.86	1.73
Slater's Point	565.64	563.74	563.09	562.44	561.67	3.97	1.30
LaSalle	566.01	564.25	563.54	562.87	561.96	4.05	1.38
NYPA Intake	565.47	563.83	563.14	562.44	561.30	4.17	1.39
Material Dock	564.49	563.36	562.77	562.04	561.27	3.22	1.32
Port Weller	249.59	248.26	246.54	245.26	244.40	5.19	3.00
Lewiston Reservoir	658.82	655.26	644.54	630.18	620.16	38.66	25.08

Notes:
"Defective Reading", "Gauge Malfunction", and "Missing Data" excluded from data analyses.
Fort Erie and Port Weller gauges located outside the investigation area.

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TABLE 2.2.1.4-1

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1995, A "TYPICAL" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Jan	High	563.46	563.73	563.46	564.17	566.33	567.16	567.30	567.79	574.63	254,000
	Low	561.76	561.95	562.25	562.63	564.48	564.88	565.64	565.62	571.67	188,500
	Diff.	1.70	1.78	1.21	1.54	1.85	2.28	1.76	2.17	2.96	65,500
Feb	High	563.48	563.87	563.90	564.36	566.32	566.83	567.45	567.60	574.26	245,500
	Low	561.60	561.88	561.97	562.37	564.24	564.77	565.63	565.72	571.67	188,500
	Diff.	1.88	1.99	1.93	1.99	2.08	2.06	1.92	1.88	2.59	57,000

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TABLE 2.2.1.4-1 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1995, A "TYPICAL" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Mar	High	563.64	563.81	563.85	564.17	565.80	566.12	566.75	566.92	573.46	227,300
	Low	561.61	561.86	561.94	562.38	564.29	564.71	565.54	565.46	571.49	184,700
	Diff.	2.03	1.95	1.91	1.79	1.51	1.41	1.21	1.46	1.97	42,600
Apr	High	563.96	564.09	564.20	564.99	566.33	567.85	567.55	567.74	574.18	243,600
	Low	561.59	561.77	561.82	562.42	564.63	565.19	565.90	566.03	571.84	192,100
	Diff.	2.37	2.32	2.38	2.57	1.70	2.66	1.65	1.71	2.34	51,500

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TABLE 2.2.1.4-1 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1995, A "TYPICAL" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
May	High	563.79	564.07	564.06	564.39	565.98	566.47	No Data	567.36	574.16	243,200
	Low	561.59	561.73	561.96	562.37	564.80	565.19	No Data	566.03	572.34	202,700
	Diff.	2.20	2.34	2.10	2.02	1.18	1.28	No Data	1.33	1.82	40,500
Jun	High	563.46	563.86	563.88	564.18	565.78	566.17	No Data	567.09	573.77	234,300
	Low	561.46	561.79	561.89	562.42	564.60	565.07	No Data	565.91	572.52	206,600
	Diff.	2.00	2.07	1.99	1.76	1.18	1.10	No Data	1.18	1.25	27,700

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TABLE 2.2.1.4-1 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1995, A "TYPICAL" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Jul	High	563.62	564.06	563.97	564.42	566.19	566.61	No Data	567.53	574.31	246,600
	Low	561.62	561.97	562.00	562.44	564.90	565.33	No Data	566.23	572.50	206,200
	Diff.	2.00	2.09	1.97	1.98	1.29	1.28	No Data	1.30	1.81	40,400
Aug	High	563.46	564.07	564.12	564.39	565.96	No Data	No Data	567.21	574.22	244,500
	Low	561.27	561.94	562.01	562.45	564.89	No Data	No Data	566.01	571.86	192,500
	Diff.	2.19	2.13	2.11	1.94	1.07	No Data	No Data	1.20	2.36	52,000

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TABLE 2.2.1.4-1 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1995, A "TYPICAL" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Sep	High	563.60	564.08	563.87	564.43	566.02	No Data	No Data	567.09	573.12	219,800
	Low	561.61	561.97	564.56	562.57	564.56	No Data	No Data	565.63	571.41	183,000
	Diff.	1.99	2.11	1.77	1.86	1.46	No Data	No Data	1.46	1.71	36,800
Oct	High	563.59	564.05	563.91	564.35	565.91	566.24	567.60	567.23	574.22	244,500
	Low	561.60	561.85	561.90	562.45	564.57	565.02	565.64	565.83	571.75	190,200
	Diff.	1.99	2.20	2.01	1.90	1.34	1.22	1.96	1.40	2.47	54,300

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TABLE 2.2.1.4-1 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1995, A "TYPICAL" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Nov	High	563.41	563.70	563.66	563.64	565.93	566.35	566.98	567.16	573.53	228,900
	Low	561.81	562.04	562.11	562.73	564.51	564.95	565.58	565.72	571.34	181,600
	Diff.	1.60	1.66	1.55	0.91	1.42	1.40	1.40	1.44	2.19	47,300
Dec	High	563.51	563.83	563.84	563.85	566.08	566.44	No Data	567.29	573.64	231,400
	Low	561.93	562.20	562.26	562.66	564.34	564.72	No Data	565.35	570.60	166,400
	Diff.	1.58	1.63	1.58	1.19	1.74	1.72	No Data	1.94	3.04	65,000

Note: High and low elevations for each gauge exclude the storm events. The monthly extremes at any given gauge may not occur on the same day.

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TABLE 2.2.1.4-2

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1997, A "WET" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Jan	High	563.77	564.72	564.59	565.67	567.01	567.60	568.26	568.42	574.63	253,877
	Low	561.99	562.65	562.62	563.11	565.18	565.73	566.39	566.42	572.00	195,467
	Diff.	1.78	2.07	1.97	2.56	1.83	1.87	1.87	2.00	2.63	58,410
Feb	High	563.40	563.93	563.86	564.06	566.29	566.62	567.44	567.64	574.07	241,023
	Low	561.96	562.45	562.62	563.11	565.31	565.47	566.23	566.46	572.03	196,138
	Diff.	1.44	1.48	1.24	0.95	0.98	1.15	1.21	1.18	2.04	44,885

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TABLE 2.2.1.4-2 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1997, A "WET" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Mar	High	563.40	563.86	563.80	No Data	566.69	567.28	568.13	568.33	575.12	265,390
	Low	562.35	562.85	562.81	No Data	565.37	565.67	566.42	566.59	572.76	211,711
	Diff.	1.05	1.01	0.99	No Data	1.32	1.61	1.71	1.74	2.36	53,679
Apr	High	564.49	564.72	564.88	565.47	567.18	567.60	568.00	568.72	575.45	273,159
	Low	562.32	562.73	562.75	563.40	565.77	566.23	567.05	567.21	573.44	226,967
	Diff.	2.17	1.94	2.13	2.07	1.41	1.37	0.95	1.51	2.01	46,192

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TABLE 2.2.1.4-2 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON-SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1997, A "WET" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
May	High	563.34	563.80	563.80	564.52	566.62	567.08	567.77	568.19	575.58	276,267
	Low	561.86	562.45	562.45	563.04	565.57	566.03	567.05	567.01	573.54	229,157
	Diff.	1.48	1.35	1.35	1.48	1.05	1.05	0.72	1.18	2.04	47,110
Jun	High	563.31	563.93	563.86	564.39	566.65	567.21	568.13	568.33	575.54	275,490
	Low	561.60	562.52	562.35	563.01	565.47	565.93	567.21	567.01	573.61	230,640
	Diff.	1.71	1.41	1.51	1.38	1.18	1.28	0.92	1.32	1.93	44,850

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TABLE 2.2.1.4-2 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1997, A "WET" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Jul	High	563.34	563.96	563.73	564.52	566.62	566.95	568.00	568.23	575.71	279,410
	Low	562.03	562.65	562.58	563.24	565.77	566.29	567.18	567.28	574.10	241,023
	Diff.	1.31	1.31	1.15	1.28	0.85	0.66	0.82	0.95	1.61	38,387
Aug	High	563.27	563.96	563.80	564.45	566.59	567.08	No Data	568.23	575.12	265,390
	Low	561.53	562.19	562.13	563.01	565.60	566.19	No Data	567.14	573.64	231,382
	Diff.	1.74	1.77	1.67	1.44	0.99	0.89	No Data	1.09	1.48	34,008

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TABLE 2.2.1.4-2 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1997, A "WET" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Sep	High	563.67	564.26	564.16	564.65	566.36	566.88	No Data	567.93	574.85	259,210
	Low	561.27	562.13	562.03	562.85	565.64	566.00	No Data	566.98	573.25	222,553
	Diff.	2.40	2.13	2.13	1.80	0.72	0.88	No Data	0.95	1.60	36,657
Oct	High	564.03	564.59	564.42	565.01	566.78	567.14	No Data	568.10	574.92	260,763
	Low	561.44	561.90	561.86	562.65	565.11	565.73	No Data	566.49	572.56	207,438
	Diff.	2.59	2.69	2.56	2.36	1.67	1.41	No Data	1.61	2.36	53,325

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TABLE 2.2.1.4-2 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 1997, A "WET" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Nov	High	563.60	564.06	563.93	564.45	566.36	No Data	567.70	567.90	574.69	255,396
	Low	562.39	562.75	562.75	563.21	565.24	No Data	566.36	566.52	572.66	209,593
	Diff.	1.21	1.31	1.18	1.24	1.12	No Data	1.34	1.38	2.03	45,803
Dec	High	563.54	563.96	563.83	564.39	566.39	No Data	567.67	567.87	574.85	259,210
	Low	562.32	562.72	562.68	563.18	565.08	No Data	566.16	566.32	572.49	206,026
	Diff.	1.22	1.24	1.15	1.21	1.31	No Data	1.51	1.55	2.36	53,184

Note: High and low elevations for each gauge exclude the storm events. The monthly extremes at any given gauge may not occur on the same day.

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TABLE 2.2.1.4-3

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 2001, A "DRY" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Peace Bridge (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Jan	High	563.05	563.26	563.29	No Data	564.88	565.80	566.36	566.42	567.50	572.02	196,138
	Low	561.82	562.19	562.20	No Data	564.07	564.47	565.12	565.08	566.16	570.36	161,600
	Diff.	1.23	1.07	1.09	No Data	0.81	1.33	1.24	1.34	1.34	1.66	34,538
Feb	High	563.46	563.68	563.66	No Data	565.13	565.84	566.37	566.49	567.70	572.26	201,046
	Low	561.94	562.28	562.29	No Data	563.86	564.25	565.16	564.84	565.86	570.00	154,466
	Diff.	1.52	1.40	1.37	No Data	1.27	1.59	1.21	1.65	1.84	2.26	46,580

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TABLE 2.2.1.4-3 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 2001, A "DRY" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Peace Bridge (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Mar	High	563.16	563.31	563.35	No Data	565.00	565.48	566.19	566.25	567.57	572.34	202,459
	Low	561.99	562.24	562.29	No Data	564.00	564.42	565.27	565.05	566.16	570.46	163,578
	Diff.	1.17	1.07	1.06	No Data	1.00	1.06	0.92	1.20	1.41	1.88	38,881
Apr	High	563.73	564.02	564.02	No Data	565.46	565.66	566.43	566.54	567.83	572.45	205,319
	Low	561.77	562.04	561.98	No Data	564.39	564.96	565.41	565.02	566.65	570.79	170,217
	Diff.	1.96	1.98	2.04	No Data	1.07	0.70	1.02	1.02	1.18	1.66	35,102

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TABLE 2.2.1.4-3 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 2001, A "DRY" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Peace Bridge (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
May	High	563.47	563.81	563.86	No Data	565.56	565.97	566.57	566.69	568.10	572.77	211,711
	Low	561.91	562.23	562.22	No Data	564.43	564.87	565.42	565.51	566.82	571.10	176,926
	Diff.	1.56	1.58	1.64	No Data	1.13	1.10	1.15	1.18	1.28	1.67	34,785
Jun	High	563.58	563.94	563.93	No Data	565.77	566.21	566.80	566.89	568.16	572.91	215,314
	Low	561.79	561.96	562.10	No Data	564.69	565.12	565.68	565.80	567.08	571.22	178,939
	Diff.	1.79	1.98	1.83	No Data	1.08	1.09	1.12	1.09	1.08	1.69	36,375

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TABLE 2.2.1.4-3 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 2001, A "DRY" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Peace Bridge (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Jul	High	563.55	563.99	563.98	No Data	565.70	No Data	566.60	566.85	568.19	572.78	212,453
	Low	561.80	561.95	562.02	No Data	564.29	No Data	565.42	565.89	566.82	570.86	171,523
	Diff.	1.75	2.04	1.96	No Data	1.41	No Data	1.18	0.96	1.38	1.92	40,930
Aug	High	563.64	564.08	563.98	No Data	565.50	566.04	566.52	566.68	568.00	572.55	207,438
	Low	561.88	562.14	562.11	No Data	564.32	564.97	565.71	565.83	566.78	570.85	171,523
	Diff.	1.76	1.94	1.87	No Data	1.18	1.07	0.81	0.85	1.21	1.70	35,915

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TABLE 2.2.1.4-3 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 2001, A "DRY" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Peace Bridge (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Sep	High	563.46	563.90	563.94	564.24	565.36	565.91	No Data	566.56	567.83	572.39	203,872
	Low	561.70	562.10	562.04	562.70	564.32	564.91	No Data	565.52	566.59	570.57	165,555
	Diff.	1.76	1.80	1.90	1.54	1.04	1.00	No Data	1.04	1.25	1.82	38,317
Oct	High	563.48	563.87	563.87	564.29	565.52	566.10	No Data	566.71	567.87	572.18	198,963
	Low	561.80	562.10	562.07	562.32	564.40	564.60	No Data	565.23	566.32	570.39	162,271
	Diff.	1.68	1.77	1.80	1.97	1.12	1.50	No Data	1.48	1.54	1.79	36,692

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TABLE 2.2.1.4-3 (CONT.)

UPPER NIAGARA RIVER MONTHLY NON- SIGNIFICANT STORM ELEVATIONS AND FLOW FOR 2001, A "DRY" YEAR (ELEVATIONS IN 1935 DATUM)

Month		Material Dock (ft)	NYPA Intake (ft)	Slater's Point (ft)	LaSalle (ft)	Black Creek (ft)	Tonawanda Island (ft)	Huntley Station (ft)	Frenchman's Creek (ft)	Peace Bridge (ft)	Fort Erie Elevation (ft)	Fort Erie Flow (cfs)
Nov	High	563.09	563.46	563.36	563.75	564.92	565.59	566.15	566.41	567.77	572.29	201,753
	Low	561.89	562.21	562.17	562.23	564.30	564.54	565.28	565.20	566.32	570.52	164,884
	Diff.	1.20	1.25	1.19	1.52	0.62	1.05	0.87	1.21	1.44	1.77	36,869
Dec	High	563.38	563.73	563.60	563.79	565.52	566.07	566.89	566.93	568.59	573.66	232,123
	Low	562.14	562.55	562.40	562.33	564.14	564.48	565.22	565.11	566.16	570.17	157,680
	Diff.	1.24	1.18	1.20	1.46	1.38	1.59	1.67	1.82	2.43	3.49	74,443

Note: High and low elevations for each gauge exclude the storm events. The monthly extremes at any given gauge may not occur on the same day.

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TABLE 2.2.2-1
LOWER NIAGARA RIVER (2002 DATA), PORT WELLER (1991-2002, 2002 DATA) AND LEWISTON RESERVOIR (1991-2002 DATA) MAXIMUM AND MINIMUM MONTHLY ELEVATIONS

Month		Artpark (SG-01)	Lewiston (SG-02)	J. Davis SP (SG-03)	Youngstown (SG-04)	Port Weller (2002)	Port Weller (1991-2002)	Lewiston Reservoir
		USLSD 1935 (Ft.)						
Jan	Max	No Data	No Data	No Data	No Data	246.40	248.21	658.48
	Min	No Data	No Data	No Data	No Data	245.46	244.50	624.16
	Diff.	No Data	No Data	No Data	No Data	0.94	3.71	34.32
Feb	Max	No Data	No Data	No Data	No Data	246.50	248.18	658.56
	Min	No Data	No Data	No Data	No Data	245.09	244.96	624.43
	Diff.	No Data	No Data	No Data	No Data	1.41	3.22	34.13
Mar	Max	No Data	No Data	No Data	No Data	246.90	248.21	658.61
	Min	No Data	No Data	No Data	No Data	245.54	245.16	627.17
	Diff.	No Data	No Data	No Data	No Data	1.36	3.05	31.44
Apr	Max	No Data	No Data	No Data	No Data	247.88	249.46	658.56
	Min	No Data	No Data	No Data	No Data	246.55	245.62	621.75
	Diff.	No Data	No Data	No Data	No Data	1.33	3.84	36.81
May	Max	No Data	No Data	No Data	No Data	248.36	249.59	658.82
	Min	No Data	No Data	No Data	No Data	247.36	246.11	621.27
	Diff.	No Data	No Data	No Data	No Data	1.00	3.48	37.55
Jun	Max	250.01	249.61	No Data	248.84	248.53	249.06	658.63
	Min	248.08	248.09	No Data	248.11	248.13	246.27	620.63
	Diff.	1.93	1.52	No Data	0.73	0.40	2.79	38.00
Jul	Max	249.77	249.38	249.05	248.75	248.30	248.51	658.58
	Min	247.22	247.16	247.26	247.01	247.36	246.21	620.49
	Diff.	2.55	2.22	1.79	1.74	0.94	2.30	38.09
Aug	Max	No Data	248.73	248.23	248.22	247.53	247.91	658.55
	Min	No Data	246.10	246.35	246.16	246.53	246.01	620.16
	Diff.	No Data	2.63	1.88	2.06	1.00	1.90	38.39
Sep	Max	No Data	247.78	247.23	No Data	246.61	247.39	658.62
	Min	No Data	245.62	245.71	No Data	245.73	245.32	620.56
	Diff.	No Data	2.16	1.52	No Data	0.88	2.07	38.06
Oct	Max	247.09*	247.21	No Data	No Data	246.01	247.00	658.43
	Min	245.21*	245.14	No Data	No Data	245.21	245.16	620.62
	Diff.	1.88	2.07	No Data	No Data	0.80	1.84	37.81
Nov	Max	246.76	246.80	No Data	No Data	245.48	247.00	658.57
	Min	244.87	244.91	No Data	No Data	244.84	244.63	621.99
	Diff.	1.89	1.89	No Data	No Data	0.64	2.37	36.58
Dec	Max	No Data	No Data	No Data	No Data	245.27	247.03	658.49
	Min	No Data	No Data	No Data	No Data	244.57	244.40	620.30
	Diff.	No Data	No Data	No Data	No Data	0.70	2.63	38.19

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Notes:
All values are based on hourly water level data.
Lower river temporary gauge data included 2002 data only.
Port Weller and Lewiston Reservoir gauge data included 1991-2002 data sorted by month.
Each month with fewer than 15 days of collected data are omitted.
* For October 2002, maximum water level occurred at SG-01A location and minimum occurred at SG-01C location. The water level at SG-01C location is approximately 1.1 feet lower than the water level at SG-01B location.

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TABLE 2.2.5-1

NIAGARA RIVER – AVERAGE RIVER VELOCITIES

Gauge	Low Elevation[1] (ft.)	Range of Velocities[2] (fps)	High Elevation[3] (ft.)	Range of Velocities[2] (fps)
Upper Niagara River				
Fort Erie	571.64	1.79 – 2.38	573.79	1.54 –2.05
Peace Bridge	567.01	6.40 – 8.50	571.33	4.99 – 6.62
Frenchman's Creek	565.61	1.94 - 2.57	567.76	1.72 – 2.28
Huntley	565.52	1.96 - 2.61	567.56	1.70 – 2.26
Tonawanda Island	564.91	2.47 – 3.28	566.87	2.19 – 2.91
LaSalle	562.34	1.88 – 2.50	564.85	1.46 – 1.95
River Intake	561.77	2.34 – 3.11	564.55	1.81 – 2.41
Lower Niagara River				
SG-URS-01	251.49	4.02 –6.85	256.56	3.76 – 6.42
SG-URS-02	250.33	2.59 – 4.42	255.39	2.21 – 3.76

1. Elevations for the upper Niagara River gauges are based on those on 4/25/00 at 9 p.m. when the Chippawa-Grass Island Pool water level was low and Fort Erie flow was 187,839 cfs. Elevations for the lower Niagara River gauges are based on those on 12/22/98 at 1 p.m. when Lake Ontario water level was low and lower Niagara flow was 240,507 cfs.

2. For upper Niagara River, 10% exceedance flow = 243,000 cfs and 90% exceedance flow = 183,000 cfs based on monthly basis of comparison flows at Fort Erie gauge for period 1900-1999. For lower Niagara River, 10% exceedance flow = 261,000 cfs and 90% exceedance flow = 153,000 cfs based on hourly flows at computed gauge for period 1991-2001.

3. Elevations for the upper Niagara River gauges are based on those on 5/2/91 at 3 p.m. when the Chippawa-Grass Island Pool water level was high and Fort Erie flow was 232,300 cfs. Elevations for the lower Niagara River gauges are based on those on May 12, 1993 at 9 p.m. when Lake Ontario water level was high and lower Niagara flow was 274,090 cfs.

4. Velocities were not calculated for locations SG-URS –03 and SG-URS-04 due to lack of available bathymetric data for the channel portion of this river section.

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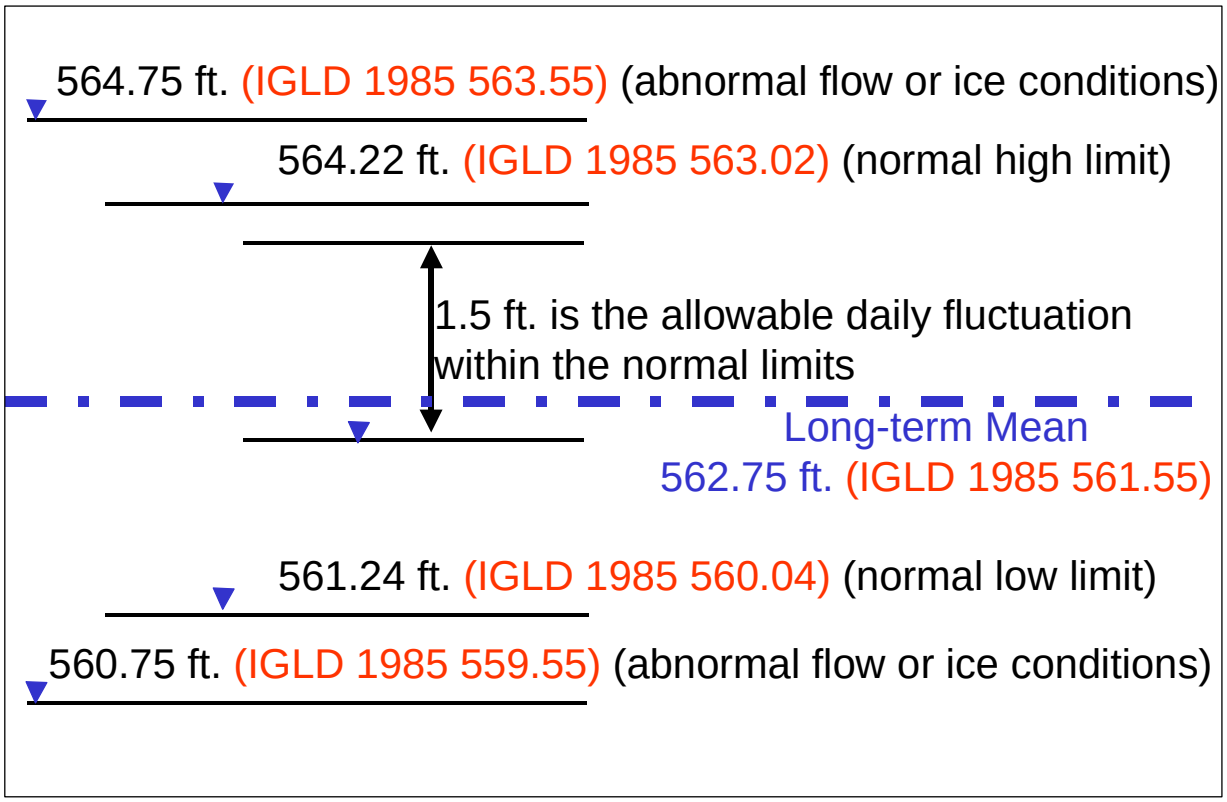
FIGURE 2.1-1

REGULATION OF THE CHIPPAWA-GRASS ISLAND POOL WATER LEVELS AS SPECIFIED BY THE INBC 1993 DIRECTIVE



Note: Elevation Datum: USLSD 1935. To convert water levels in the upper Niagara River from USLSD to IGLD subtract 1.2 feet

Abnormal flow conditions are considered to exist when any four consecutive hourly mean Niagara River flows, as determined from levels at the Fort Erie gauge, are greater than 270,000 cfs or less than 150,000 cfs.

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This material is contained in:
Volume 2
Section: Effect of Water Level and Flow Fluctuations on Aquatic and Terrestrial Habitat

FIGURE 2.2-1

NIAGARA RIVER GAUGE LOCATIONS

[NIP – General Location Maps]

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FIGURE 2.2.1-1

CROSS-SECTIONAL VIEW OF THE NIAGARA RIVER AT THE FRENCHMAN'S CREEK GAUGE SHOWING WATER LEVEL FLUCTUATIONS AND INFLUENCE OF PROJECT OPERATION AND OTHER FACTORS

[NIP – General Location Maps]

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FIGURE 2.2.1-2

CROSS-SECTIONAL VIEW OF THE NIAGARA RIVER AT THE MATERIAL DOCK GAUGE SHOWING WATER LEVEL FLUCTUATIONS AND INFLUENCE OF PROJECT OPERATION AND OTHER FACTORS

[NIP – General Location Maps]

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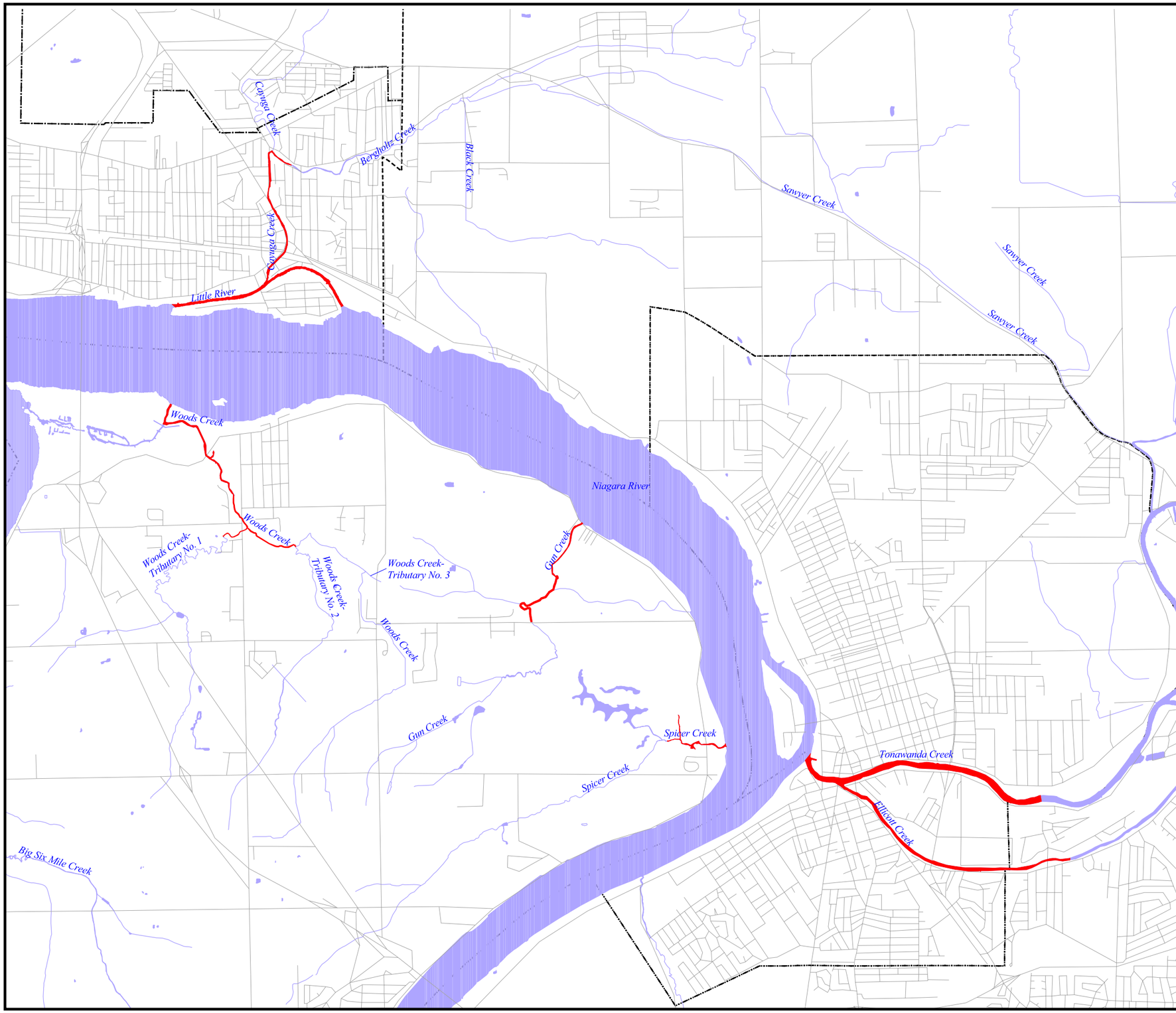


NIAGARA POWER PROJECT (FERC N0. 2216)

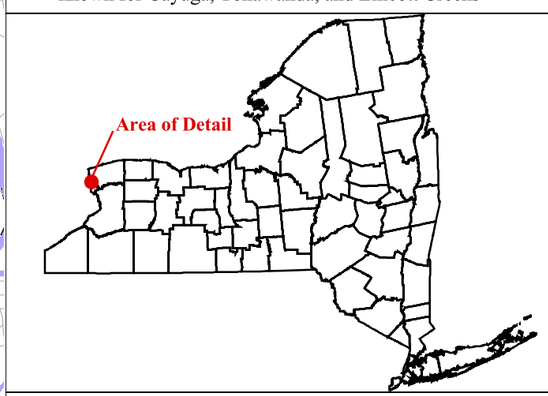
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

Influence from Niagara River

LEGEND:

- Backwater Influence
- Streams
- Water Bodies
- Municipal Boundary
- Roads

NOTE: Upstream extent of the Niagara backwater is not known for Cayuga, Tonawanda, and Ellicott Creeks



0 4000 8000 Feet

1" = 4,000

N

FIGURE 2.2.1.1-1

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NIAGARA POWER PROJECT

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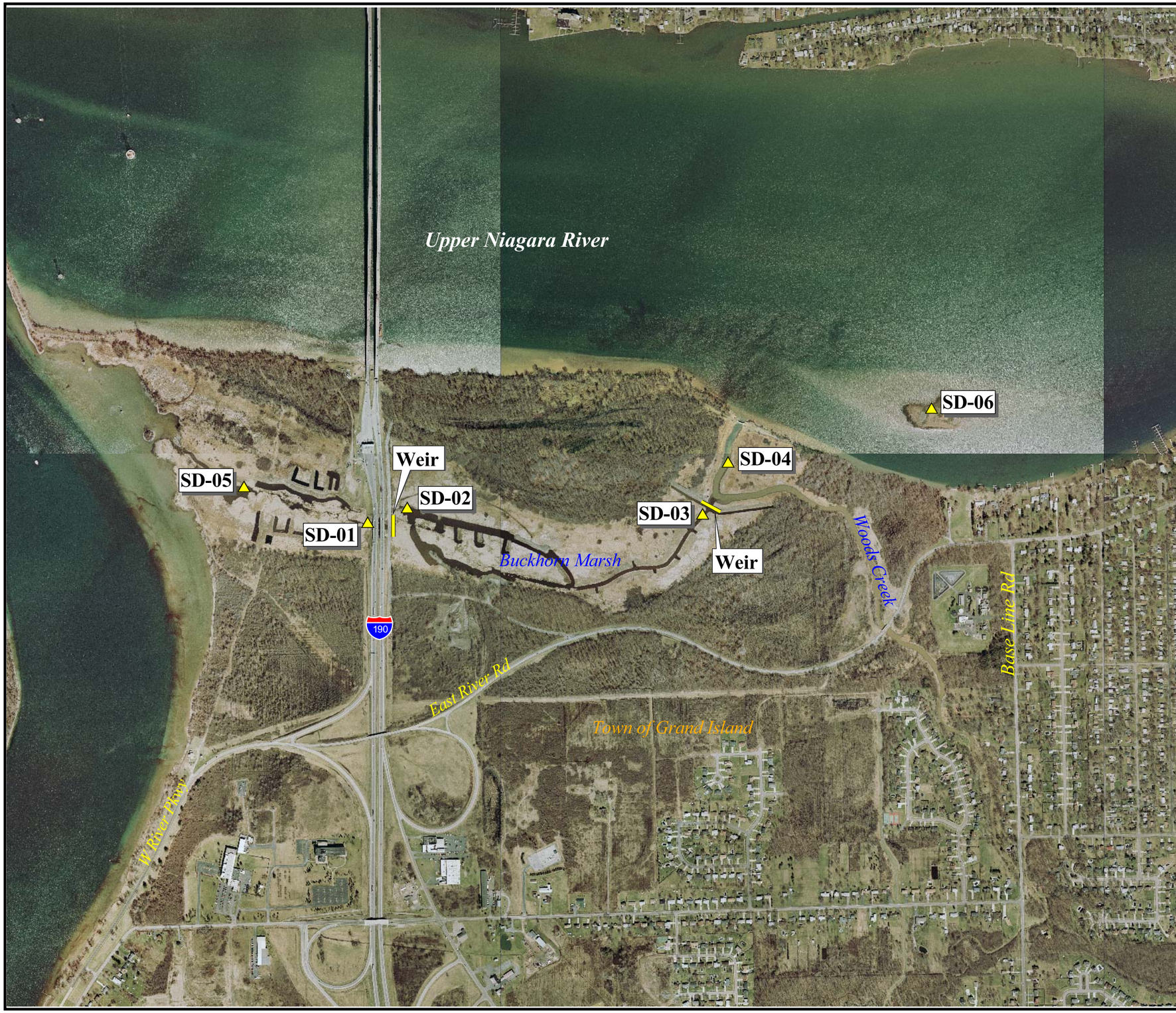
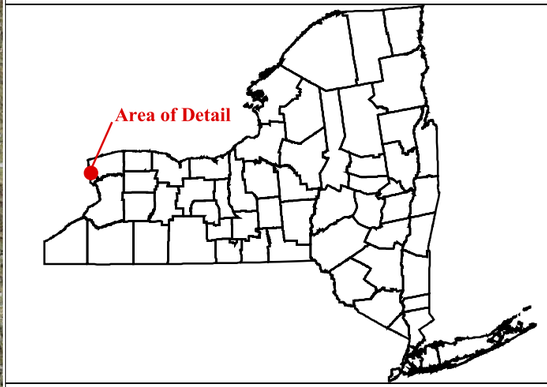
NIAGARA POWER PROJECT (FERC N0. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

Location of Temporary Gauges in the Vicinity of Buckhorn Marsh



LEGEND:

- Temporary Water Level Gauge
- Weir Location



1000 0 1000 Feet

1" = 1,000'

N

FIGURE 2.2.1.2-1

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NIAGARA POWER PROJECT

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3.0 METHODS

3.1 Habitat Mapping Across the Investigation Area

Aquatic and wetland habitats were mapped across the investigation area, using existing data sources and information collected in the Investigation Area in 2002. Key habitat features that were mapped included water depth zones, the location and relative extent of areas with little or no current, dominant substrates, the location of submerged aquatic vegetation (SAV) and emergent aquatic vegetation (EAV), and the location of documented large wetland areas that could potentially be affected by water level fluctuations. In 2002, field verification of the supplied information was completed along 24 transects in the upper and lower river and Lewiston Reservoir. In addition, three cross-sectional transects per tributary were established in Tonawanda, Cayuga, and Ellicott Creeks. The resulting habitat information was used in assessing habitat availability and distribution in relation to fluctuating water levels. The following sections describe the methods used to map these habitats.

3.1.1 Water Depth Zones

Water depth zones were identified for the investigation area so that associations between water depths and other habitat features (e.g., substrates, SAV) could be analyzed in relation to water level fluctuation patterns. The depth zones established for the water bodies within the investigation area were as follows:

- 0-2 feet,
- 2-6 feet,
- 6-20 feet, and
- >20 feet

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The depth zones are defined as the water depth at the median water elevation. This definition provides for a very conservative estimate of the effects of water level fluctuations on habitat because the minimum and maximum water elevations generally straddle the median water elevation (i.e., water levels generally fluctuate around the median elevation, not from the median elevation down to the minimum water elevation in a given month). This definition is important to understand particularly when evaluating effects on SAV distribution, as water elevations are generally above the depth at which SAV is established (based on data collected at the transects). The finest resolution feasible for the water depth zones was 2 feet because NYPA's Geographic Information System (GIS) bathymetric layer follows a 2-foot contour interval. The shallowest water depth zone used for this investigation was 0-2 feet. At the start of the investigation, it was anticipated that this zone would best represent the typical range of water level fluctuation for the upper river and lower river considering water level fluctuations in the upper river and lower river downstream of the Robert Moses tailrace are approximately 1.5 feet per day (Sections 2.2.1 and 2.2.2). This zone also corresponds with the typical boat wake height observed in those areas. The next water depth zone was 2-6 feet. This zone was chosen because it represents the typical outer water depth limit for EAV in the Niagara River and corresponds closely to the defined landward limit of deepwater habitat (i.e., 6.6 feet as defined in Cowardin et al. 1979). Deepwater habitats were represented by two water depth zones, 6-20 feet and >20 feet. The boundary between those zones was set at 20 feet because that was approximately the maximum water depth at which SAV had been observed in the Niagara River and Lewiston Reservoir and it is the approximate water depth at the outer limit of an underwater shelf in the lower river. Water depth maps were prepared for the upper river using NYPA's GIS bathymetric layer.

3.1.2 Areas of Little or No Velocity

Water velocity can determine the composition and abundance of flora and fauna found in rivers. Therefore, flow was used to classify aquatic habitats found in the Niagara River as having either: (1) velocity or (2) little or no velocity. Habitats with little or no velocity include protected nearshore areas, embayments, and areas downstream of islands. They were initially identified from maps and aerial photos subsequently confirmed based on field observations of ice formation on the river in December

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2002. This information was used to construct a GIS layer. Areas not classified as having no velocity were classified as having velocity.

3.1.3 Dominant Substrates

Dominant substrates in the upper and lower river were mapped using sediment maps prepared during a 1983-84 geophysical survey of the Niagara River (Mudroch and Williams 1989). In that study, exposed bottom sediments were defined in general terms based on particle size and were mapped using side-scan sonar. The substrate types included sand, gravel, coarse gravel, till, and bedrock (Table 3.1.3-1). A GIS layer was prepared which reproduced the substrate maps as presented in the publication. Upon completion of the 2002 field surveys, the GIS substrate maps were compared to in-field observations (as described in Section 3.2.1) to assess the relative accuracy of the literature source.

3.1.4 Submerged Aquatic Vegetation

EarthData International used September 2001 aerial photos to delineate the boundaries of SAV across most of the investigation area. GIS polygons were then generated for those SAV delineations.

Once the SAV polygons were geo-referenced and adjusted, their accuracy (relative to the extent of SAV) was evaluated using SAV data collected along geo-referenced transects during the 2002 field investigation (Section 3.2.1). Generally, SAV along the transects were found to extend to a maximum depth of approximately 16-20 feet while the EarthData International interpretations indicated SAV generally extended to about 12-15 feet deep (see Section 4.1.4). Therefore, the EarthData International interpretations underrepresent the lakeward extent of SAV in the vicinity of the study transects.

3.1.5 Wetlands

Wetlands were mapped across the investigation area during NYPA's Wildlife Resource Inventory and Description survey (Beak 2002). In that study, wetlands were mapped by interpreting vegetation

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signatures on aerial photographs (including digital natural color aerial photography and false color infrared contact prints, supplemented with other GIS layers such as the existing U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory maps and New York State Department of Environmental Conservation (NYSDEC) Freshwater Wetlands maps. Wetland habitats were identified using a classification system based on the New York Natural Heritage Program (NYNHP) system (Reschke 1990) and the USFWS wetland classification system (Cowardin et al. 1979) (Table 3.1.5-1). The mapping of wetlands during the Beak (2002) survey was field verified at 27 field sample points and other representative areas. The GIS wetland polygons were geo-referenced to the existing digital orthophoto base maps. In the current investigation, wetland polygons were modified slightly at several locations to better reflect habitat boundaries observed during field surveys (Section 3.2.1).

For the purpose of this investigation, a distinction was made between wetlands located within a zone influenced by water level fluctuations and those located outside that zone. Based on a review of wetland distribution information for the investigation area, water level data analyses by URS et al. (2005a), applicable literature (Cowardin et al. 1979), field observations such as debris lines, water marks, and vegetative zones, and professional judgement by Stantec wetland scientists, the cutoff for the zone influenced by water level fluctuations was estimated to be the 5% exceedance level (i.e., water levels equaled or exceeded 5% of the time). Comparisons between field observations of wetland boundaries and the mapped locations of the 5% exceedance levels correlated well. Wetlands located above the 5% exceedance level cutoff receive hydrological input primarily from upslope sources, such as runoff and precipitation, and are therefore independent of Niagara River water levels, other than occasional flooding during infrequent high water periods.

3.1.6 Emergent Aquatic Vegetation

Because of its importance as fish and wildlife habitat, EAV was mapped on the upper Niagara River and Little River (at Cayuga Island) during the 2002 field studies. For the purpose of this investigation, EAV was differentiated from the emergent wetland cover type by its occurrence along the shoreline of the Niagara River. The entire U.S. shoreline of the upper Niagara River downstream of Strawberry Island was surveyed by boat to locate EAV beds. This included the entire shoreline of Grand

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Island. The start and end point coordinates of each bed were delineated with GPS and the width of the bed was estimated. The species composition and a visual estimate of percent cover were also recorded. These data were used to prepare GIS polygons of the shoreline EAV habitat along the river and associated islands.

3.2 Habitat Characterization Along Transects

Habitats were characterized along a total of 24 transects on the mainstem Niagara River, its tributaries, and the Lewiston Reservoir to determine bottom elevations, the location and areal extent of SAV and EAV, substrates, and any unique habitat features. These data were used to delineate aquatic habitat boundaries specific to the Niagara River and Lewiston Reservoir (based on physical measurements or biological characteristics) and to generally describe the habitat in a given area. The data were also used in the analysis of the potential effect of water level fluctuations on riparian and littoral habitats by relating the existing habitat along a transect with the magnitude and timing of water level fluctuations that occur there. For the purpose of this investigation, these habitats included a nearshore zone that is directly exposed to water level fluctuations from natural and manmade factors as well as a zone that extends further into the water column to the point where aquatic vegetation was no longer present. The zone exposed to water level fluctuations was determined using data from long-term monitoring gauges on the Niagara River and Lewiston Reservoir or temporary gauges installed by URS (see Section 2.2).

Cross-sectional drawings were prepared for each mainstem, tributary, and Lewiston Reservoir transect to present the distribution of upland, wetland, and aquatic habitats; water depth zones; and dominant substrates. The zones exposed to longer-term water level fluctuations were also depicted to illustrate habitat occurrence relative to fluctuating water levels. These zones were identified using absolute maximum and minimum water elevations recorded from applicable gauges. For transects located in the vicinity of one or more long-term monitoring gauges, additional data were available from duration analyses of annual water level data (Section 2.2.1.3) from the nearest gauge (or by interpolating water elevations from the two nearest gauges) for the period 1991-2002. The cross-sectional drawings for those transects included the median water elevation (i.e., 50% exceedance level); 5 and 95% exceedance

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elevations (i.e., elevations that are equaled or exceeded 5% and 95% of the time, respectively); and absolute maximum and minimum water elevations. For transects located near temporary gauges, the cross-sectional drawings included the median water elevation (i.e., 50% exceedance level) and absolute maximum and minimum water elevations. Table 3.2-1 lists the water elevations plotted for each transect.

3.2.1 Upper Niagara River, Lower Niagara River, and Lewiston Reservoir Transects

Fifteen transects on the mainstem upper Niagara River (Figure 3.2.1-1) and six transects on the mainstem lower Niagara River (Figure 3.2.1-2) were selected for field characterization surveys by reviewing existing GIS information and observations during a two-day reconnaissance trip (March 19-20, 2002). Three transects on the Lewiston Reservoir (Figure 3.2.1-3), selected by review of existing GIS bathymetry data, were added later in the season. Most transects extended from a point above the high water mark to an offshore point within 16-20 feet of water. However, four transects (Transects 6, 7, 11, and 13) spanned water bodies or wetlands and therefore started and ended at points above the high water mark. Two transects (Transects 3 and 15) had no landfall.

Field data collected at the transects included:

- Transect ground elevation profile;
- Water surface elevation at the time of data collection;
- Location and percent coverage of SAV and EAV;
- The depth to which SAV extends from bottom to the surface;
- Habitat identification (Table 3.1.5-1) and distribution;
- Species composition of riparian vegetation, EAV, and SAV;
- Substrate types along transects; and
- Unique habitat features (e.g., fallen trees, submerged caissons, break walls, large velocity shelters).

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Transect ground elevation profiles and water surface elevations were developed using a combination of instrument surveys, GPS positioning, and sonar and manual depth measurements that were related to a benchmark surveyed to a true ground elevation. Additional water surface elevation data were acquired from gauges located throughout the investigation area.

Substrate types, species composition, and percent coverage of SAV and EAV beds were determined by visual observation using a view tube, grab sampler, or underwater video system. Depth at which the SAV extended from bottom to the surface was determined using a stadia rod observed through a view tube. All positioning of habitat boundaries was done using a sub-meter accuracy GPS.

3.2.2 Tonawanda, Ellicott and Cayuga Creeks

Habitats were characterized within Tonawanda, Ellicott, and Cayuga Creeks using a thalweg survey (traversing the thalweg, the deepest portion of the creek) and by establishing three cross-sectional transects between the creek mouths and the upstream extents of water level fluctuations, as determined using an initial hydraulic backwater model:

- Tonawanda Creek: 10,600 feet upstream of the confluence with the Niagara River (Figure 3.2.2-1);
- Ellicott Creek: 12,600 feet upstream of the confluence with Tonawanda Creek (Figure 3.2.2-1); and
- Cayuga Creek: 6,800 feet upstream of the confluence with the Little River at Cayuga Island (Figure 3.2.2-2).

The thalweg surveys consisted of recording water depth along the thalweg (i.e., the deepest part of the stream channel) for each tributary from the creek mouth to the upstream extent of the investigation areas. Water depth was recorded using a depth-recording sonar linked to a sub-meter accuracy GPS. EAV and riparian habitat types along both banks were recorded and mapped during the thalweg mapping survey. Because of high turbidity at the time of the surveys, it was not possible to map SAV.

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In addition to the thalweg survey, habitats were characterized at three cross section transects along each stream. Data were collected along the transects following the procedures used for the mainstem river and Lewiston Reservoir transects (as described in Section 3.2.1).

3.2.3 Twomile Creek and Grand Island Tributaries

The objective of this task was to map aquatic habitat along the length of tributaries to the upper Niagara River (located mostly on Grand Island), from the mouth of each tributary upstream to a point just above the extent of backwater influence due to water levels in the Chippawa-Grass Island Pool. The tributaries mapped were:

- Twomile Creek;
- Woods Creek;
- Tributaries to Woods Creek;
- Gun Creek;
- Spicer Creek;
- Big Six Mile Creek; and
- Beaver Island backwater channel.

The upstream and downstream ends of each riffle, run, and pool habitat were determined and then mapped using a sub-meter precision GPS unit or by measuring distances from a known point using a hip-chain. Within each habitat type, a visual estimate was made of the percent coverage of SAV, EAV, and riparian vegetation and the dominant and subdominant species were recorded. At the upstream and downstream boundaries of the habitats, the bankfull width, wetted width, substrate, instream cover, and depth were measured approximately every 656 feet. Sample data point locations are shown in Figure 3.2.3-1.

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3.3 Evaluation of Water Level and Flow Fluctuation Effects on Habitats and Species

The potential effects of water level and flow fluctuations on aquatic and terrestrial habitats and associated species were assessed by analyzing water level data (URS et al. 2005a) relative to habitat information. To assist with this qualitative analysis, information on the habitat requirements of specific focus species (Section 3.3.2) and literature on the effects of water level and flow fluctuations on aquatic and terrestrial habitats and species that use those habitats were reviewed. Because of the importance of physiography and differing water fluctuation regimes, the upper Niagara River, lower Niagara River, and Lewiston Reservoir were evaluated separately. In 2002, water temperatures were monitored at several locations. The analysis of water level fluctuations on water temperatures at each location is the subject of another report. Therefore, for purposes of this study it was assumed that thermal regimes are adequate for focus species' life cycles and temperature was not considered as a factor in the analyses of potential effects.

3.3.1 Potential Effects on Aquatic and Terrestrial Habitats

The assessment of potential effects of water level and flow fluctuations due to all factors on aquatic and terrestrial habitats was made using the analyses of water level data for the investigation area (specifically in Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3) and habitat information collected for this study (see Section 3.2). The assessment was based on visual analyses of relationships between habitats in a given area and the water level fluctuations that occur there. This assessment focused primarily on nearshore habitats, including SAV, wetlands (including EAV), unvegetated shallows, and shore communities.

For the purpose of this assessment, zones potentially affected by water level fluctuations were identified for the upper and lower Niagara River, and Lewiston Reservoir transects. Because it is not possible to determine the exact amount of water level fluctuation caused by each factor (i.e., Treaty flows, NYPA and OPG operations, smaller wind events on Lake Erie, and local environmental conditions), these zones provided a conservative estimate of the range of elevations over which water levels may fluctuate at

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the transect locations due to all combined factors (as discussed in Section 2.3). The upper and lower limits of the zones of potential effect were determined using water level monitoring data from established gauges, as well as temporary gauges installed by URS. For the upper river, the limits of the zones of potential effect were determined using monthly maximum and minimum non-significant storm water elevations from the nearest permanent gauge, recorded during typical (1995), wet (1997), and dry (2001) years (as described in Section 2.2.1.4). Comparable analyses were not possible for the lower river (the water level elevation of the lower Niagara River is a complex function of Lake Ontario level, discharge from the Robert Moses and Canadian plants, and flow rate over Niagara Falls, and there are no permanent water level elevation gauges in the lower Niagara River downstream of the Robert Moses tailrace) and Lewiston Reservoir (Niagara Power Project operations determine the water level of Lewiston Reservoir, and Project operations react to the demand for energy and the Niagara River flow); the upper and lower limits of the zones of potential effect in those areas were identified using the absolute monthly maximum and minimum water elevations recorded at the nearest permanent or temporary gauge (i.e., storm events included). For the lower river, 2002 data were used; data from 1991-2002 were used for the Lewiston Reservoir. For illustrative purposes, the minimum, 95%, 50%, 5%, maximum, and time of survey water elevations are shown at each transect (Table 3.2-1 and Appendix A).

This approach to identifying zones of potential effect provided a resource conservative assessment of the potential effects due to NYPA and OPG operations. Even the efforts to remove water level data recorded during significant storm events could not isolate the effects of NYPA and OPG operations on water levels in the upper Niagara River as there are other influencing factors, such as localized environmental conditions on Lake Erie and smaller wind events, that were included in the analysis (Section 2.2.1.4). The zones of potential effect identified for the lower river and Lewiston Reservoir were even more conservative because no efforts were made to remove data recorded during any storm events.

As described in Section 3.1.1, the depth zones are defined as the water depth at the median water elevation. This definition provides for a very conservative estimate of the effects of water level fluctuations on habitat because the minimum and maximum water elevations generally straddle the median water elevation (i.e., water levels generally fluctuate around the median elevation, not from the

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median elevation down to the minimum water elevation in a given month). This definition is important to understand particularly when evaluating effects on SAV distribution, as water elevations are generally above the depth at which SAV is established (based on data collected at the transects).

3.3.2 Aquatic and Terrestrial Focus Species

Subsequent to assessing the potential effects of water level and flow fluctuations on existing aquatic and terrestrial habitats, efforts were made to identify potentially affected habitat used by specific species (focus species) associated with those habitats. These species were chosen by USFWS, NYSDEC, the Tuscarora Environment Program, and NYPA because they represent all the species that use the various habitats in the investigation area. Habitat preferences and requirements were determined from literature review.

Once a determination was made that a given focus species uses an affected habitat for at least one life stage, a more detailed evaluation was completed to determine whether water level fluctuations at the times of expected species occurrences in aquatic and terrestrial habitats are severe enough to have a potential effect. This was accomplished by determining where suitable habitat for a given species occurred in the investigation area, the times (months in the year and seasons) the species would be expected to use the habitat there, and the difference in water elevations for each month from non-storm water elevation data recorded during a typical (1995), wet (1997), and dry (2001) year (as described in Section 2.2.1.4 and in Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3). Comparable analyses were not possible for the lower river and Lewiston Reservoir. There are no long-term data for the lower river. Niagara Power Project operations determine the water level of Lewiston Reservoir, and Project operations react to the demand for energy and the Niagara River flow. Therefore, the differences between maximum and minimum water elevations for each month in those areas were determined using all available data (i.e., storm events included) from permanent and temporary gauges. The differences between maximum and minimum water elevations for each month identified for upper river gauges are listed in Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3, and those for lower river and Lewiston Reservoir gauges are listed in Table 2.2.2-1.

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In assessing the potential effects on the habitat used by focus species, both direct effects (i.e., dewatering of fish and amphibian spawning and rearing areas, desiccation of benthic macroinvertebrates, desiccation of hibernating amphibians and turtles, flooding of turtle and bird nests) and indirect effects (i.e., exposure to predators during low water periods, foraging efficiency of wildlife species) were considered. As in the use of zones potentially affected by water level fluctuations for evaluating potential effects on habitats, the use of maximum monthly fluctuations within each of the three years provides a conservative assessment of the possible effects on species due to NYPA and OPG operations. For the upper river, efforts to remove water level data recorded during significant storm events did not completely isolate the effects of power operations on water levels in the upper Niagara River (Section 2.2.1.4). The maximum monthly fluctuations identified for the lower river and Lewiston Reservoir were even more conservative because no efforts were made to remove data recorded during any storm events.

For the purpose of this investigation, determinations were made whether focus species may or may not be affected by water level and flow fluctuations, and the relative significance of the habitat that may be affected was assessed.

3.3.2.1 Fish Focus Species

Ninety-two species of fish have been recorded in the Niagara River and Lewiston Reservoir (Table 3.4.2.1-1). From these, a list of 19 species was prepared for the upper Niagara River and its tributaries, the lower Niagara River, and the Lewiston Reservoir. These species were chosen by USFWS, NYSDEC, the Tuscarora Environment Program and NYPA because they represent all the fish species that use the various habitats in the investigation area.

In the upper Niagara River and its tributaries, thirteen fish species were selected as focus species. These species were:

- bluntnose minnow (*Pimephales notatus*),
- brown bullhead (*Ameiurus nebulosus*),

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- emerald shiner (*Notropis atherinoides*),
- greater redhorse (*Moxostoma valenciennesi*),
- lake sturgeon (*Acipenser fulvescens*),
- lake trout (*Salvelinus namaycush*),
- largemouth bass (*Micropterus salmoides*),
- muskellunge (*Esox masquinongy*),
- northern pike (*Esox lucius*),
- smallmouth bass (*Micropterus dolomieui*),
- walleye (*Stizostedion vitreum*),
- white sucker (*Catostomus commersoni*), and
- yellow perch (*Perca flavescens*).

In the lower Niagara River fourteen species were selected as focus species. These species were:

- American eel (*Anguilla rostrata*, juvenile lifestage only),
- bluntnose minnow (*Pimephales notatus*),
- Chinook Salmon (*Oncorhynchus tshawytscha*),
- emerald shiner (*Notropis atherinoides*),
- lake sturgeon (*Acipenser fulvescens*),
- lake trout (*Salvelinus namaycush*),
- largemouth bass (*Micropterus salmoides*),
- muskellunge (*Esox masquinongy*),
- northern pike (*Esox lucius*),

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- rainbow smelt (*Osmerus mordax*),
- smallmouth bass (*Micropterus dolomieui*),
- walleye (*Stizostedion vitreum*),
- white sucker (*Catostomus commersoni*), and
- yellow perch (*Perca flavescens*).

In the Lewiston Reservoir four species were selected as focus species. These species were:

- emerald shiner (*Notropis atherinoides*),
- rock bass (*Ambloplites rupestris*)
- smallmouth bass (*Micropterus dolomieui*), and
- yellow perch (*Perca flavescens*).

Mooneye (*Hiodon tergisus*) was originally proposed as a focus species for the upper and lower Niagara River, but this species has not been documented there. Therefore, mooneye was not included as a focus species.

Information on the habitat used by the focus species by life stage (adult, adult spawning, fry, and juvenile) was collected from general fish literature sources, reports prepared for the NYPA's St. Lawrence-FDR Power Project, habitat suitability criteria, fisheries journals, resource agency's reports, theses and dissertations, unpublished literature, and agency fisheries professionals. This information was used to determine each species/life stage's habitat requirements relative to water depth, water temperature, current speed, substrate, and vegetative condition. The habitat requirements were used in conjunction with habitat data collected for this report (SAV and EAV occurrence, water depths, and data collected along the transects) to infer the potential effects of water level fluctuations on habitats used by the focus species. To simplify the analysis of the potential effects of water level fluctuations, information on flow, depth, vegetation, and substrate was divided into the several categories. Flow conditions were defined as having either (1) velocity or (2) little or no velocity. Depth categories included 0-2 feet, 2-6

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feet, 6-20 feet, and >20 feet for the mainstem upper and lower Niagara River and tributaries. In the Lewiston Reservoir a single depth zone (i.e., the entire drawdown zone of zero feet to bottom) was used. Substrates were described as bedrock, coarse (gravel, cobble, or boulder), and fine (sand, silt, mud, clay, or organic material). Vegetation was classified as either present or absent (i.e., an area is vegetated or unvegetated).

Each focus species/life stage was assigned a habitat preference classification that was used to assess the potential effects of water level fluctuations on the habitat used by the focus species.

3.3.2.2 Benthic Macroinvertebrate Focus Species

Three macroinvertebrate taxa (crayfish, *Cambarus* spp.; mussel, *Pyganodon grandis*; and mayfly, *Hexagenia* spp.) were selected as representative focus species to determine the potential effect of water level fluctuations on the benthic invertebrate community. Each species represents varying mobility and habitat requirements of the invertebrate community found in the Investigation area. Habitat preference information was developed from literature, habitat suitability criteria, and from resource agency reports.

The macroinvertebrate species were assigned a macrohabitat preference classification that was used to assess the potential effects of water level and flow fluctuations on the habitat used by the benthic invertebrate focus species. Macrohabitat classifications were the same as those used for the fish focus species.

3.3.2.3 Wildlife Focus Species

Fifteen species of wildlife were selected as focus species for the evaluation of the potential effects of water level and flow fluctuations on habitats used by those species. These species were chosen by USFWS, NYSDEC, the Tuscarora Environment Department, and NYPA because they are representative of broad spectrum of wildlife species that use various habitats in the investigation area during certain life-stages.

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In the upper Niagara River and its tributaries these fifteen species included:

- common mudpuppy (*Necturus maculosus*),
- northern spring peeper (*Pseudacris crucifer*),
- green frog (*Rana clamitans*),
- northern leopard frog (*Rana pipiens*),
- common snapping turtle (*Chelydra serpentina*),
- midland painted turtle (*Chrysemys picta marginata*),
- great blue heron (*Ardea herodias*)
- mallard (*Anas platyrhynchos*),
- canvasback (*Aythya valisineria*),
- greater scaup (*Aythya marila*),
- Virginia rail (*Rallus limicola*),
- American coot (*Fulica americana*),
- spotted sandpiper (*Actitis macularia*),
- Bonaparte's gull (*Larus philadelphia*), and
- muskrat (*Ondatra zibethica*).

In the lower Niagara River, ten species were selected as focus species. These species included:

- common mudpuppy (*Necturus maculosus*),
- green frog (*Rana clamitans*),
- common snapping turtle (*Chelydra serpentina*),
- midland painted turtle (*Chrysemys picta marginata*),

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- great blue heron (*Ardea herodias*)
- mallard (*Anas platyrhynchos*),
- canvasback (*Aythya valisineria*),
- greater scaup (*Aythya marila*),
- spotted sandpiper (*Actitis macularia*), and
- Bonaparte's gull (*Larus philadelphia*).

In the Lewiston Reservoir, six wildlife focus species were selected. These species included:

- common mudpuppy (*Necturus maculosus*),
- common snapping turtle (*Chelydra serpentina*),
- great blue heron (*Ardea herodias*)
- canvasback (*Aythya valisineria*),
- greater scaup (*Aythya marila*), and
- spotted sandpiper (*Actitis macularia*).

Efforts were made to select relatively common species that were representative of potentially affected habitats of the investigation area, and for which there exists sufficient literature sources regarding habitat requirements. Special attention was made to include at least one species that requires, for at least one life stage, each of the following habitats: temporary wetlands, permanently/semi-permanently flooded wetlands, unvegetated shoals, aquatic bed, and deepwater habitat.

Wildlife focus species were reviewed in relation to breeding, feeding, and overwintering habitat requirements. Information sources used to define habitat requirements included habitat suitability index (HSI) models, where available, as well as handbooks with detailed natural history information (Bellrose 1976; Bishop 1994; Wright and Wright 1994; Carr 1995; Kurta 1995; Harding 1997; Whitaker and Hamilton 1998; Petranka 1998; Wilson and Ruff 1999; Ernst et al. 1994), The Birds of North America

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series, wildlife journals, and resource agency reports. These information sources were used primarily to determine specific breeding, feeding, and overwintering habitat requirements.

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TABLE 3.1.5-1

AQUATIC AND TERRESTRIAL HABITATS IDENTIFIED DURING THE INVESTIGATION

Label	Habitat Name	Habitat Description
SNHF	Successional Northern Hardwoods Forest	Upland forest dominated by pioneering species
OH	Oak-Hickory Forest	Upland forest dominated by oaks and hickories
SS	Successional Shrubland	Upland shrubland (<50% tree canopy coverage)
SOF	Successional Old Field	Upland field with <50% shrub or tree cover
MG	Mowed Grass	Cultivated lawn with grass mowed regularly
FW	Forested Wetland	All forested wetlands (>50% tree canopy coverage)
SSW	Scrub-Shrub Wetland	Shrub wetland (<50% tree canopy coverage)
WM	Wet Meadow	Seasonally flooded/saturated and dominated by grasses, sedges, rushes, and/or bulrushes
SEM	Shallow Emergent Marsh	Seasonally flooded/saturated and typically dominated by robust emergent plants (e.g., cattails, arrowhead)
DEM	Deep Emergent Marsh	Permanently or semi-permanently flooded (up to 6.6 feet water depth) and dominated by floating-leaved plants (e.g., white water-lily) or robust emergent plants
AB	Aquatic Bed	Submerged Aquatic Vegetation - permanently or semi-permanently flooded areas with at least 25% cover of SAV
RS	Rocky Shore	Intermittently to regularly flooded shorelines with <25% vegetation and at least 75% bedrock or boulders (>10")
US	Unconsolidated Shore	Intermittently to regularly flooded shorelines with <25% vegetation and <75% bedrock or boulders (>10")
RB	Rock Bottom	Permanently or semi-permanently flooded areas with <25% vegetation and at least 75% bedrock or boulders (>10")
UB	Unconsolidated Bottom	Permanently or semi-permanently flooded areas with <25% vegetation and <75% bedrock or boulders (>10")

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TABLE 3.2-1
WATER LEVELS AT HABITAT TRANSECTS BASED ON PERMANENT AND TEMPORARY GAUGE DATA

Transect	Water Elevation (Ft., USLSD 1935) Equaled or Exceeded							Water Level Data Source (Gauge)
	Max.	5%	50% (Median)	95%	Min.			
1	570.71	567.54	566.39	565.45	564.00			Huntley
2	570.71	567.54	566.39	565.45	564.00			Huntley
3	570.71	567.54	566.39	565.45	564.00			Huntley
4	570.12	567.48	566.47	565.47	563.82			Interpolation - Frenchman's Ck & Black Ck
5	569.69	567.09	566.13	565.17	563.61			Interpolation - Frenchman's Ck & Black Ck
6	569.63	567.03	566.08	565.12	563.59			Interpolation - Frenchman's Ck & Black Ck
7	570.71	567.54	566.39	565.45	564.00			Huntley
8	568.86	566.33	565.48	564.59	563.22			Interpolation - Black Ck & Frenchman's Ck
9	569.23	566.65	565.82	564.92	563.37			Tonawanda Isl.
10	569.23	566.65	565.82	564.92	563.37			Tonawanda Isl.
11	565.57	N/A	563.91	N/A	563.46			Interpolation - Temporary Gauges SD-02 and SD-03
12	565.64	563.74	563.09	562.44	561.67			Slater's Point
13	564.74	N/A	563.67	N/A	562.25			Temporary Gauge SD-04
14	566.48	564.60	563.87	563.17	562.17			Interpolation - LaSalle & Tonawanda Isl.
15	566.46	564.59	563.86	563.16	562.16			Interpolation - LaSalle & Tonawanda Isl.
16	249.73		247.19		244.90			Interpolation - Temporary Gauges SG-02 & SG-01
17	249.46		247.06		244.83			Interpolation - Temporary Gauges SG-03 & SG-02
18	249.25		247.09		244.71			Interpolation - Temporary Gauges SG-03 & SG-02
19	249.05	N/A	247.12	N/A	244.59			Temporary Gauge SG-03
20	248.84	N/A	247.64	N/A	245.85			Temporary Gauge SG-04
21	249.59	248.26	246.54	245.26	244.40			Port Weller
22	658.82	655.26	644.54	630.18	620.16			Lewiston Reservoir
23	658.82	655.26	644.54	630.18	620.16			Lewiston Reservoir
24	658.82	655.26	644.54	630.18	620.16			Lewiston Reservoir

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TABLE 3.2-1 (CONT)

WATER LEVELS AT HABITAT TRANSECTS BASED ON PERMANENT AND TEMPORARY GAUGE DATA

Transect	Water Elevation (Ft., USLSD 1935) Equaled or Exceeded							Water Level Data Source (Gauge)
	Max.	5%	50% (Median)	95%	Min.			
Cayuga 1	566.60	563.26	563.97	564.69	562.35			Backwater Model
Cayuga 2	566.60	563.25	563.97	564.69	562.30			Backwater Model
Cayuga 3	566.60	563.24	563.96	564.69	562.25			Backwater Model
Ton. Ck. 1	569.23	566.65	565.82	564.92	563.37			Backwater Model
Ton. Ck. 2	569.23	566.65	565.82	564.92	563.37			Backwater Model
Ton. Ck. 3	569.23	566.65	565.82	564.92	563.37			Backwater Model
Ell. Ck. 1	569.23	566.65	565.82	564.92	563.37			Backwater Model
Ell. Ck. 2	569.23	566.65	565.82	564.92	563.37			Backwater Model
Ell. Ck. 3	569.23	566.65	565.82	564.92	563.37			Backwater Model

Maximum and minimum values are for the period 1991-2002, except for transects using temporary gauge data.
Temporary gauges SD-03, SD-04, and SG-01 through SG-04 were monitored during 2002 only.
5% and 95% exceedance levels were possible only for permanent gauge data.

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TABLE 3.4.2.1-1

FISH SPECIES OF THE NIAGARA RIVER AND LEWISTON RESERVOIR

Common Name	Scientific Name	Circa 1927	1960-2000	2001
Alewife	*Alosa pseudoharengus*	x	x	x
American brook lamprey	*Lampetra appendix*		x	
American eel	*Anguilla rostrata*	x	x	x
Banded killifish	*Fundulus diaphanous*	x	x	x
Black bullhead	*Ameiurus melas*		x	
Black crappie	*Pomoxis nigromaculatus*		x	x
Black redhorse	*Moxostoma duquesnei*		x	
Blackchin shiner	*Notropis heterodon*	x		x
Blacknose dace	*Rhinichthys atratulus*		x	
Blacknose shiner	*Notropis heterolepis*	x	x	
Blue pike	*Sander vitreus glaucus*	x	x	
Bluegill	*Lepomis macrochirus*		x	x
Bluntnose minnow	*Pimephales notatus*	x	x	x
Bowfin	*Amia calva*		x	x
Bridle shiner	*Notropis bifrenatus*		x	
Brindled madtom	*Noturus miurus*		x	x
Brook silverside	*Labidesthes sicculus*	x	x	x
Brook stickleback	*Culaea inconstans*	x	x	x
Brown bullhead	*Ameiurus nebulosus*	x	x	x
Brown trout	*Salmo trutta*		x	
Burbot	*Lota lota*		x	
Central mudminnow	*Umbra limi*	x	x	x
Central stoneroller	*Campostoma anomalum*	x	x	
Channel catfish	*Ictalurus punctatus*	x	x	
Chinook salmon	*Oncorhynchus tshawytscha*		x	
Coho salmon	*Oncorhynchus kisutch*		x	
Common carp	*Cyprinus carpio*	x	x	x
Common shiner	*Luxilus cornutus*	x	x	x

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TABLE 3.4.2.1-1 (CONT.)

FISH SPECIES OF THE NIAGARA RIVER AND LEWISTON RESERVOIR

Common Name	Scientific Name	Circa 1927	1960-2000	2001
Creek chub	*Semotilus atromaculatus*	x	x	x
Emerald shiner	*Notropis atherinoides*	x	x	x
Fallfish	*Semotilus corporalis*		x	
Fantail darter	*Etheostoma flabellare*		x	
Fathead minnow	*Pimephales promelas*	x	x	
Freshwater drum	*Aplodinotus grunniens*	x	x	x
Gizzard shad	*Dorosoma cepedianum*		x	x
Golden redhorse	*Moxostoma erythrurum*		x	
Golden shiner	*Notemigonus crysoleucas*	x	x	x
Goldfish	*Carassius auratus*		x	x
Grass pickerel	*Esox americanus vermiculatus*	x	x	
Greater redhorse	*Moxostoma valenciennesi*		x	x
Green sunfish	*Lepomis cyanellus*		x	
Greenside darter	*Etheostoma blennioides*		x	
Hornyhead chub	*Nocomis biguttatus*	x	x	x
Hybrid Carp x Goldfish	NA		x	
Iowa darter	*Etheostoma exile*	x	x	x
Johnny darter	*Etheostoma nigrum*	x	x	x
Lake chub	*Couesius plumbeus*		x	
Lake chubsucker	*Erimyzon sucetta*	x		
Lake sturgeon	*Acipenser fulvescens*	x	x	
Lake trout	*Oncorhynchus namaycush*		x	
Largemouth bass	*Micropterus salmoides*		x	x
Logperch	*Percina caprodes*	x	x	x
Longnose dace	*Rhinichthys cataractae*	x	x	
Longnose gar	*Lepisosteus osseus*	x	x	x
Mimic shiner	*Notropis volucellus*	x	x	
Mooneye	*Hiodon tergisus*		x	
Mottled sculpin	*Cottus bairdi*	x	x	x

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TABLE 3.4.2.1-1 (CONT.)

FISH SPECIES OF THE NIAGARA RIVER AND LEWISTON RESERVOIR

Common Name	Scientific Name	Circa 1927	1960-2000	2001
Muskellunge	*Esox masquinongy*	x	X	x
Nine-spine stickleback	*Pungitius pungitius*		X	
Northern hog sucker	*Hypentelium nigricans*	x	X	x
Northern pike	*Esox lucius*	x	X	x
Pumpkinseed	*Lepomis gibbosus*	x	X	x
Quillback	*Carpiodes cyprinus*		X	x
Rainbow darter	*Etheostoma cearuleum*	x	X	
Rainbow smelt	*Osmerus mordax*		X	x
Rainbow trout/Steelhead	*Oncorhynchus gairdneri*		X	x
Redfin shiner	*Notropis umbratilis*	x	X	
River chub	*Nocomis micropogon*	x	X	
Rock bass	*Ambloplites rupestris*	x	X	x
Round goby	*Neogobius melanostomus*		X	
Rudd	*Scardinius erythrophthalamus*		X	x
Sand shiner	*Notropis stramineus*	x	X	
Satinfin shiner	*Cyprinella analostana*	x	X	
Sauger	*Sander canadensis*	x	X	
Sea lamprey	*Petromyzon marinus*		X	
Shorthead redhorse	*Moxostoma macrolepidotum*	x	X	x
Silver redhorse	*Moxostoma anisurum*	x	X	x
Smallmouth bass	*Micropterus dolomieui*	x	X	x
Spotfin shiner	*Notropis spilopterus*	x	X	x
Spottail shiner	*Notropis hudsonius*	x	X	x
Stonecat	*Noturus flavus*	x	X	
Striped shiner	*Luxilus chrysocephalus*	x	X	
Tadpole madtom	*Noturus gyrinus*		X	x
Threespine stickleback	*Gasterosteus aculeatus*	x		x
Trout perch	*Percopsis omiscomaycus*	x	X	
Walleye	*Sander vitreus vitreus*	x	X	x

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TABLE 3.4.2.1-1 (CONT.)

FISH SPECIES OF THE NIAGARA RIVER AND LEWISTON RESERVOIR

Common Name	Scientific Name	Circa 1927	1960-2000	2001
White bass	*Morone chrysops*	x	X	x
White crappie	*Pomoxis annularis*		X	x
White perch	*Morone americana*		X	x
White sucker	*Catostomus commersoni*	x	X	x
Yellow bullhead	*Ameiurus natalis*		X	
Yellow perch	*Perca flavescens*	x	X	x

Notes
1. Fish community composition of the Niagara River, circa 1927 and 1960-2000, based on Greeley (1929) and Carlson (2001), respectively.
2. Fish species listed in each source are indicated with an X. Lists include species present in the Niagara River only as migrants, species found either upstream or downstream of the Falls, and species found in the Lewiston Reservoir.
3. Scientific and common names after Nelson et al. (2004). Hubbs and Lagler (1958) was used to determine contemporary names of reclassified species appearing in Greeley (1929).
4. 2001 data from NYPA 2002

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TABLE 3.1.3-1

SUBSTRATE SIZE CLASSES

	Diameter	
Substrate	**millimeters**	**inches**
Bedrock	N/A	N/A
Boulder	>256	>10
Large Cobble	128-256	5-10
Small Cobble	64-128	2.5-5
Pebble	16-64	0.625-2.5
Gravel	2-16	0.08-0.625
Sand	0.063-2	N/A
Silt	<0.062	N/A
Hard Clay	N/A	N/A
Mud Clay	N/A	N/A
Organic Fibric	(e.g., peat)	
Organic Sapric	(e.g., muck)	

Substrates (based on the modified Wentworth scale, Lane 1947)

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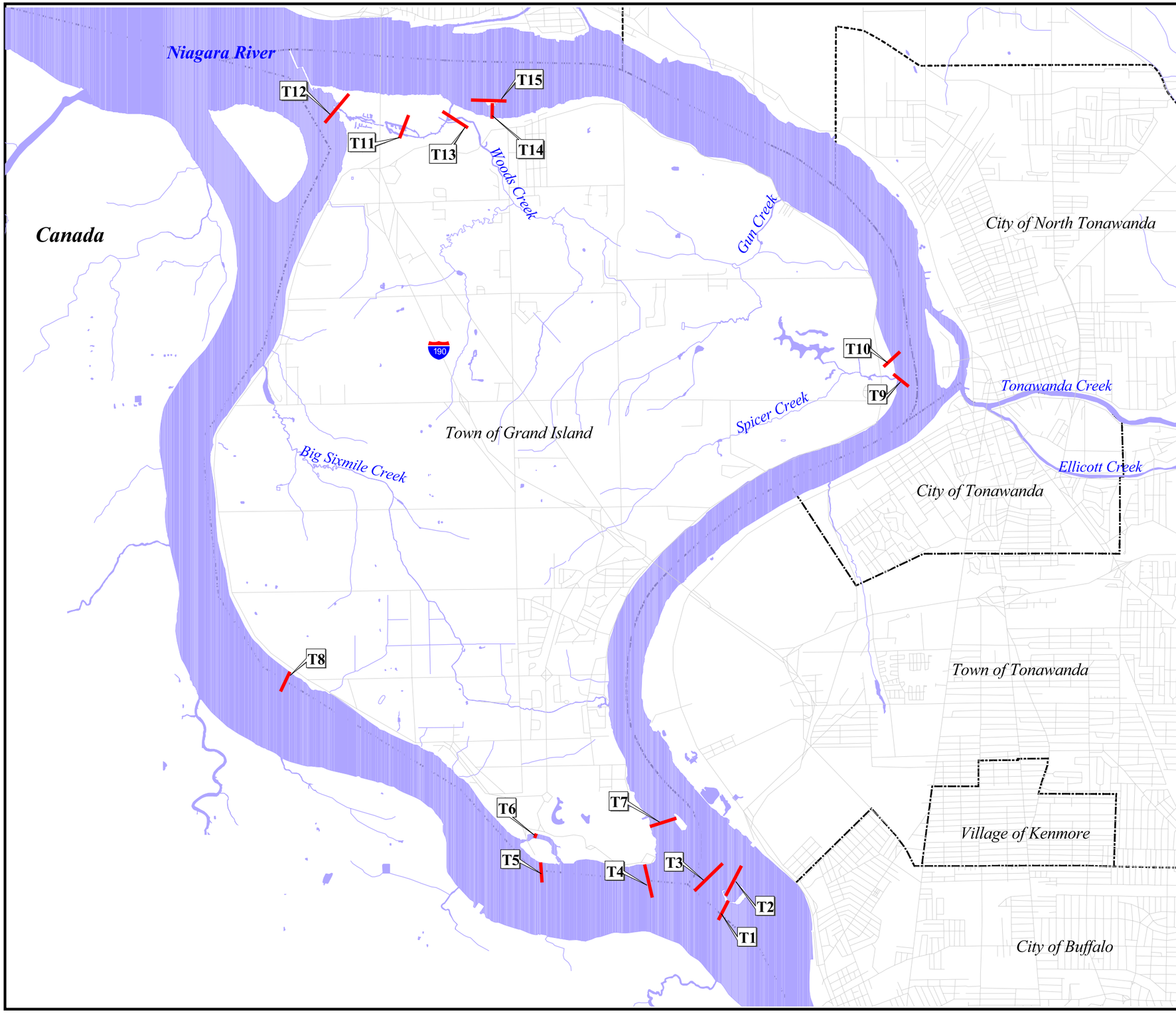
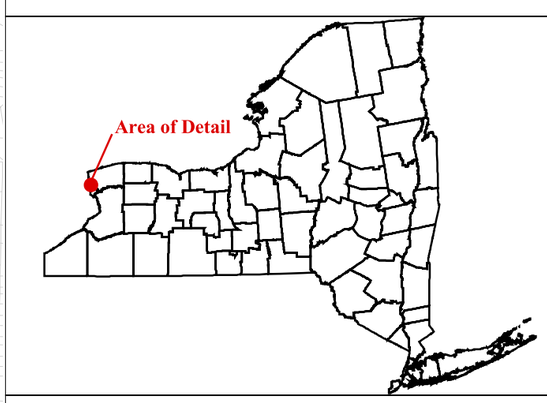


NIAGARA POWER PROJECT (FERC N0. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

Locations of Upper River Transects

LEGEND:

- Transect
- Municipal Boundary
- Water Bodies
- Roads



5000 0 5000 Feet

1" = 5,000'

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FIGURE 3.2.1-1

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This material is contained in:
Volume 2
Section: Effect of Water Level and Flow Fluctuations on Aquatic and Terrestrial Habitat

FIGURE 3.2.1-2

LOCATIONS OF LOWER NIAGARA RIVER TRANSECTS

[NIP – General Location Maps]

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FIGURE 3.2.1-3

LOCATIONS OF LEWISTON RESERVOIR TRANSECTS

[NIP – General Location Maps]

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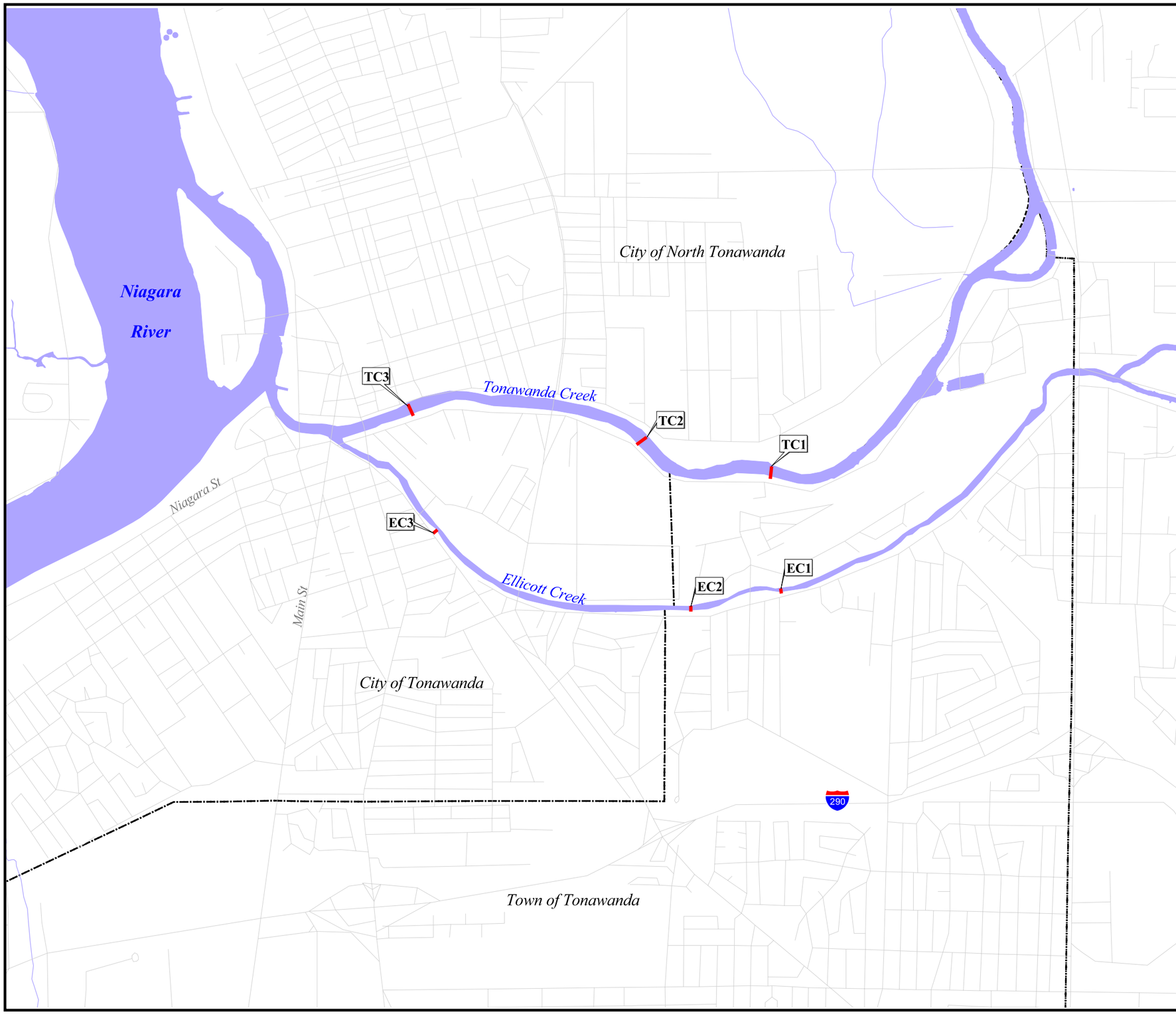
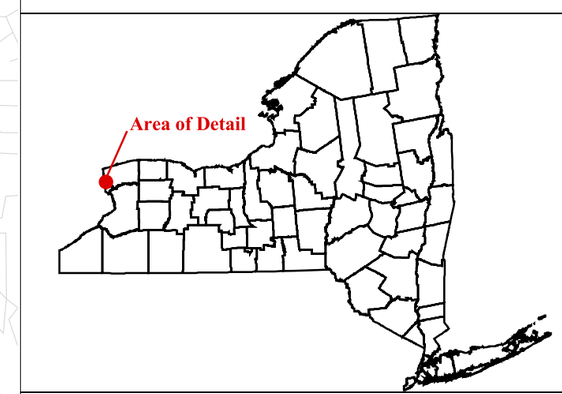


NIAGARA POWER PROJECT (FERC N0. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

Locations of Tonawanda and Ellicott Creek Transects

LEGEND:

- Transect
- Municipal Boundary
- Water Bodies
- Roads



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1" = 2,000'

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FIGURE 3.2.2-1

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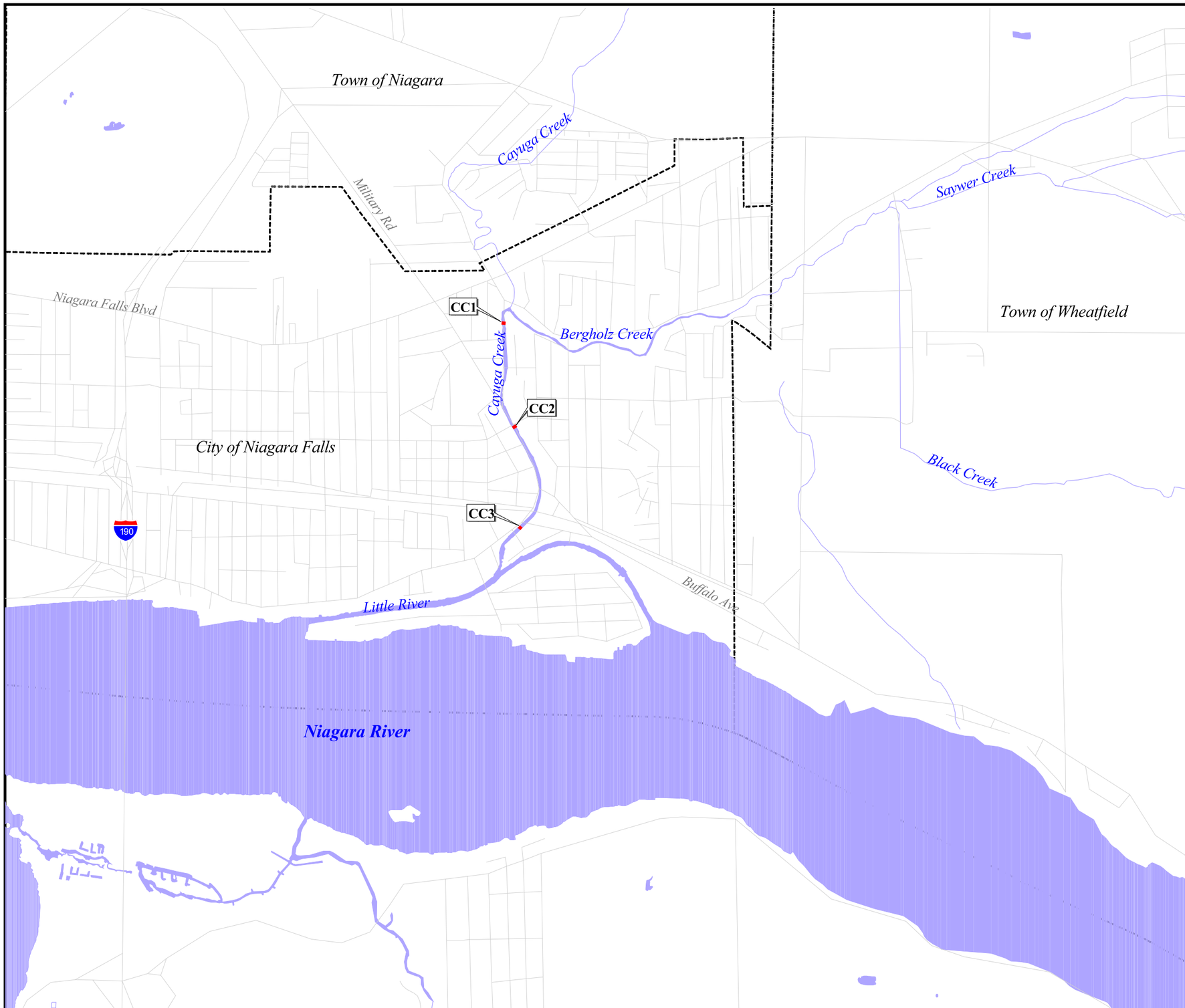
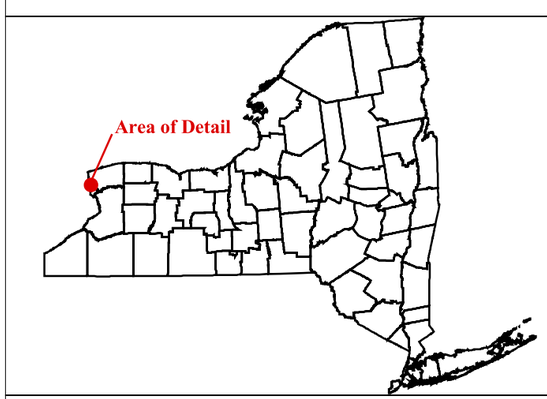
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

Locations of Cayuga Creek Transects



LEGEND:

- Transect
- Municipal Boundary
- Water Bodies
- Roads



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1" = 2,000'

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FIGURE 3.2.2-2

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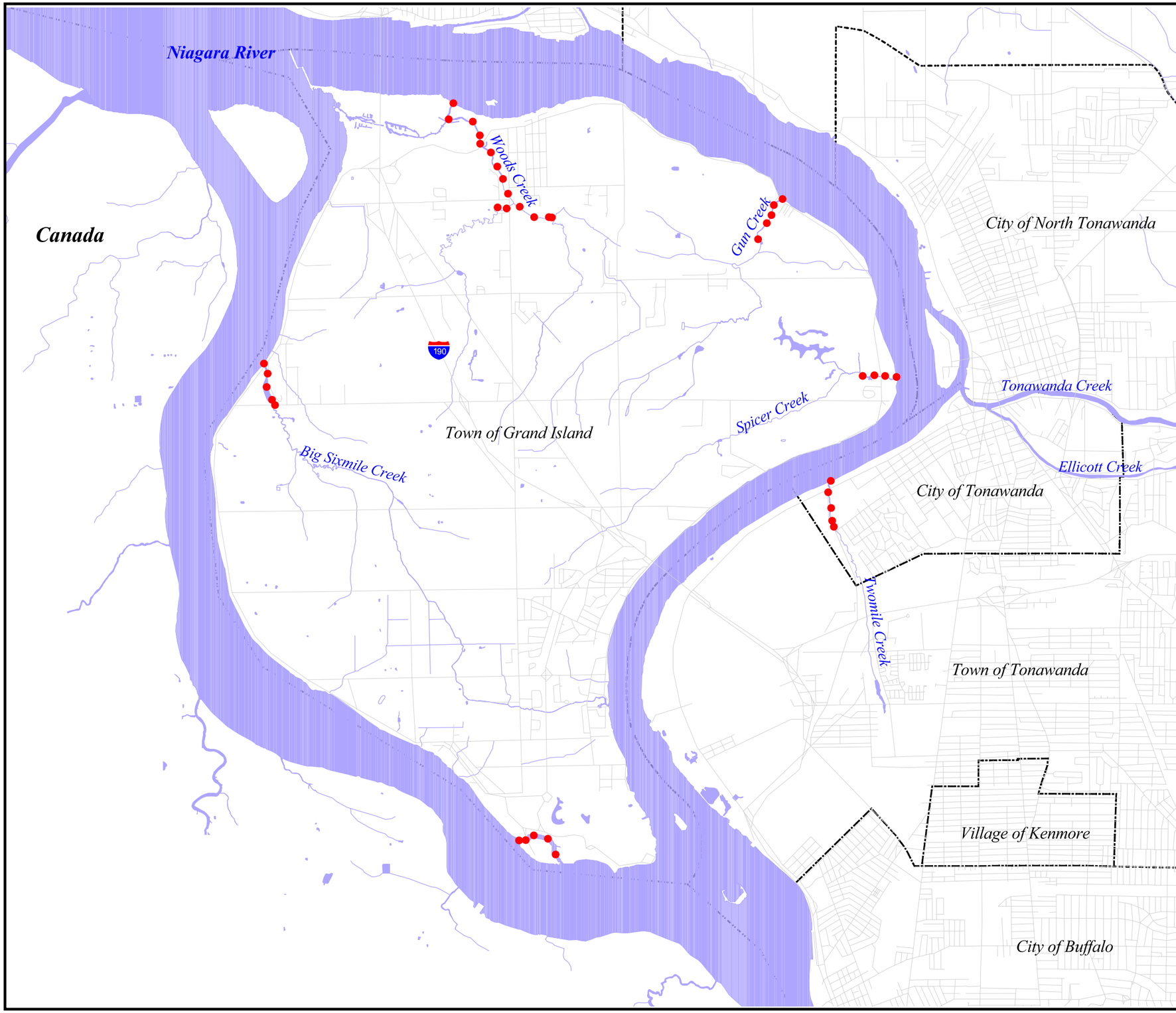
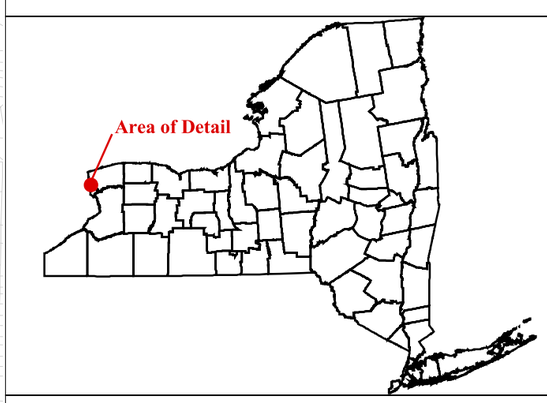
NIAGARA POWER PROJECT (FERC N0. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

Locations of Twomile Creek and Grand Island Tributary Data Points



LEGEND:

- Transects - Secondary Tributary
- Municipal Boundary
- Water Bodies
- Roads



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1'' = 5,000'

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FIGURE 3.2.3-1

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4.0 HABITAT DISTRIBUTION AND CHARACTERIZATION

This section describes the aquatic and terrestrial habitats present within the investigation area. Section 4.1 reviews habitat mapping that was completed across the investigation area, primarily using existing data sources. Section 4.2 describes habitat features collected along the transects.

4.1 Habitat Distribution Across the Investigation Area

A variety of aquatic and terrestrial habitats were found in the investigation area during the 2002 field surveys. These habitats can be described by the various physical characteristics that make them suitable to various species. These characteristics include water depth, water velocity, water temperature, dominant substrate, and vegetative community. Each of these characteristics is discussed below. The extent and general location of such habitats in the investigation area are presented. A discussion of the limitations and relative accuracy of the available habitat information sources compiled for this investigation is also provided, based on field observations completed in 2002.

4.1.1 Water Depth Zones

Except for the Tonawanda Channel along the east side of Grand Island, the upper Niagara River is relatively shallow, with water depths rarely exceeding 20 feet (Figures 4.1.1-1 – 4.1.1-8). Moreover, the dropoff in depths from shore is generally quite gradual in much of the upper river. The Strawberry Island/ Motor Island area, which includes the southern tip of Grand Island, is an especially large shoal where water depth rarely exceeds 6 feet. Other areas in the upper Niagara River where relatively large areas of shallow water exist are (1) an area in the river near the mouth of Burnt Ship Creek (2) an area along the east shore of Grand Island near Spicer Creek; and (3) the area surrounding Grass Island on the north shore of Grand Island. The tributaries of Grand Island are shallow, rarely exceeding 4 feet in depth with the exception of the portion of Woods Creek near its mouth and much of Big Six Mile Creek Marina. Cayuga, Tonawanda, and Ellicott Creeks are also shallow, but include water deeper than 6 feet, especially in those areas dredged for navigation (i.e., most of Tonawanda Creek).

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The investigation area in the lower river is typified by a narrow zone (<100 feet) along the shoreline where depth is less than 20 feet. The only area with a somewhat larger area of shallow water is near the boat launch in Fort Niagara State Park near the mouth of the river.

4.1.2 Areas of Little or No Velocity

Areas of little or no velocity, generally located downstream of islands, in coves, and in bends of the river, are more prevalent in the upper Niagara River than in the lower Niagara River. The largest of these areas in the upper river is located along the north shore of Grand Island in and around Buckhorn Marsh. The areas of little or no velocity in and near the marsh are (1) the Burnt Ship Creek and Woods Creek complex, including the area between the weirs; (2) much of the northern shore of Grand Island, namely, the area that is protected from the direct current of the river; and (3) the shallows in the Niagara River near the mouth of Burnt Ship Creek. Just offshore of the northern side of Grand Island is another area of little or no velocity that includes Grass Island and its sand/gravel shoal. Another complex exists in the Strawberry Island/Motor Island Shoal and the southern shore of Grand Island. The principal areas of little or no velocity in this complex are (1) the Strawberry Island lagoon; (2) the north (i.e., downstream) side of Motor Island; (3) the shallows near the old ferry dock site on Grand Island across from Motor Island; and (4) the shoreline and backwater channel in Beaver Island State Park. Other areas of little or no velocity in the upper Niagara River investigation area are the shallows adjacent to the mouth of Spicer Creek, the Little River in Niagara Falls, the shoreline in the City of Tonawanda downstream of a major river bend at the South Grand Island Bridge, an area immediately to the east of Cayuga Island, and the tributaries of Grand Island (Big Six Mile Creek Marina, much of Spicer Creek, Gun Creek, and Woods Creeks, and Buckhorn Marsh from the Chippawa Channel of the Niagara River to Woods Creek), and Cayuga, Tonawanda, and Ellicott Creeks (Figures 4.1.1-1 – 4.1.1-8).

Two areas of little or no velocity are present in the lower river investigation area. These areas do provide velocity shelters uncommon in the lower river. One of these areas is downstream of a river bend at Joseph Davis State Park and the other is further downstream at Fort Niagara State Park (Figures 4.1.1-1 – 4.1.1-8).

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The Lewiston Reservoir was also considered to be an area with little or no velocity, although the area near the LPGP likely has at least some water velocity during pumping and generation.

4.1.3 Dominant Substrates

Mudroch and Williams (1989) determined that coarse sand, gravel, glaciolacustrine clay and till, and bedrock were the dominant substrate types in the upper Niagara River. Because their methodology was based on side-scan sonar and bottom profile, only a gross determination of substrate composition was possible. However, substrates were not identified by Mudroch and Williams (1989) for a large portion of the Tonawanda Channel (Figure 4.1.3-1). Gravel was the dominant substrate identified by Mudroch and Williams in the Strawberry Island/Motor Island Shoal. Although pockets of gravel were noted during the 2002 transect effort conducted for this investigation, it was not the dominant substrate identified (except the area off the west shore of Strawberry Island). The dominant substrate in the shoals downstream of Strawberry Island was sand, while in the Strawberry Island lagoon and between Motor Island and Grand Island it was silt. Bedrock was the dominant substrate along a transect (Transect 4) that extended from the southern tip of Grand Island (a bedrock bottom in the upstream portion of the Chippawa Channel was confirmed during the 2002 fieldwork). Downstream, a sandy area was mapped. The middle reach of the Chippawa Channel was mapped as bedrock with a coarse gravel bed. Gravel was the dominant substrate type in the Chippawa Channel near Navy Island (Mudroch and Williams 1989).

The dominant substrates mapped for the river near the northern shore of Grand Island were sand and till. The dominant substrate in the rest of the northern half of the Tonawanda Channel was mapped as bedrock, with an area of sand and a smaller area of silt found along the mainland shore (Mudroch and Williams 1989). The results of the transect surveys conducted in 2002 at Transects 9 and 10 near Spicer Creek on the Grand Island (Figure 3.2.1-1) shore indicated the presence of a large reach with sand and silt bottom, with no exposed bedrock found within approximately 1,000 feet of shore. Although the upstream portion of the Tonawanda Channel just downstream of Peace Bridge was not mapped, (due to safety considerations associated with high water velocity) it is likely that the dominant substrate is coarse material or bedrock.

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Mudroch and Williams (1989) mapped the investigation area in the lower river as having extensive areas of sand, gravel, and till. Transect data collected in 2002 generally confirmed the presence of these substrates in the lower river.

The transect surveys conducted in 2002 found the dominant substrates in the tributaries of Grand Island and Cayuga, Tonawanda, and Ellicott Creeks to be fine material, generally silt, sand and muddy clay.

4.1.4 Submerged Aquatic Vegetation

Large beds of SAV were found in the investigation area (Figures 4.1.1-1 – 4.1.1-8). Based on the EarthData International mapping of SAV, the largest SAV beds were found in the Strawberry Island/Motor Island Shoal (including the southern shore of Grand Island), the Grass Island shoal, the shoreline near the Little River (both east and west of Cayuga Island), and the eastern shore of Grand Island north of Spicer Creek. A thinner strip of SAV was mapped along much of the rest of the shoreline in the upper river. The results of the field surveys performed for this investigation along selected transects indicated that the maps generated by EarthData International probably underrepresented the extent of SAV beds in the upper river. The maps showed the outer limits of SAV in the vicinity of the transects at depths of 12-15 feet whereas the field investigations documented the outer limits of SAV in those areas at depths of 16-20 feet. SAV was present in the tributaries of Grand Island, being dense in some areas (e.g., Woods Creek) and nearly non-existent in others (e.g., portions of Spicer Creek). At the time of the thalweg surveys in Cayuga, Tonawanda and Ellicott Creeks, the water was too turbid to determine the presence of SAV. During the transect surveys of these three creeks, which were conducted later than the thalweg surveys, SAV was found to be sparse to dense along the three transects in each of these creeks.

In the lower river, a relatively large SAV bed was found near the U.S. Coast Guard Station and Fort Niagara State Park. Much smaller areas of SAV were encountered in the investigation area as intermittent, narrow strips along shore. The results of the transect data collection indicated that the SAV beds in the lower river may extend somewhat further offshore than what was mapped, out to a maximum

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water depth of about 20 feet. This did not greatly increase the size of the beds because, in this reach, the river bottom drops off rapidly from shore, resulting in conditions of light transmissivity unsuitable for SAV.

4.1.5 Wetlands (Including Emergent Aquatic Vegetation)

The USFWS National Wetlands Inventory and NYSDEC have mapped wetlands in the investigation area (Figures 4.1.5-1 and 4.1.5-2). Although most of the mapped wetlands are well above the river high water mark, out of the zone directly exposed to water level fluctuations, and are not contiguous with the river surface water, a few are contiguous with the river, and are potentially influenced by water fluctuation. These include (1) Buckhorn Marsh (outside of the water control weirs); (2) a large wetland on Grand Island just north of Spicer Creek; (3) the backwater channel in Beaver Island State Park; and (4) a wetland near the old ferry dock site on Grand Island across from Motor Island.

As part of this investigation, narrow strips of EAV were identified along the upper river shore and as larger areas associated with backwater, lower energy habitats (Figures 4.1.5-1 and 4.1.5-2). The larger areas of EAV included (1) the southern side of the mouth of Burnt Ship Creek; (2) Grass Island; (3) the backwaters of Strawberry Island; (4) the old ferry docks site on the Grand Island shore across from Motor Island; (5) the mouth of Big Six Mile Creek; and (6) the mouth of Spicer Creek. Major strips of EAV occurred (1) along both shores of the Little River (at Cayuga Island); (2) along the northern shore of Grand Island in Buckhorn Island State Park; and (3) along most of the western Grand Island shoreline (Chippawa Channel). Limited areas of EAV were observed along the shoreline of the Tonawanda Channel, which has been extensively disturbed and heavily riprapped. There are two sites along the eastern shoreline of the Tonawanda Channel that each have about two acres of created EAV wetland and SAV beds. These are associated with two remediated and capped landfills; one at the Gratwick Riverside Park and one found at a site known as Cherry Farm. The EAV and SAV at both of these sites was established at the interface between the waterline and the landfill caps. These areas are found behind and protected by barrier break walls composed of riprap. Goals for creating these wetland areas were to provide supplemental forage habitat for various species of heron and other bird species such as American

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coot, Virginia rail, and possibly pied-billed grebe, and provide rearing and forage habitat for certain young-of-the-year fish species such as black bass.

No wetlands influenced by water level fluctuations were identified in the lower river by resource agencies or during this investigation. Also, no major occurrences of EAV were found in the investigation area downstream of the Robert Moses tailrace.

4.2 Habitat Characterization Along Transects

This section presents the results of habitat characterization field surveys completed for the upper river, upper river tributaries, lower river, and Lewiston Reservoir. Plan view and cross-section figures of transects for the upper river, lower river, Lewiston Reservoir, and Tonawanda, Ellicott, and Cayuga Creeks are presented in Appendix A. Common and scientific names for all plants are provided in Appendix B.

4.2.1 Upper Niagara River

The 15 transects in the mainstem upper Niagara River (Figure 3.2.1-1) were established in areas either that represented the major habitat types known to be present, or that were of a type (such as shoals and wetlands) that possess greater potential to be affected by water level fluctuations. Seven transects were set up in the Strawberry Island/Motor Island Shoal area, including the south shore of Grand Island and the backwater channel in Beaver Island State Park. A transect was established in the Chippawa Channel (on the southwest side of Grand Island) near Fix Road. Two transects were established at the mouth of Spicer Creek. Five transects were distributed in the vicinity of Buckhorn Marsh, the mouth of Burnt Ship Creek, and Grass Island on the northern shore of Grand Island. No transects were established along the eastern shore of the river because much of it is made land with riprap and sheet piling that armors the shoreline, and very little natural habitat that could be affected by water level and flow fluctuations exists in this area.

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The transects in the Strawberry Island/Motor Island Shoal and the south shore of Grand Island (Transects 1-7) were typified by shallow waters and a gradual slope, with depths generally less than 15 feet at 1,000 feet from shore. Plan and cross-sectional views of the transects are shown in Appendix A. The transects were characterized by moderate to dense SAV beds. Wild-celery (*Vallisneria americana*) was the most abundant species at depths less than 10 feet. In deeper waters, other species were more abundant, including sago pondweed (*Potamogeton pectinatus*), clasping-leaf pondweed (*Potamogeton richardsonii*), common waterweed (*Elodea canadensis*), and muskgrass (*Chara* spp.), although wild-celery was still present. The deeper portion of the Strawberry Island lagoon (Transect 2) was the only area where SAV was not abundant. EAV consisting primarily of common arrowhead (*Sagittaria latifolia*), sedges (*Carex* spp.), soft-stem bulrush (*Scirpus validus*), broad-leaf cattail (*Typha latifolia*), and three-square (*Scirpus americanus*) was abundant on the northeast wing of Strawberry Island (Transect 2), and along the backwater channel in Beaver Island (Transect 6). Strawberry Island creates a velocity break, forming a lower energy area in the lagoon and over much of the shoal. Finer substrates were seen to dominate much of this area, although exposed bedrock occurs offshore of Beaver Island (Transects 4 and 5). While silt and muck were dominant in the Strawberry Island lagoon (Transect 2) and the backwater channel in Beaver Island State Park (Transect 6), pockets of sand that supported SAV were common within the exposed bedrock areas. Poorly mixed sand and gravels dominated the rest of this area.

The bottom along the transect established in the Chippawa Channel near Fix Road was irregular (Transect 8, Appendix A). The shallow zone that extended about 325 feet from shore was moderately vegetated. There was a gradual drop-off to a depth of about 15 feet at about 1,100 feet from shore. The substrate was mixed, with most sizes from silt to boulder represented. Exposed bedrock occurred in the deeper water. Wild-celery was the dominant SAV, and the abundance of SAV along the transect varied from sparse (<25% areal coverage) to dense (>75% areal coverage). The upland shore was fairly steep-banked, but a narrow strand of EAV, consisting primarily of three-square and river bulrush (*Scirpus fluviatilis*), was present near the water's edge. The habitat along this transect was lotic.

The Tonawanda Channel at Spicer Creek (Transects 9 and 10, Appendix A) exhibits a relatively short (150 to 300 feet) reach of shallow water (up to 2 feet deep) with steep drop off to 15 to 20 feet. The

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shallows, marked by a silt and sand bottom, range from sparsely vegetated to unvegetated. The 15- to 20-foot zone is variably vegetated, with wild-celery being the dominant species. The substrate in the deeper zone is a mix of silt, sand, and large cobble. A current was noted in both the river and the creek mouth. Although emergent vegetation was encountered at the mouth of Spicer Creek (Transect 9), the wetlands documented along the transects were largely wet meadow (especially at Transect 9) and forested wetland (especially at Transect 10). The dominant emergent marsh plants were great burreed (*Sparganium eurycarpum*), broad-leaf cattail, white water lily (*Nymphaea odorata*), pickerel-weed (*Pontederia cordata*), and common arrowhead. The dominant plants in the wet meadow communities included handsome sedge (*Carex comosa*), tussock sedge (*Carex stricta*), and bluejoint grass (*Calamagrostis canadensis*). In the forested wetland, the dominant plants were green ash (*Fraxinus pennsylvanica*), spicebush (*Lindera benzoin*), and fowl manna grass (*Glyceria striata*).

Two transects traversed Buckhorn Marsh and Woods Creek on the north side of Grand Island (Transects 11 and 13, Appendix A). Woods Creek is a deeply notched channel that passes through Buckhorn Marsh on the marsh's eastern side. It has a silt bottom that is heavily vegetated with a variety of SAV species, including wild-celery, coontail (*Ceratophyllum demersum*), common waterweed, and various pondweeds (*Potamogeton* spp.). The creek has a very low gradient, providing lower energy habitat. The transects cross extensive areas of emergent marsh and wet meadow. The predominant plant in the emergent marsh communities was broad-leaf cattail, although handsome sedge and a variety of other plants were also observed there. The wet meadow communities were found to support a diversity of plants, with the dominant plants being tussock sedge and bluejoint grass.

Transect 12 (Appendix A) was established in the western part of Buckhorn Marsh, at the mouth of Burnt Ship Creek, and extended out into the Chippawa Channel of the upper river. An extensive emergent marsh is found at the mouth of Burnt Ship Creek and to the northeast along the transect, intermixing with wet meadow. Dominant plants in the emergent marsh include broad-leaf cattail, narrow-leaf cattail (*Typha angustifolia*), false-nettle (*Boehmeria cylindrica*), and swamp smartweed (*Polygonum coccineum*). Dominant plants in the wet meadow community included tussock sedge, mild water pepper (*Polygonum hydropiperoides*), spotted joe-pye-weed (*Eupatoriadelphus maculatus*), and blue vervain (*Verbena hastata*). The mouth of Burnt Ship Creek is less than 2 feet deep, with very slow-moving

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water, with small amounts of muskgrass. The marsh and the creek-mouth substrates are mucky. At the mouth, the bottom is heavily vegetated with muskgrass, common waterweed, and a variety of pondweed species. The main river off the creek mouth is less than 4 feet deep for about 500 feet, then rapidly drops off to about 10 feet deep. The substrate is mixed, with sediment ranging from silt to small cobble. Coarser components are more common further offshore. This area of the river is densely vegetated with SAV (predominantly wild-celery) and the water current is relatively strong.

Two transects (Transects 14 and 15, Appendix A) ran across Grass Island, one from the Grand Island shore (north-south) and the other parallel to the Grand Island shore (east-west). Grass Island is a very shallow, permanently watered shoal that lies in a sheltered reach of the upper river where water depth is less than 2 feet, and substrate is a mix of silt and sand. Bulrush and cattail (emergent species) dominate Grass Island. A relatively deep (up to 18 feet) channel with a densely vegetated bottom separates Grass Island from the Grand Island shore. SAV was also dense along Transect 15 in water 2-10 feet deep.

4.2.2 Upper Niagara River Tributaries

Habitat information was collected along three representative cross-sections in each of three major mainland tributaries to the upper Niagara River: Cayuga Creek, Tonawanda Creek, and Ellicott Creek (Appendix A). Transects were established within the zone of water level fluctuations in each creek.

Cayuga Creek is a relatively shallow water body with uniform depth, substrate, and channel width throughout the investigation area. Silt and sand were found to be the dominant substrates at each transect, although patches of coarser substrate were also present. Beds of SAV were intermittent, with none found along the middle transect. Along the upper transect, wild-celery dominated. Along the lower transect the SAV beds were sparse to moderate, with coontail and Eurasian water milfoil (*Myriophyllum spicatum*) present. Thalweg depths gradually decreased from 12 feet in the downstream sections to 4 feet at the upstream end without any abrupt changes. The average thalweg depth was 6 feet.

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Ellicott Creek is wider and somewhat deeper than Cayuga Creek, with depths greater than 8 feet measured at each transect. The substrate was muck and silt, with SAV beds occurring intermittently. No SAV was noted at the lower transect. At the middle transect, SAV occurred in narrow bands along both shores, and at the upper transect it was sparse. Coontail was the only SAV species identified in Ellicott Creek. A limited amount of EAV was observed along one shore of the middle transect. Thalweg depths gradually decreased from 16 feet in the downstream sections to 4 feet at the upstream end without any abrupt changes. The average thalweg depth was 10 feet.

Of the three major mainland tributaries of the upper river, Tonawanda Creek is the widest and deepest. Depths in excess of 15 feet were recorded along each transect. In general, the banks of Tonawanda Creek were steeper than either of the other creeks. The bottom was silt, although coarser material was encountered along the shores. SAV was relatively more abundant and the beds much denser in Tonawanda Creek than in Ellicott or Cayuga Creeks. The SAV beds were restricted to the nearshore area. SAV species noted include coontail, Eurasian water milfoil, and wild-celery. EAV was encountered along one shore at the upper transect. Thalweg depths in Tonawanda creek are maintained by the New York State Thruway Authority to allow navigation as part of the New York State Barge Canal system. Measured thalweg depths gradually decreased from 20 feet in the downstream sections to 15 feet at the upstream end without any abrupt changes. The average thalweg depth was 15 feet.

Five sample points were established within Twomile Creek, a relatively shallow stream that appears to be affected by both point and nonpoint-source run-off. In the downstream section, maples and willows were the dominant trees and there was little shrub or herbaceous vegetation, while the riparian vegetation of the upstream section was dominated by shrubs and upland herbs. At one of the five sample points, no SAV was noted in the channel. At the four other transects, five species of SAV were noted, with water star-grass (*Zosterella dubia*) being most abundant. SAV coverage ranged from zero to 75% in the survey reaches. The lower sections of the stream had a soft clay and muck bottom that gradated to a gravel-cobble-boulder mix further upstream. The water depth declined from over 4 feet at the mouth to less than one foot at the upstream extent of the investigation area. SAV was abundant even in these upstream areas where the water depths were <~1.5 feet. No EAV was observed in the Twomile Creek investigation area.

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The Beaver Island backwater channel is highly vegetated and with the exception of the areas underneath the two bridges and near the marina, SAV coverage was 90-100%. The areas under the bridges, devoid of vegetation, had cobble-pebble-gravel substrates, unlike the soft mucky clay bottom found elsewhere in the investigation area. The SAV comprised seven species, of which wild-celery, muskgrass, and common waterweed were most abundant. With the exception of the area beneath the two bridges (which was shallower), water depth was a uniform 2.5-3.5 feet. The riparian vegetation consisted of trees and shrubs with narrow bands of EAV, shrubs and wetland herbs.

Big Six Mile Creek is unique among the Grand Island tributaries in the fact that much of it is a dredged and maintained state marina. Shrubs, small trees, and some willows were dominant along the northeast side of the marina, while the southwest side was mostly mowed grass and bulkheads maintained for the marina. The SAV cover in most of the marina basin and downstream of it is moderate (30-50% cover), and consisted of six species. The most upstream portion of the investigation area was heavily vegetated (100% SAV cover) near the upstream end of the marina. The substrate in Big Six Mile Creek was predominantly clay and silt or muck, with areas of boulder-gravel-pebble mix. The depth of the dredged marina area (6-7 feet) was twice that of the region near the inlet.

The reaches of Woods Creek near the upper river were typically deeper, slower moving, and more highly vegetated with SAV than upstream sections, and had clay-mucky substrates. There were substantial beds of EAV, consisting of arrow arum (*Peltandra virginica*), pickerel-weed, and yellow pond lily (*Nuphar luteum*), along the lower reaches of Woods Creek. Progressing upstream, the SAV cover decreased to zero in most areas and the substrate became less organic. The declining SAV coverage may be attributable to the increasing riparian canopy coverage (more trees) as the bed width narrows, coarser substrates, and steeper streambed slopes that result in faster water velocities and scouring.

The downstream reaches of Gun Creek were slow moving with moderate to dense SAV. The substrate was silt and gravel near the mouth and comprised of finer substrates further upstream of the mouth. Along almost all of Gun Creek, the riparian vegetation was dominated by large oak trees that shade much of the creek. Gun Creek showed no EAV when the investigation was conducted in August 2002.

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Spicer Creek was also generally deeper and slower moving very near the upper river, but the area near the golf course was wider and deeper, functioning more like an impoundment than a creek. Downstream of East River Road, Spicer Creek was 1-2.5 feet deep, had gravel substrates near East River Road and sand and silt substrates near the mouth, and was bordered by tall stands of oak and willow trees with dense upland and herbaceous herbs. In the area very near the upper river, there was abundant SAV comprised of two species. Upstream of East River Road, Spicer Creek was composed of a large pond area (2-8 feet deep, 120 feet wide) that becomes narrower as it winds through a golf course. In the ponded area there was one area of moderate SAV growth with cattails scattered throughout.

4.2.3 Lower Niagara River

The bottom profile of the six transects in the investigation area in the lower river (Transects 16-21) was much steeper than in the upper river, with water depths reaching 18 feet within 400 feet of shore (Appendix A). Coarser substrates, including gravel, cobble, and boulder were dominant. In some areas, silts and sand were present as embedded material (fine materials filling interstitial areas between coarser substrates). Exposed bedrock was encountered at Fort Niagara (Transects 20 and 21). Hard clay was also documented near the Fort. SAV was sporadic along each transect, wild celery being the dominant species. Other species such as sago pondweed, slender naiad (*Najas flexilis*), Eurasian water milfoil, common waterweed, and water star-grass were also documented. Little EAV was observed, and no wetland areas were documented.

4.2.4 Lewiston Reservoir

Habitat information was collected along three transects in the Lewiston Reservoir, one on the northeast side (Transect 22), one on the southeast side (Transect 23) and one on the south side (Transect 24) (Appendix A). Information was collected when the reservoir was partially drawn down. The reservoir interior consists of steep-sided (dropping vertically about 45 feet over a linear distance of about 200 feet) riprap that extends down to a relatively flat bottom composed of hard packed clay, silt, and muck. SAV was observed along Transects 22 (the south transect) and 23 (the southeast transect). However, it was limited to an elevated area crossed by Transect 22, and a narrow, near-shore band

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crossed by Transect 23.. No SAV was documented along the south transect (Transect 24). Wild-celery, common waterweed, sago pondweed and Eurasian water milfoil were identified. The areas at the three transects were considered to be areas with little or no velocity. No EAV or wetland areas were encountered. Substrates on the bottom of the reservoir were primarily clay, mud, muck and silt.

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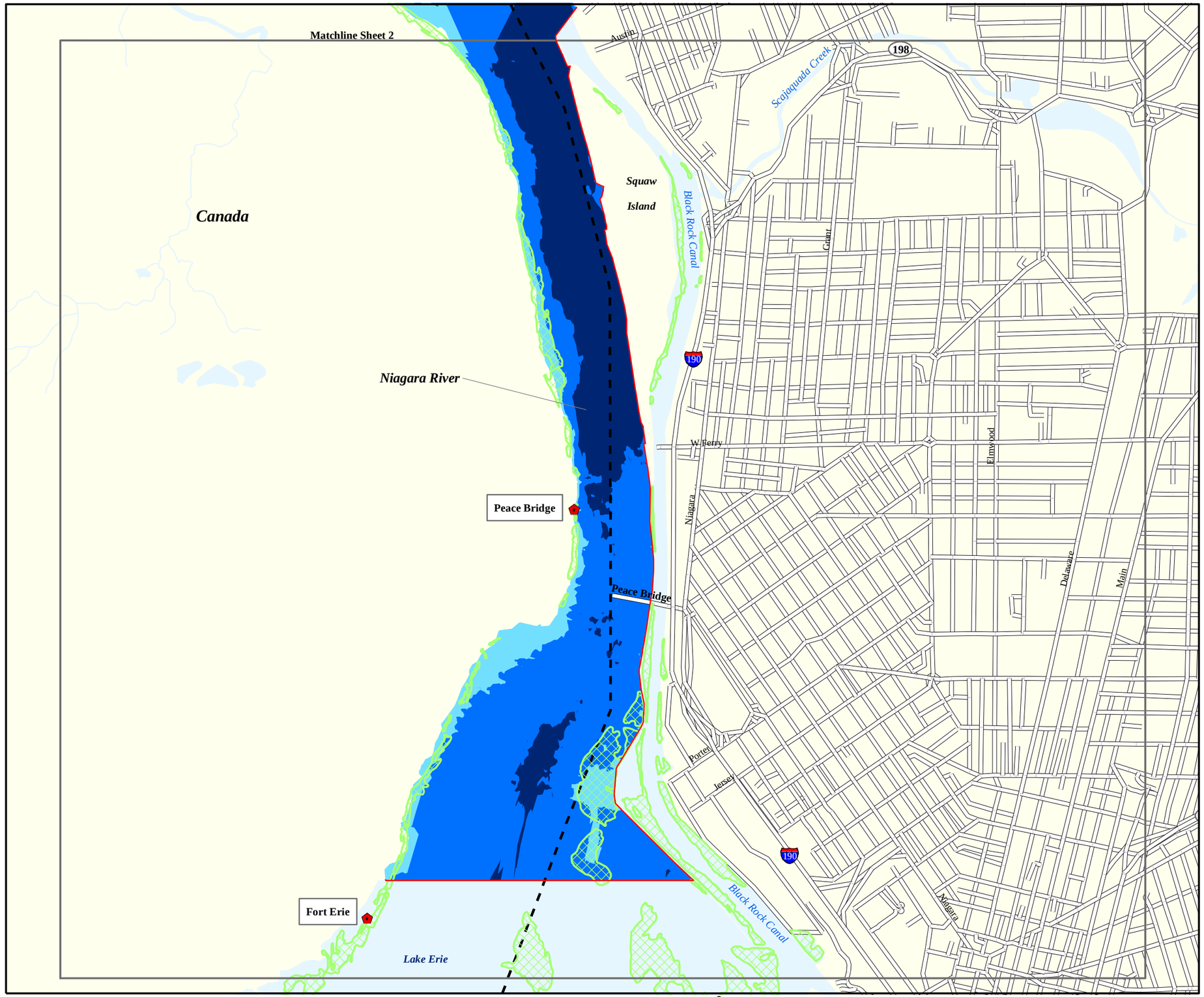

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

LEGEND

Water Depth at 50% Exceedance levels from a duration analysis of annual water elevation data

- Limit of Bathymetry Data
- < 6 feet
- 6 to 20 feet
- > 20 feet

- Submerged Aquatic Vegetation (SAV)
- Emergent Aquatic Vegetation (EAV)
- Water Gauge
- International Boundary

Data Sources:
The Bathymetry used to develop water depth is based on several sources (USACE, TVGA, and others) with different map accuracy. EAV, SAV, and Lentic data provided by Stantec

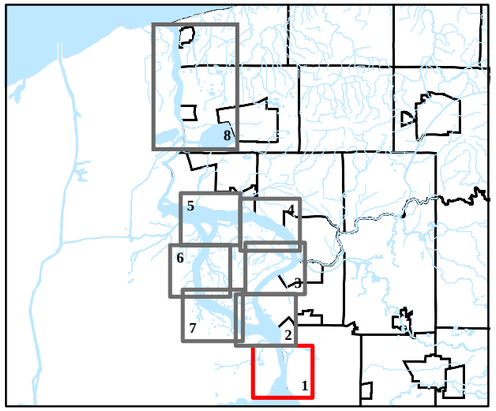

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FIGURE 4.1.1-1

0 1,000 2,000 4,000 Feet

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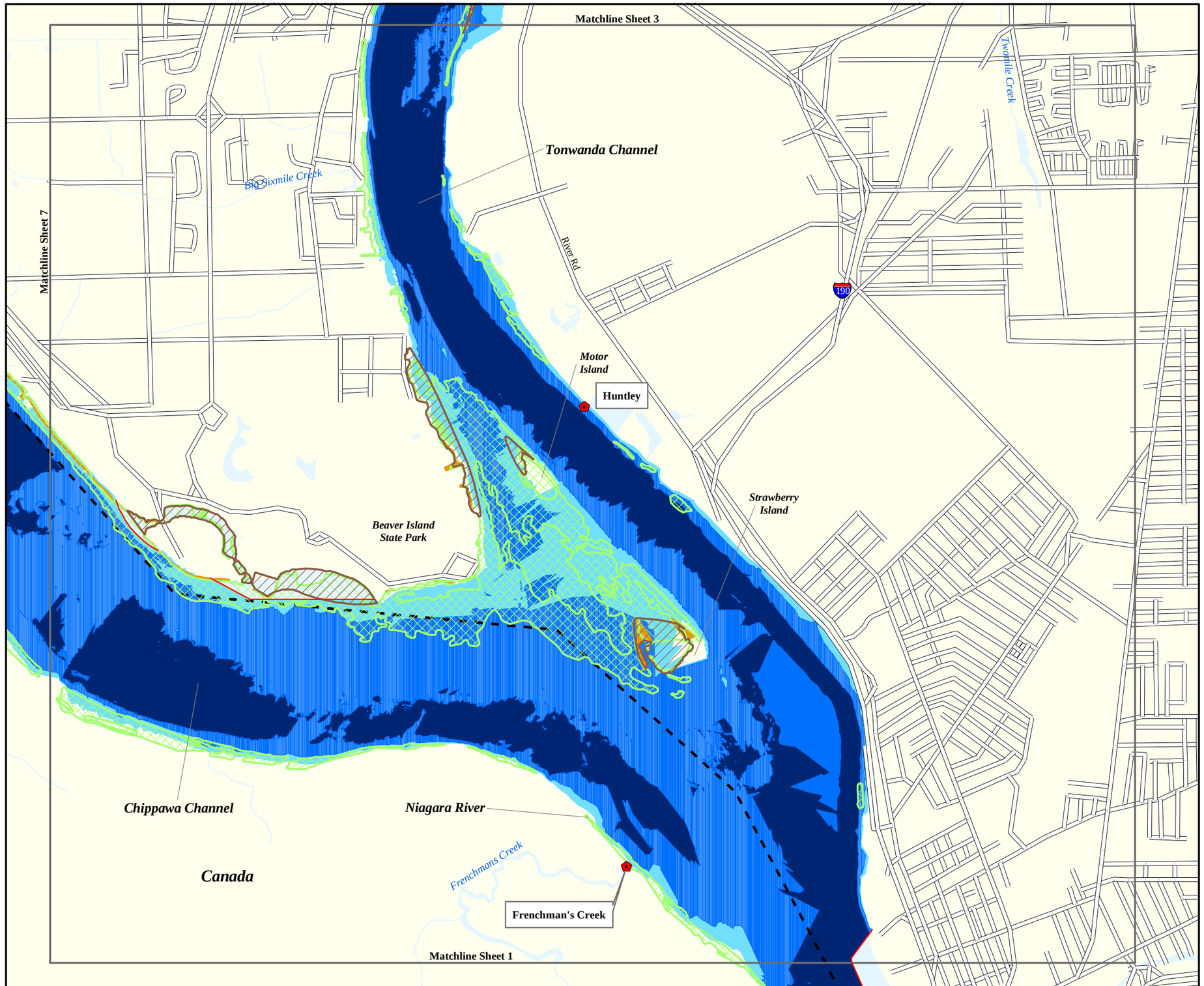

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

LEGEND

Water Depth at 50% Exceedance levels from a duration analysis of annual water elevation data

- Limit of Bathymetry Data
- < 6 feet
- 6 to 20 feet
- > 20 feet

- Little or No Velocity Habitat
- Submerged Aquatic Vegetation (SAV)
- Emergent Aquatic Vegetation (EAV)
- Water Gauge
- International Boundary

Data Sources:
The Bathymetry used to develop water depth is based on several sources (USACE, TVGA, and others) with different map accuracy. EAV, SAV, and Lentic data provided by Stantec

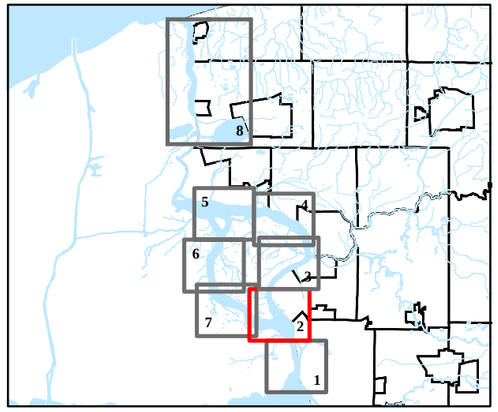

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FIGURE 4.1.1-2

0 1,000 2,000 4,000 Feet

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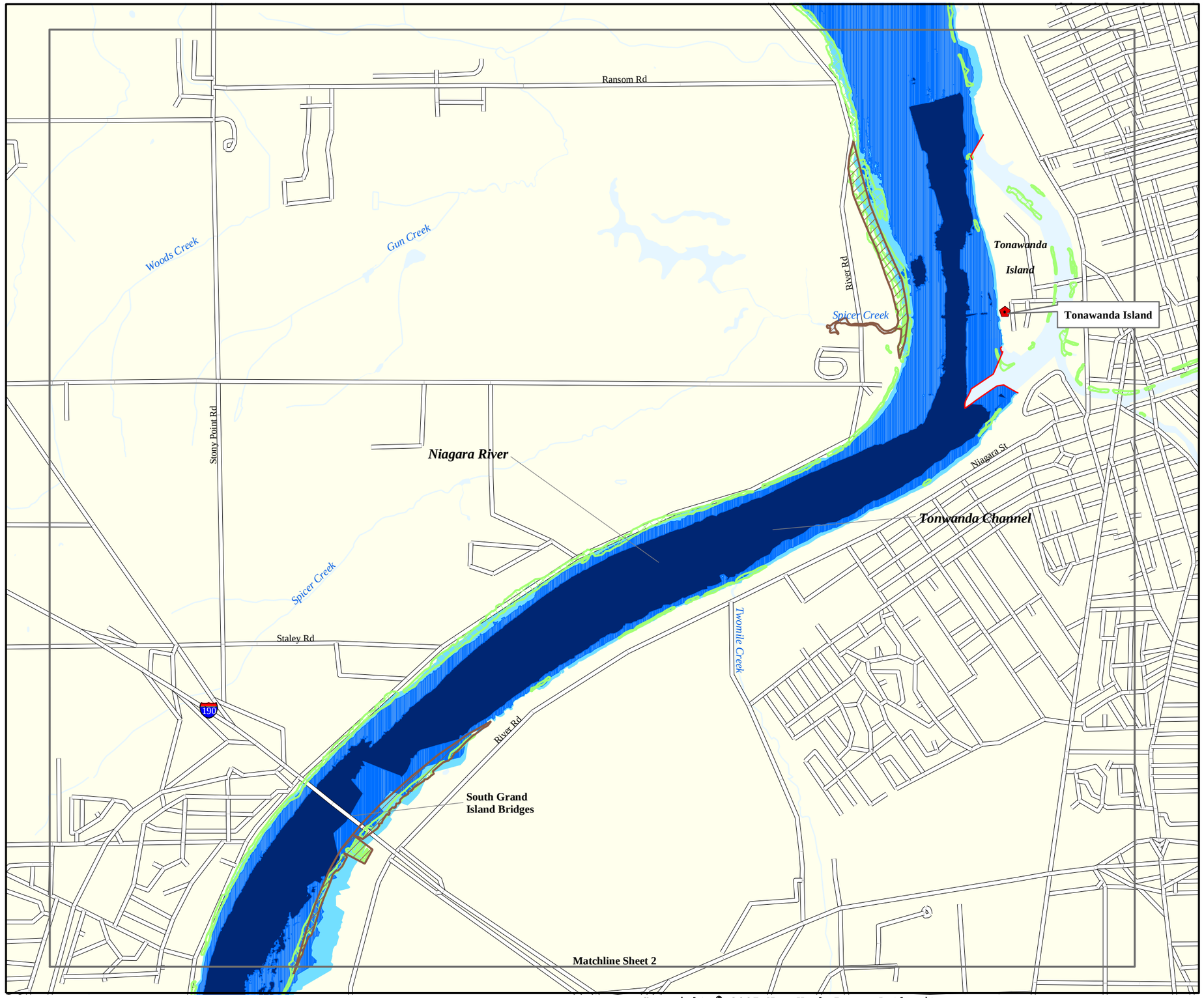

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

LEGEND

Water Depth at 50% Exceedance levels from a duration analysis of annual water elevation data

- Limit of Bathymetry Data
- < 6 feet
- 6 to 20 feet
- > 20 feet

- Little or No Velocity Habitat
- Submerged Aquatic Vegetation (SAV)
- Emergent Aquatic Vegetation (EAV)
- Water Gauge
- International Boundary

Data Sources:
The Bathymetry used to develop water depth is based on several sources (USACE, TVGA, and others) with different map accuracy. EAV, SAV, and Lentic data provided by Stantec

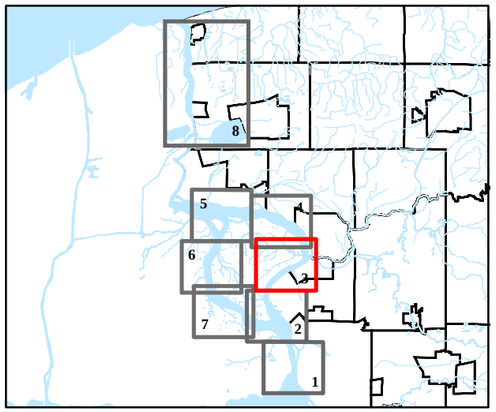

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FIGURE 4.1.1-3

0 1,000 2,000 4,000 Feet

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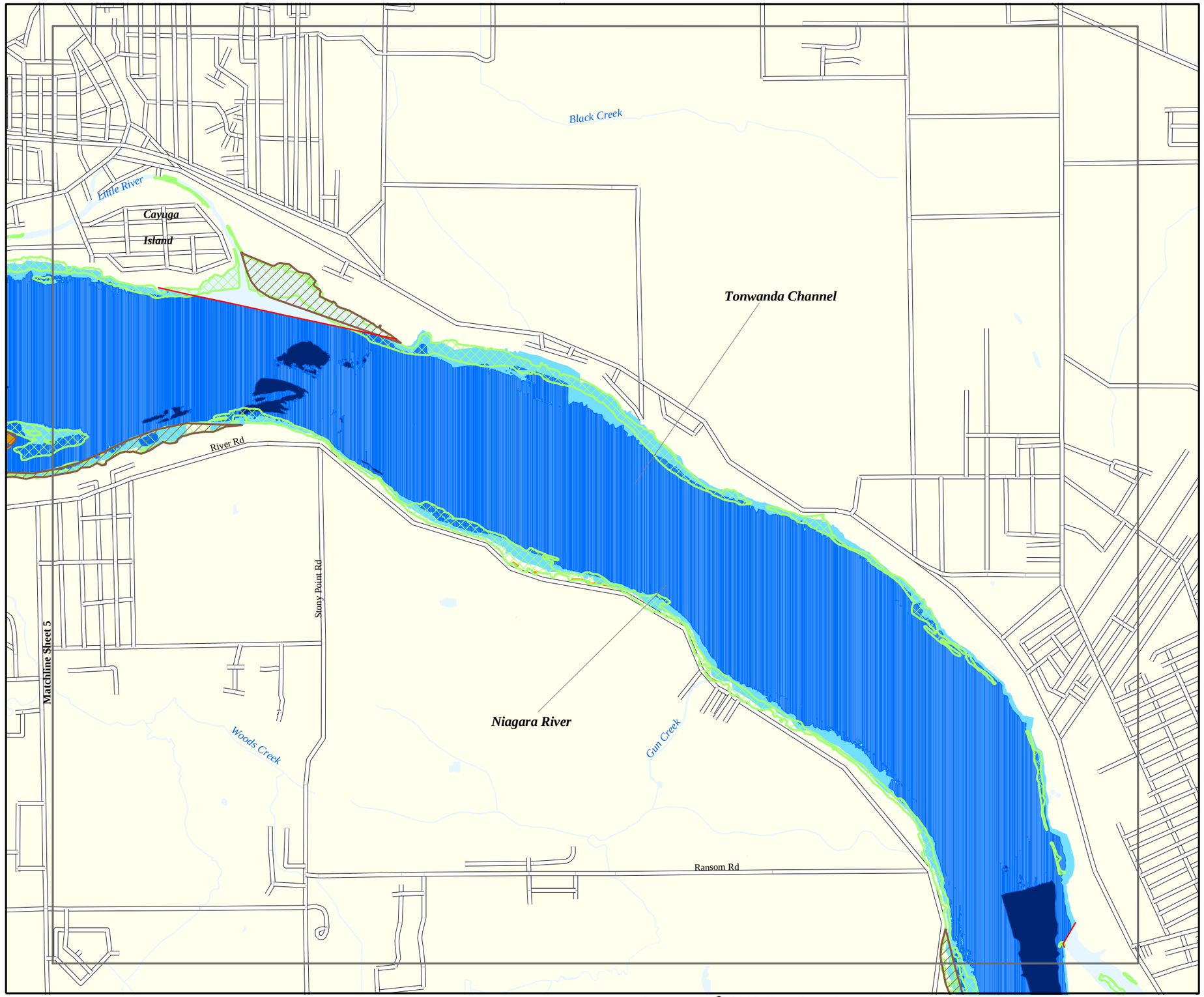

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

LEGEND

Water Depth at 50% Exceedance levels from a duration analysis of annual water elevation data

- Limit of Bathymetry Data
- < 6 feet
- 6 to 20 feet
- > 20 feet

- Little or No Velocity Habitat
- Submerged Aquatic Vegetation (SAV)
- Emergent Aquatic Vegetation (EAV)
- Water Gauge
- International Boundary

Data Sources:
The Bathymetry used to develop water depth is based on several sources (USACE, TVGA, and others) with different map accuracy. EAV, SAV, and Lentic data provided by Stantec

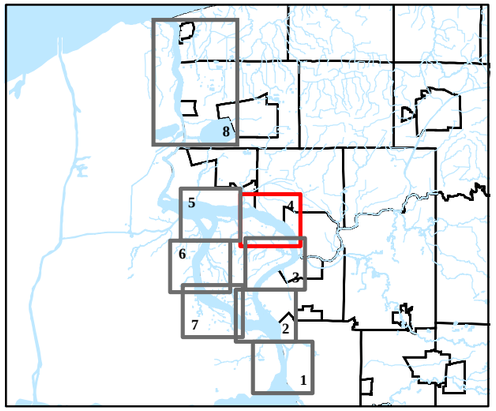

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FIGURE 4.1.1-4

0 1,000 2,000 4,000 Feet

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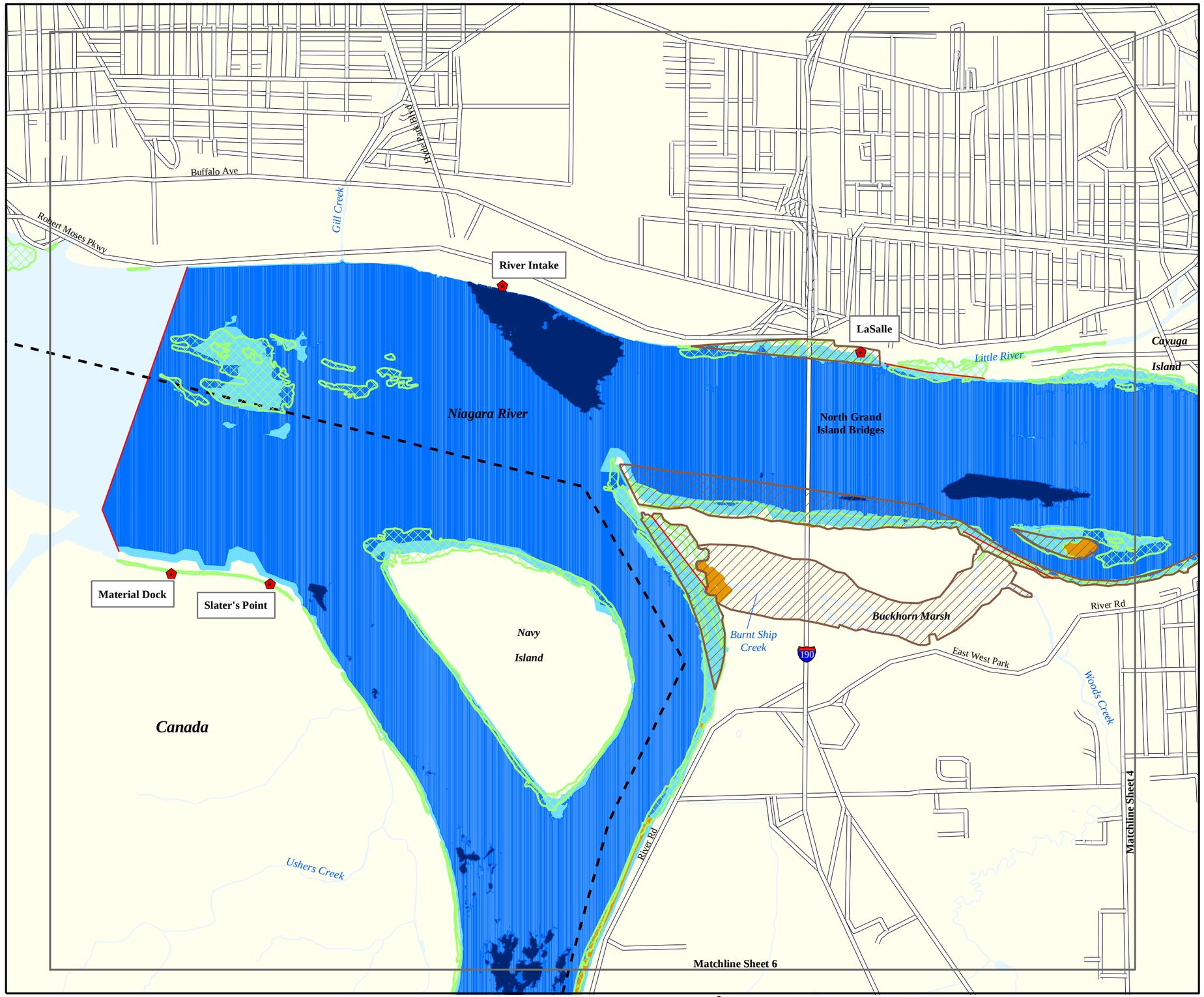

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

LEGEND

Water Depth at 50% Exceedance levels from a duration analysis of annual water elevation data

- Limit of Bathymetry Data
- < 6 feet
- 6 to 20 feet
- > 20 feet

- Little or No Velocity Habitat
- Submerged Aquatic Vegetation (SAV)
- Emergent Aquatic Vegetation (EAV)
- Water Gauge
- International Boundary

Data Sources:
The Bathymetry used to develop water depth is based on several sources (USACE, TVGA, and others) with different map accuracy. EAV, SAV, and Lentic data provided by Stantec

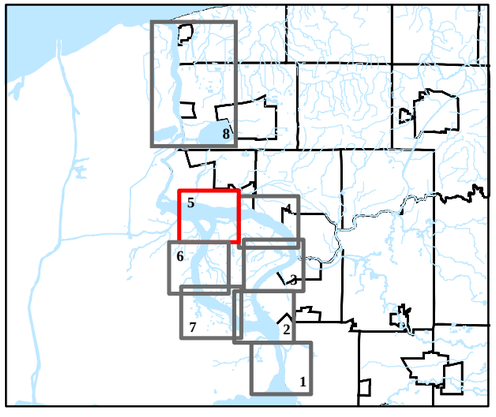

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FIGURE 4.1.1-5

0 1,000 2,000 4,000 Feet

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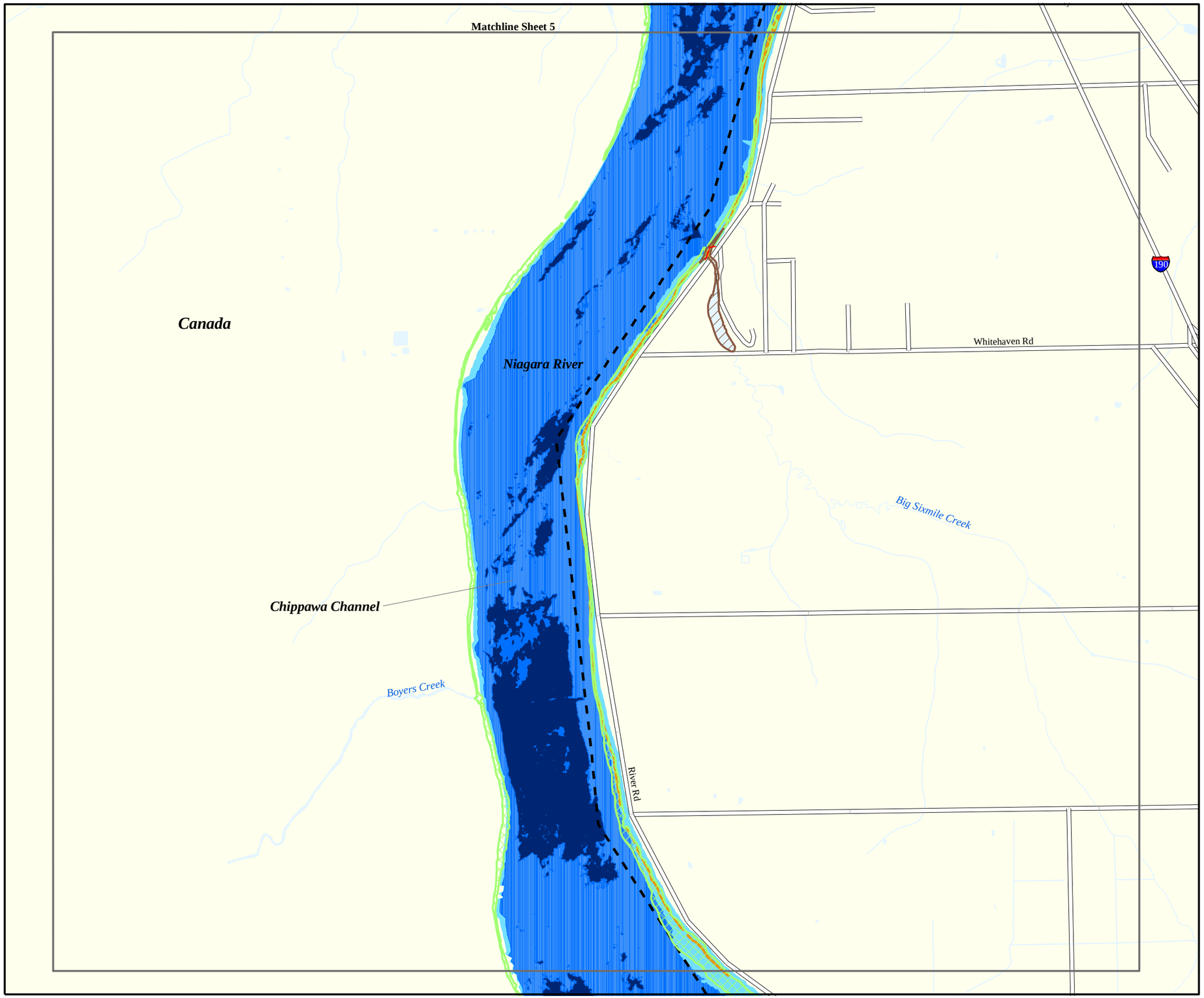

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

LEGEND

Water Depth at 50% Exceedance levels from a duration analysis of annual water elevation data

- Limit of Bathymetry Data
- < 6 feet
- 6 to 20 feet
- > 20 feet

- Little or No Velocity Habitat
- Submerged Aquatic Vegetation (SAV)
- Emergent Aquatic Vegetation (EAV)
- Water Gauge
- International Boundary

Data Sources:
The Bathymetry used to develop water depth is based on several sources (USACE, TVGA, and others) with different map accuracy. EAV, SAV, and Lentic data provided by Stantec

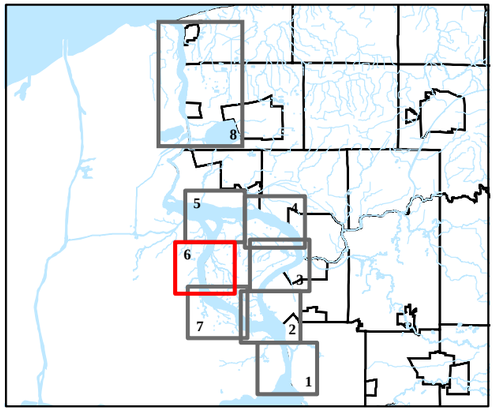

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FIGURE 4.1.1-6

0 1,000 2,000 4,000 Feet

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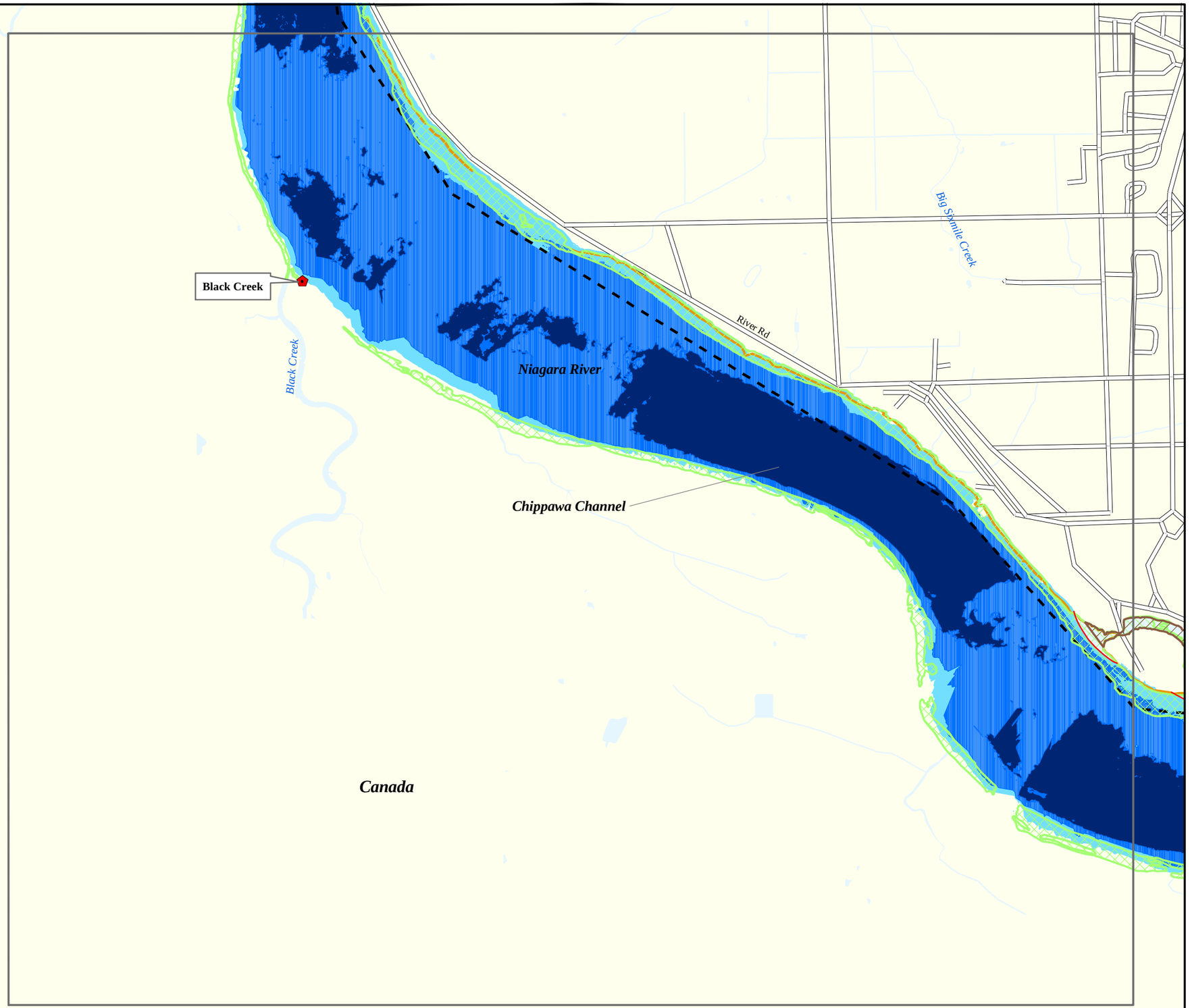

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

LEGEND

Water Depth at 50% Exceedance levels from a duration analysis of annual water elevation data

- Limit of Bathymetry Data
- < 6 feet
- 6 to 20 feet
- > 20 feet

- Little or No Velocity Habitat
- Submerged Aquatic Vegetation (SAV)
- Emergent Aquatic Vegetation (EAV)
- Water Gauge
- International Boundary

Data Sources:
The Bathymetry used to develop water depth is based on several sources (USACE, TVGA, and others) with different map accuracy. EAV, SAV, and Lentic data provided by Stantec

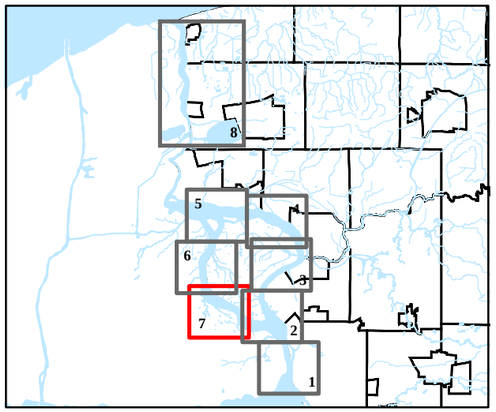

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FIGURE 4.1.1-7

0 1,000 2,000 4,000 Feet

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This material is contained in:
Volume 2
Section: Effect of Water Level and Flow Fluctuations on Aquatic and Terrestrial Habitat

FIGURES 4.1.1-1 TO 4.1.1-8

WATER DEPTH ZONES, AREAS WITH LITTLE OR NO VELOCITY, AND SUBMERGED AQUATIC VEGETATION DISTRIBUTION IN THE INVESTIGATION AREA

Figure 1 in pdf format

Figure 2 in pdf format

Figure 3 in pdf format

Figure 4 in pdf format

Figure 5 in pdf format

Figure 6 in pdf format

Figure 7 in pdf format

Figure 8 **[NIP – General Location Maps]**

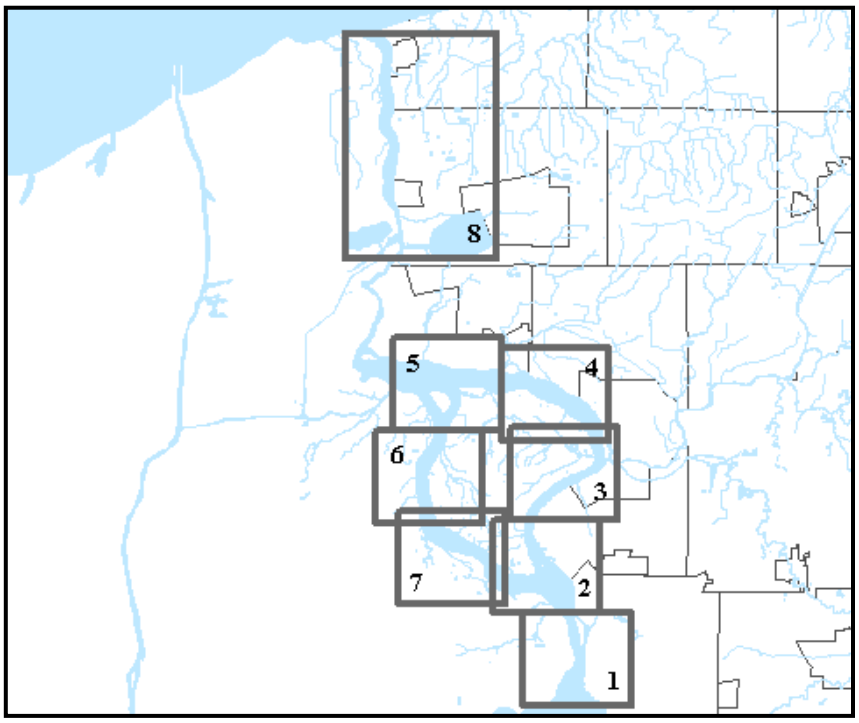

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FIGURE 4.1.3-1

DOMINANT SUBSTRATES OF THE INVESTIGATION AREA

[NIP – General Location Maps]

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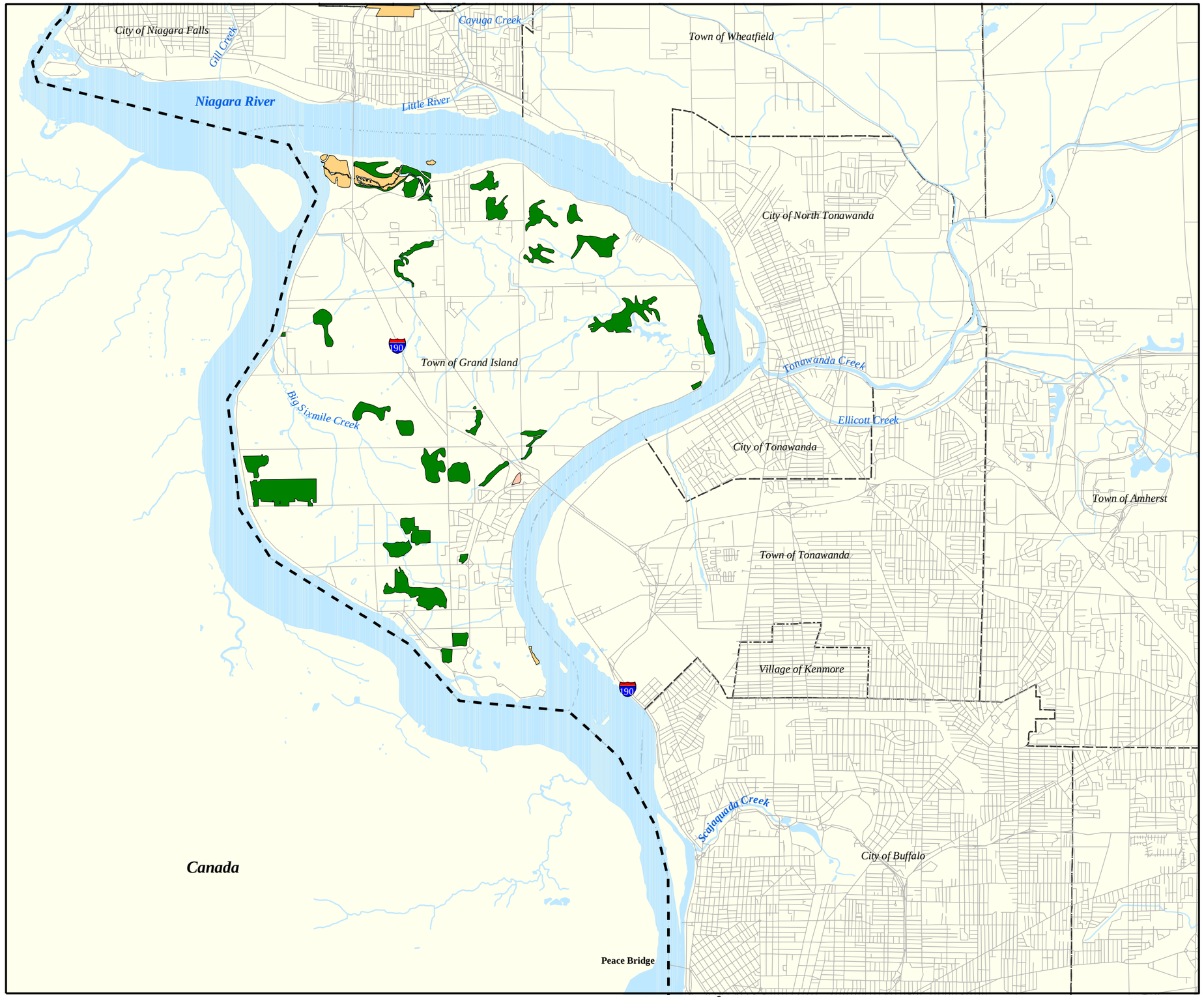

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

Wetlands of the Upper Niagara River

LEGEND

Wetlands
- Emergent Wetland
- Forested Wetland
- Scrub-Shrub Wetland

- International Boundary
- Municipal Boundary

Wetlands were delineated from April 1999 aerial photographs

Wetland habitat assignments were based on the Classification of Wetlands and Deepwater Habitats of the U.S.

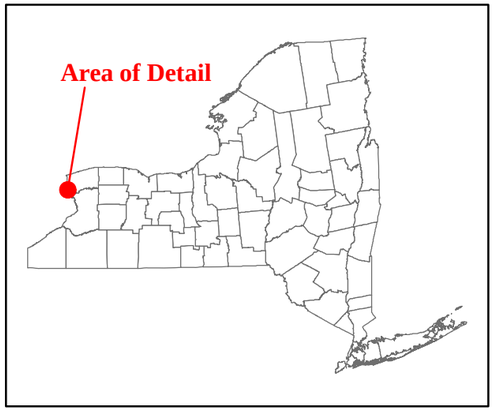

FIGURE 4.1.5-1

N

0 3,500 7,000 14,000 Feet

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Section: Effect of Water Level and Flow Fluctuations on Aquatic and Terrestrial Habitat

FIGURE 4.1.5-2

WETLANDS OF THE LOWER NIAGARA RIVER

[NIP – General Location Maps]

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5.0 POTENTIAL EFFECTS OF WATER LEVEL AND FLOW FLUCTUATIONS ON HABITATS AND SPECIES

Section 5.1 discusses water depth zones, areas of little or no velocity, substrates, SAV, wetlands including EAV, and upland shore communities. Sections 5.2 and 5.3 discuss aquatic focus species and wildlife focus species, respectively. Because there are substantial physiographic differences between the upper river, lower river, and Lewiston Reservoir, the potential effects of water fluctuations on habitats are broken down by region, where applicable.

5.1 Potential Effects of Water Level and Flow Fluctuations on Habitats

The evaluation of potential effects of water level and flow fluctuations focused on aquatic and terrestrial habitats located within zones of potential effect identified for the transects. For the purpose of this investigation, the zones of potential effect were determined to lie between non-significant storm maximum and minimum water levels for each month within a year in the upper river and between the absolute maximum and minimum water levels recorded in the lower river in 2002 and Lewiston Reservoir from 1991-2002 (as discussed in Section 3.3.1, and Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3).

The vertical span of the zone of potential effect was generally <2 feet for all areas of the upper Niagara River (Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3), although there were several months within a year in which the difference between monthly maximum and minimum water elevations was >2 feet. However, the largest difference between monthly maximum and minimum water elevations was 2.69 feet at the Tonawanda gauge in April 1995 (larger differences were recorded at the Fort Erie gauge, but this gauge is outside (upstream) of the investigation area), nearly all monthly differences were < 2.5 feet, and there were many months in which the difference was <1.5 feet (e.g., Black Creek, Tonawanda Island, Huntley Station and Frenchman's Creek gauges in 2001). The vertical span of the zone of potential affect for the lower Niagara River (from the Project's tailrace to the mouth of Lake Ontario) was generally < 2 feet, although there were several months in 2002 in which the water level fluctuations were 2 - 2.63 feet

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(Table 2.2.2-1). The vertical span of the zone of potential effect for the Lewiston Reservoir is approximately 39 feet. It is important to note that the zones of potential effect are conservative estimates of the potential effects of NYPA and OPG operations for the upper and lower river because water level fluctuations are due to a combination of influencing factors (Section 3.3.1). The influence of these factors on water levels is interrelated and dynamic. Because the water level in the Niagara River at any location at any time is a complex function of natural and manmade factors, distinguishing the exact amount of water level fluctuation attributable to each factor is difficult. In Lewiston Reservoir, the zone of potential effect is entirely due to operation of the Niagara Power Project.

The following sections describe the potential effects from water level fluctuations on nearshore habitats.

5.1.1 Water Depth Zones

The breadth of water depth zones in any given area is determined by topography and bathymetry. In relatively flat areas, water depth zones occur as fairly broad bands. In areas with steep banks and bathymetry, water depth zones occur as narrow bands. This distribution ultimately affects the distribution and abundance of other habitat features such as SAV, EAV and other wetlands, as discussed in Sections 5.1.4 and 5.1.5.

Water level fluctuations cause temporal shifts in water depth zones as water levels rise and fall. As water levels rise, the depth zones shift in position upslope. Conversely, as water levels fall, these zones shift downslope. This movement results in temporal changes in the relative extent of each water depth zone, with the greatest changes occurring in areas with gentle nearshore slopes. In such areas, relatively small vertical fluctuations can affect relatively broad bands of nearshore habitat. This movement may also result in temporal changes in the availability of aquatic habitat features (e.g., substrate types, SAV presence or absence) within each depth zone to fish and aquatic/semi-aquatic wildlife.

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5.1.1.1 Upper Niagara River and Tributaries

The physiography of the upper river has a strong influence on the amplitude of water level fluctuations that occur there. The broad river bed, with water spread over a relatively wide area, attenuates water level fluctuations. Therefore, large variations in river flow affect river width more than water depth, with the effects focused near shorelines (i.e., shallow nearshore habitats).

Based on non-significant storm water elevation data, the zone potentially affected in the upper river was <2.5 feet (typical difference between monthly maximum and minimum water level elevations). Therefore, the direct effect of water level on aquatic habitats in the upper river is focused primarily in the 0 to 2-foot water depth zone, with little direct effect in the 2 to 6-foot zone (only in the shallowest 0.5 feet), and no direct effect in the 6 to 20-foot and >20-foot water depth zones.

The 0 to 6-foot water depth zone occurs as fairly broad bands along the shore of the upper river due to the low gradient throughout most of this area (see Figures 4.1.1-1 to 4.1.1-8). The 0 to 2-foot water depth zone exists within this 0 to 6-foot zone. As a result of the gentle slope, water level fluctuations have the potential to cause relatively large changes in the horizontal location and relative extent of this 0 to 2-foot water depth zone.

Near the mouths in all tributaries, water depths are generally 2-6 feet deep. Therefore, in these areas only the top two feet of the water column is affected by water level fluctuations and there is watered habitat below the zone of fluctuation. However, the Beaver Island Backwater and the area of Spicer Creek that is downstream of East River Road are generally shallow (1-2.5 feet), thus the aquatic habitat there would likely be affected more so than that in the other tributaries or the area in Spicer Creek that is upstream of East River Road. Farther upstream in all the Grand Island tributaries and in Twomile Creek, the depths generally range from ~1-3 feet deep.

Throughout the field effort for this investigation, which occurred from May to October, large dewatered areas of the Grand Island tributaries and Twomile Creek were not observed. It is possible that,

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as water levels in the upper Niagara River decrease, there is enough flow from the creeks themselves that there are no large dewatered areas even in the shallower sections upstream where the water depths are generally ~1-3 feet. It is also possible that these upstream sections are less influenced by upper Niagara River water elevations than the downstream sections near the mouths.

5.1.1.2 Lower Niagara River

In contrast to the upper river, the physiography of portions of the lower river magnifies water level fluctuations. The lower river flows through approximately 1.4 miles of narrow gorge between the Robert Moses tailrace and Artpark. In this area, a change in flow affects water depth more than river width. Water levels downstream of Artpark fluctuate less because the river is wider throughout this reach and is subject to a backwater effect from Lake Ontario (URS et al. 2005a).

Based on gauge data, the zone potentially affected by water level fluctuations is generally <2.5 feet (Table 2.2.2-1). Therefore, water level fluctuations in the lower river downstream of the Robert Moses tailrace can affect aquatic habitats in the 0 to 2-foot and the 2 to 6-foot water depth zones. Water level fluctuations have no direct effect on aquatic habitats in the 6 to 20-foot and the >20-foot water depth zones.

The 0 to 6-foot water depth zone occurs as very narrow bands along the shore of the lower river in the reach between the Robert Moses tailrace and Artpark where the bottom slopes steeply from the shore (see Figure 4.1.1-7). The 0 to 2-foot water depth zone exists within this 0 to 6-foot zone. In the reach below Artpark, the bands associated with these depth zones are wider (see Figure 4.1.1-8), although considerably narrower than those in the upper river. As a result of the relatively steep slope, water level fluctuations cause small to moderate changes in the horizontal location and relative extent of these shallow-water zones.

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5.1.1.3 Lewiston Reservoir

Water levels in the Lewiston Reservoir are subject to daily and weekly drawdown and recharge schedules, resulting in large daily and seasonal water level fluctuations. The zone potentially affected by water level fluctuations is 39 feet (Table 2.2.2-1), based on 1991-2002 gauge data. Therefore, water level fluctuation in the Lewiston Reservoir have the potential to directly affect aquatic habitats in the 0 to 20-foot and the >20-foot water depth zones. In fact, much of the >20-foot water depth zone is converted to 0 to 20-foot zone during low water periods.

5.1.2 Areas of Little or No Velocity

Distinctions between areas with little or no velocity and those with velocity are based on the relative degree of water flow. Areas with little or no velocity include protected nearshore areas, embayments, and areas located downstream of velocity shelters such as islands and points. Water level and flow fluctuations of the magnitude documented for the investigation area have little effect on the boundaries between areas with little or no velocity and areas with velocity. However, the extent of areas with little or no velocity decreases slightly as water levels fall and increases slightly as water levels rise because most of these areas that are present within the investigation area are associated with nearshore areas (see Section 4.1.2 and figures in Figure 4.1.1-1 – 4.1.1-8) and the extent of nearshore areas is affected most by water level fluctuations (see Section 5.1.1). Therefore, water level fluctuations potentially affect the extent of areas of little or no velocity in the upper and lower rivers, causing slight decreases in extent as water levels fall and slight increases in extent as water levels rise.

5.1.3 Substrates

Based on field observations during the habitat characterization surveys, the typical substrates encountered within the 0 to 2-foot water depth zone and unvegetated shore communities (i.e., the “splash zone”) consist of sand and coarser particles. These observations are consistent with a literature account that erosion and sorting of littoral sediments in wave-mixed zones typically contribute to the formation of

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a zone of coarser sediments on the surface (Carpenter and Lodge 1986). However, sites within the investigation area protected from waves and other erosive forces, such as the open water area surrounded by Strawberry Island (Transect 2, Appendix A) and the mouth of Spicer Creek (Transect 9, Appendix A), do not experience this degree of erosion within the 0 to 2-foot depth zone. Finer materials (e.g., silt, muck) were typically observed in such protected areas.

Ice typically forms near the shore and in other areas with little or no flow in the investigation area during average and colder than average winters. In Lake St. Lawrence and other locations on the Great Lakes, ice formation has been identified as a potential cause of erosion in nearshore areas through bottom freezing and lifting and transporting of finer sediments and vegetation during ice breakup (Maynard and Wilcox 1996; Duke et al. 2001). This typically occurs when water levels are at much lower elevations during the winter months, ice extends to the bottom in some areas of shallow water, and water levels are then increased during ice breakup. Based on professional judgment during the collection of data along the transects, ice-induced erosion does not seem to occur extensively in the Niagara investigation area and appears to have the potential to affect only narrow bands of very shallow water along some shorelines. Bottom freezing and lifting is likely not widespread because median water levels decrease little during winter months (i.e., the non-tourist season) of 1991-2002 (typically <0.5 feet, based on Figures 4.3.1-4 through 4.3.1-11 in URS et al. 2005a) and median daily water level fluctuations are smallest during the non-tourist season (<0.5 feet, as shown in Table 2.2.1-1), which ends on April 1 of every year. Therefore, in most years ice breakup has already occurred before water level fluctuations increase (tourist season) and the opportunity for freezing, lifting, and transport of finer sediments and vegetation to occur is limited. A more substantial effect from ice may occur when ice floes travel down the river. Ice floes may uproot persistent emergent plants (e.g., cattails) and scrape sediments, causing moderate disturbance to substrates in some exposed nearshore areas.

In general, water level fluctuations affect the area exposed to waves, ice floes, boat wakes, and storm surges, and therefore affect substrate distribution in the littoral zone. Water level fluctuations are not a driving or causal factor of erosion; but water levels do determine where erosive forces will be focused (Baird 1999). With fluctuating water levels, the erosive forces may act on different areas of the

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littoral zone, depending upon the water level at the time these forces are acting. As a result, the substrates exposed most to fluctuating water levels and the associated erosive forces in the investigation area are sand and coarser particles, except in protected areas where finer sediments may predominate.

5.1.4 Submerged Aquatic Vegetation

As described in Section 3.1.1, the depth zones are defined as related to the water depth at the median water elevation. This definition provides for a very conservative estimate of the effects of water level fluctuations on habitat because the minimum and maximum water elevations generally straddle the median water elevation (i.e., water levels generally fluctuate around the median elevation, not from the median elevation down to the minimum water elevation in a given month. This definition is important to understand particularly when evaluating effects on SAV distribution, as water elevations are generally above the depth at which SAV is established (based on data collected at the transects).

In general, water level fluctuations have the potential to affect SAV both directly and indirectly. Fluctuations may directly affect the survival of submerged aquatic plants if they cause exposure and desiccation or, in contrast, extended flooding to excessive depths. Although some species can tolerate exposure to air for brief periods (i.e., hours to days), frequent or prolonged exposure will limit their survival and distribution, and could lead to changes in species composition. Frequent or prolonged flooding by deep water limits SAV growth through lack of sufficient light penetration for photosynthesis, but if this occurs in the upper Niagara River, it would only occur in areas at the deepwater extent of SAV establishment (~20 feet deep). Because the water level fluctuations are almost always <2.5 feet in all areas of the upper river (URS et al. 2005a), it is likely that SAV growth is not limited in deep water by water level fluctuations.

Water level fluctuations can potentially affect SAV distribution indirectly by altering erosive forces and their potential effects on plants and substrates. The areas most likely to be affected are the upper (shallow) extent of SAV, which is usually separated from shore by an unvegetated zone, along unprotected shorelines. Energy associated with waves along unprotected shorelines may be the most

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transects were located in exposed areas that may be subjected to relatively high degrees of erosion. Overall, the extent of the unvegetated zone is comparable between the upstream and downstream reaches of the upper river despite the fact that the seasonal and daily water level fluctuation patterns vary considerably between those areas.

These findings are similar to those reported from a field survey of the upper river completed by the U.S. Bureau of Biological Survey and Bureau of Fisheries (Eldredge 1955), in cooperation with the New York State Conservation Department (NYSCD). The survey was carried out in support of evaluations of potential effects that may result from construction of the Niagara Power Project. That survey focused primarily on the distribution of wild-celery because of its importance to fish and wildlife. In 1955, wild-celery occurred primarily at depths of 1.5-5.5 feet. It was also found in water <1.5 feet, but only in the most sheltered bays. It was not indicated what the water level was during the time of the 1955 survey. No field observations were made by Eldredge in the vicinity of Transects 1 and 5, where unvegetated areas were found to a depth of approximately 4 feet in 2002. The 1955 survey determined that, among other factors, strong wave action precluded the growth of wild-celery and most other SAV species in shallow water (Eldredge 1955). A survey conducted by the New York State Conservation Department in 1928 (NYSCD 1929) also found SAV distributed in the same areas as in 1955 and 2002. Although the water depths at which the SAV occurred in 1928 are not reported, the fact that they existed in the same areas as in 1955 and 2002 indicates that the water depths are likely similar for all years (although SAV also occurred in water depths up to about 20 feet in 2002). Species composition was slightly different in each year, but *Potamogeton* species and wild-celery were the dominant species in all years.

Water level fluctuations directly affect the 0 to 2-foot water depth zone of the upper river (see Section 5.1.1). Since most SAV occurs mostly in waters >2 feet deep in the upper river (often due to strong wave action and unsuitable substrate for establishment of SAV in shallower water), SAV distribution in the shallow areas is not likely to be directly affected by water level fluctuations. While water level fluctuations do not directly affect deeper zones (i.e., 2-6 feet and 6-20 feet), they may cause

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slight shifts in the locations of water depth zones (Section 5.1.1) and therefore may have a very limited influence on the distribution and abundance of SAV.

SAV is present in the Grand Island tributaries in water >~2 feet deep, and is often in dense stands at water depths >~2.5 feet (Transect 9, mouth of Spicer Creek, Transect 13, Woods Creek, Section 4.2.2). SAV is also abundant to moderately dense at depths ~0.5-1.5 feet in the upstream areas of these tributaries where water level fluctuations occur. These areas are likely not subjected to erosive forces as strong as those near the mouths of the tributaries. The general presence of SAV in the upper river tributaries at water depths that are similar to those of the upper river indicate that SAV distribution is not likely affected by water level fluctuations in the upper river.

5.1.4.2 Lower Niagara River

The occurrence of SAV is limited in the lower river, due primarily to the steep topography/bathymetry and the resulting narrow width of the littoral zone. Based on transect data, the unvegetated zone separating SAV from the shoreline in the lower river below the Robert Moses tailrace typically occurs in water depths ranging between zero and 3 feet (see Transects 16-20 in Appendix A). Overall, the extent of the unvegetated zone is comparable between these five transects.

Water level fluctuations affect the 0 to 2-foot and 2 to 6-foot water depth zones in the lower river downstream of the Robert Moses tailrace where SAV occurs (see Section 5.1.1.2). Since SAV occurs at water depths of ~3 to 20 feet in that area, SAV in the very shallowest areas (<2.5 – 3 feet) is potentially affected by water level fluctuations. While water level fluctuations do not directly affect deeper zones containing SAV (i.e., 6-20 feet), they cause slight shifts in the locations of water depth zones and therefore may have a very limited influence on the distribution and abundance of SAV. A 1928 survey of the lower river (NYSCD 1929) found that SAV was uniformly distributed in the nearshore area at depths of 3-13 feet, which is similar to that found in 2002 (although SAV occurred to depths up to ~20 feet in 2002).

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5.1.4.3 Lewiston Reservoir

The presence of SAV was documented along two Lewiston Reservoir transects (Transects 22 and 23). SAV occurred as isolated beds with sparse to moderate plant density (Appendix A). The dominant plants were identified as clasping-leaf pondweed, common waterweed, and Eurasian water milfoil. The SAV occurs primarily in the northeastern portion of the reservoir (Transect 22) in an area that is dewatered during periods of very low water (approximately the 95% exceedance level, generally each week on Thursday or Friday during tourist season) and flooded with about 20 feet of water during periods of very high water (approximately the 5% exceedance level). This suggests that the large swings in water level that are characteristic of the reservoir have acted to inhibit extensive establishment of SAV, such that it is restricted to a few small areas that provide marginal habitat in terms of the water depth requirements for these plants. The sides of the reservoir are composed of large boulder riprap, which is not suitable habitat for SAV establishment.

5.1.5 Wetlands (Including Emergent Aquatic Vegetation)

The assessment of the potential effects of water level fluctuations on wetlands (including EAV along the shoreline of the Niagara River) was restricted to wetlands that occur below the upper limit of influence from water level fluctuations (i.e., approximately the 5% exceedance water level, as described in Section 3.1.5). These wetlands, which are commonly referred to as Great Lakes coastal wetlands, are typically emergent marsh communities in the investigation area (for example, see the cross-sectional drawing for Transect 9 in Appendix A). Emergent marshes are the most prevalent wetland type in coastal wetlands, since emergent vegetation can tolerate the large short and long-term fluctuations in water levels that occur in the Great Lakes (Maynard and Wilcox 1996). Wetlands located above the upper limit of influence (i.e., approximately the 5% exceedance water level) are commonly composed of forested and scrub-shrub wetland communities (for example, see the cross-sectional drawing for Transect 10 in Appendix A). Wetlands dominated by trees or shrubs are found along the upland margin of coastal wetlands because the woody vegetation that characterizes them cannot tolerate the extensive flooding regimes of the Great Lakes (Maynard and Wilcox 1996). Surface water level fluctuations have little or no

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effect on these wetlands. Infrequent flooding when Niagara River water levels are very high typically does not harm the trees and shrubs that dominate these communities as they are adapted to tolerate short duration flooding, especially during the winter dormancy period.

The factors that can affect wetlands in the investigation area include water level fluctuations, stabilized water levels, and ice. These are discussed in detail in Section 5.1.5.1.

5.1.5.1 Upper Niagara River and Tributaries

Great Lakes coastal wetlands are found in shallow bays and shoals in the upper river and its tributaries, and stands of EAV occur in protected shoreline areas where erosive forces are relatively low (Figures 4.1.5-1 and 4.1.5-2). The only tributaries of the upper river that are associated with coastal wetlands are found on Grand Island. Therefore, for purposes of this report mainland tributaries of the upper river are not considered. Review of habitat data collected along Transects 6, 8, 9, and 11-15 revealed that considerable portions of coastal wetlands are situated within the zone of water level fluctuation (See Appendix A). Coastal wetlands are those within the influence of the Niagara River; these wetlands are in very close proximity to the Niagara River. Inland wetlands are those not influenced by water levels in the Niagara River and receive hydrological input from surface water run off and/or groundwater sources. Maximum monthly and daily water level fluctuations in the downstream reaches of the upper river, where the largest acreage of coastal wetlands and EAV occur, are greatest during times of greatest biological activity during the spring, summer, and early fall (Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3). In general, as average water levels change from year to year, vegetation communities experience a locational shift: landward during high-water years, and waterward during low-water years (Minc and Albert 2001). This phenomenon would not occur at the wetlands areas associated with Gratwick State Park and Cherry Farm because these areas occur between riprap breakwater barriers and capped landfills. This precludes landward or waterward shifting of vegetation communities. Relatively small variations in water levels can potentially have widespread effects on vegetation zones in these wetlands as a result of the flat topography (Maynard and Wilcox 1996). This is a common phenomenon in water bodies that experience annual and seasonal water level fluctuations.

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Water level fluctuations can indirectly influence wetland (particularly EAV) plant distribution by influencing erosive forces and their effects on plants and substrates. Energy associated with waves may be an important factor affecting the local extent of EAV in nearshore habitats, physically uprooting and removing EAV in exposed nearshore habitats (Maynard and Wilcox 1996). These potential effects have the greatest influence on the lower (deeper) extent of EAV growing in nearshore habitats because these areas are the first to encounter waves and they help absorb wave energy. Flooding and wave action can also affect vegetation density indirectly by creating bands of coarser substrates (typically sand and coarser) in nearshore areas (see Section 5.1.3). Coarse-textured substrates are generally poor for supporting plant growth due to their low nutrient status, poor anchoring medium, and limited rates of nutrient diffusion and exchange (Barko and Smart 1986). Seasonal and daily fluctuations in water levels may influence the portion of the nearshore zone affected by waves by exposing a wider area of this zone to wave action than if there were no fluctuations, as described in Section 5.1.3.

Coastal wetlands are heavily influenced by natural water level fluctuations including short-term fluctuations associated with seiches and long-term seasonal and year to year fluctuations. These fluctuations have varying magnitudes, frequencies, timing, and duration, each with different effects on wetlands, and are important to the maintenance of coastal wetlands. They are caused by a combination of short-term, seasonal, and long-term weather conditions, as well as climate changes. They can have a frequency of hours (seiches), as well as seasonal, annual, and various multiple-year frequencies (Maynard and Wilcox 1996).

Annual fluctuations in Great Lakes water levels, resulting from variable precipitation and evaporation within drainage basins, impose the greatest stresses on coastal wetlands (Maynard and Wilcox 1996; Minc and Albert 2001). Large changes in Great Lakes water elevations, such as a 4.2-foot decline in Lake Erie water levels between June 1997 and February 1999 (Cashell 2002), have a profound effect on wetland plant communities, causing landward or lakeward shifting of vegetation communities. As a result, coastal wetlands are dynamic ecosystems. They sometimes require extreme water level fluctuations (both high and low water levels) to maintain habitats and the diversity of plant and animal species (Maynard and Wilcox 1996, USGS 2003). Based on this information, it is possible that some of

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the potential effects of water level fluctuations on coastal wetlands in the upper river are similar to the effects on other Great Lakes coastal wetlands.

Conversely, the absence or dampening of natural water level fluctuations alters species composition as well. Coastal wetland systems are adapted to and require periodic inundation. Where water-level regulation has significantly reduced the occurrence of extreme high and low water levels, disruption of the natural cycle favors species intolerant of water-depth change and associated stresses, and/or excludes species requiring periodic exposure of fertile substrates, potentially leading to a reduction of species diversity (Maynard and Wilcox 1996; Minc and Albert 2001). For example, the dominance of cattails in many Lake Ontario marshes suggests a trend toward reduced species diversity following a reduction in the amplitude of natural water level fluctuations (Wilcox and Meeker 1992; Minc and Albert 2001, USGS 2003). The NYSDEC and New York State Office of Parks, Recreation and Historic Preservation (NYSOPRHP), concerned about a lack of occurrence of high water levels in Buckhorn Marsh due to water-level regulation, initiated a restoration project. Specifically, in the mid-1990s, a review of historic aerial photographs conducted by NYSDEC indicated that the marsh was undergoing habitat changes and water levels were lower than in previous years (NYSDEC and NYSOPRHP 1995). Because of the regional importance of Buckhorn Marsh to fish and wildlife, NYSDEC and NYSOPRHP undertook a major habitat restoration project in the marsh (NYSDEC and NYSOPRHP 1995).

One of the primary goals of this restoration project was the reestablishment of a mixture of open water, emergent marsh and wet meadow habitats that could support an increased diversity and abundance of wetland species. Other goals included increasing the public awareness and appreciation of the function and values of Niagara River wetlands, and to obtain the necessary resources to support programs and projects as identified by the Buckhorn Marsh restoration committee. This committee, made up of local stakeholders, developed a number of specific objectives for the project (NYSDEC and NYSOPRHP 1995). Among the stated objectives was the restoration and maintenance of water levels conducive to increased abundance and diversity of species, the creation of an increased ratio of open water to marsh habitat, and the creation of a warm water fishery with emphasis on northern pike (NYSDEC and NYSOPRHP 1995).

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significant factor affecting the local extent of SAV in nearshore habitats (EI and Woodlot 2001). Erosion in the "splash zone" creates a zone of coarser substrate types (typically sand and coarser) in the nearshore zone (see Section 5.1.3). These substrates do not present favorable conditions for SAV growth, possibly due to their low nutrient status, poor anchoring medium, or limited rates of nutrient diffusion and exchange (Barko and Smart 1986). Seasonal and daily fluctuations in water levels influence the portion of the nearshore zone affected by waves by exposing a wider area of this zone to wave action than if there was no fluctuation, as described in Section 5.1.3.

In some regulated and unregulated areas of the Great Lakes, ice has been identified as a significant factor affecting the distribution of SAV due to bottom freezing as well as lifting and transporting finer sediments and vegetation during ice breakup (Maynard and Wilcox 1996; Duke et al. 2001). However, as described in Section 5.1.3 these do not seem to cause extensive problems in the Niagara investigation area. No evidence of more than minor effects of bottom freezing was observed during this investigation.

Ice floes traveling down the river may scrape sediments, causing moderate disturbance to some exposed nearshore habitats. Water level fluctuations at the time of ice breakup may expose larger areas of the littoral zone to this type of disturbance. Disturbance from ice-related forces appears to be restricted to narrow bands along some exposed shorelines.

5.1.4.1 Upper Niagara River and Tributaries

As a result of the presence of extensive littoral areas, dense SAV occurs commonly in the upper river and tributaries. Based on transect data, the unvegetated zone separating SAV from the shoreline in the upper river typically occurs in water depths (at the time of the survey) between zero and 2.0 feet. However, submerged aquatic plants were found within shallower water depths (<2.0 feet) at Transects 12 (Mouth of Burnt Ship Creek) and 14 (Grass Island), in areas that are relatively protected from erosive forces (Appendix A). The unvegetated zone extended to a maximum water depth of approximately 4 feet at Transects 1 (Strawberry Island Southwest) and 5 (Beaver Island Southwest) (Appendix A). Those

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The Buckhorn Marsh restoration project included the completion of a Plant Resources Assessment and a Wildlife Resources Assessment (NYSDEC and NYSOPRHP 1995). The Plant Resource Assessment noted that the maintenance of higher stable water levels should favor the preservation and reestablishment of the former plant communities of the marsh. The Wildlife Resource Assessment noted surprisingly low diversity and densities of breeding marsh birds and amphibians, although several threatened bird species were known to nest or forage at Buckhorn Marsh including common tern, least bittern, northern harrier, and sedge wren (NYSDEC and NYSOPRHP 1995). One objective of the project was to restore and maintain water levels in the marsh at depths conducive to increasing the abundance and diversity of terrestrial and aquatic species by constructing water level control structures and excavating open water channels (NYSDEC and NYSOPRHP 1995). On the east side of the marsh, two water level control structures were installed in Burnt Ship Creek to increase and stabilize water levels. During the spring, high water levels would overtop the weirs, and this water would be retained on the marsh as the level of the river decreased during summer. In addition, several thousand feet of open water channel were excavated throughout the marsh to create additional nesting habitat for marsh birds. The purpose of this effort was to provide nesting, brooding, escape, and resting habitat for waterfowl, as well as new and improved habitat for several species of threatened and endangered birds such as common tern, sedge wren, northern harrier, least bittern, and possibly pied-billed grebe. The overall design for the marsh would encourage the use of the east side of the marsh by threatened bird species, and the use of the west side of the marsh by spawning fish.

Water level data indicate that the weirs were successful at increasing and stabilizing water levels in the marsh (URS et al. 2005a). In the spring, water levels inside the water control weirs were typically about 1.0 foot higher than in the west side of the marsh and these levels were much more constant than in the portions of Burnt Ship Creek and Woods Creek open to the Niagara River (URS et al. 2005a). These data suggest that the water levels in the marsh between the weirs are largely independent of the Niagara River and the marsh restoration project appears to have been successful at keeping these water levels higher and more stable than they were previously.

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In some impoundments and unregulated areas of the Great Lakes, ice has been identified as a significant factor affecting the distribution of wetlands and EAV due to bottom freezing, as well as vertical lifting and transporting finer sediments and vegetation during ice breakup (Maynard and Wilcox 1996; Duke et al. 2001). However, these do not seem to be widespread problems in the Niagara investigation area as median water levels decrease little (<0.5 feet) during winter months (i.e., the non-tourist season) and median daily water level fluctuations are at the lowest levels during the winter (<0.5 feet, see Section 5.1.3). No evidence of more than minor effects of bottom freezing was observed during this investigation (see Transect 7 in Appendix A).

Ice floes traveling down the river may scour and uproot persistent emergent plants (e.g., cattails) and scrape sediments, causing moderate disturbance to some exposed nearshore habitats. Water level fluctuations at the time of ice breakup may expose larger areas of the littoral zone to this type of disturbance. Disturbance from ice-related forces appears to be restricted to narrow bands along exposed shorelines. Larger wetlands in the investigation area (e.g., Buckhorn Marsh) are located in sheltered areas and are therefore unaffected by the erosive forces of ice floes.

5.1.5.2 Lower Niagara River

In the lower river the topography/bathymetry is steep, currents are swift, and the banks are primarily composed of rock and gravel near the waterline. These conditions preclude the extensive development of wetland habitats. No EAV or other wetlands were observed within the lower river during this investigation (Figures 4.1.5-1 and 4.1.5-2). The lack of protected shallow littoral zones and fine sediments appear to be the determining factors in these areas (see cross-sections of Transects 16-20 in Appendix A), with water level fluctuations apparently having little or no direct effect.

5.1.5.3 Lewiston Reservoir

The interior wall of Lewiston Reservoir is very steep (dropping vertically about 45 feet over a linear distance of about 200 feet), leading down to a relatively flat bottom composed of hard packed clay,

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silt, and muck. The extreme weekly water level fluctuations (up to 39 vertical feet) that result in weekly inundation and dewatering combined with unsuitable substrates on the lower portions of the interior wall of the Reservoir preclude the development of EAV and other wetland habitat types.

5.1.6 Upland Shore Communities

For the purpose of this investigation, upland shore communities are defined as upland habitats located above the shoreline (i.e., the median or 50% exceedance water level) and below the upper limit of the influence from fluctuating water levels (i.e., approximately the 5% exceedance water level, as described in Section 3.1.5). In general, these communities are subject to occasional flooding that may influence habitat features such as vegetation density and substrate. Frequent or prolonged flooding has the potential to affect vegetation directly, especially upland plant species that are not tolerant of high water levels. Flooding may also physically uproot and remove plants in exposed nearshore habitats. In addition, flooding and wave action may affect vegetation density indirectly by creating bands of coarser substrate types, which are generally poor for supporting plant growth (see Section 5.1.3). Seasonal and daily fluctuations in water levels influence the portion of the upland shore affected by waves and other erosive forces by exposing a wider area of this zone to direct and indirect effects of flooding and wave action than if there were no fluctuations, as described in Section 5.1.3.

The breadth of the upland shore community exposed to occasional flooding is determined by topography. In relatively flat areas, these communities occur as fairly broad bands. In areas with steep banks, they occur as narrow bands. Throughout most of the investigation area, upland shore areas have moderate to high and relatively steep banks. This is especially true for the lower river and Lewiston Reservoir.

The affected flooding zones (i.e., the limits of the zones of potential effect above median water elevations and below maximum water elevations) are mostly <2.0 feet for upper river transects and mostly <2.5 feet for lower river transects. For the Lewiston Reservoir, the affected flooding zones are approximately 14 feet (Table 2.2.2-1). Consequently, water level fluctuations affect narrow strips of

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upland in the upper and lower rivers. For example, the breadth of the upland shore community affected by flooding is <20 feet at Transects 5, 7, and 10 in the upper river and at Transects 16 and 20 in the lower river (Appendix A). Although the Lewiston Reservoir experiences large water level fluctuations, the breadth of the man-made upland interior affected by flooding is relatively narrow (<50 feet, Transects 22-24 in Appendix A), due to its very steep riprapped banks.

5.2 Water Level and Flow Fluctuation Effects on Aquatic Focus Species

This section presents the aquatic focus species and life stages that may utilize habitats potentially affected by water level and flow fluctuations (as described in Section 5.1). The aquatic focus species and life stages assessed are listed for each region of the investigation area (upper Niagara River, lower Niagara River, and Lewiston Reservoir) in Section 2.2.1.4 of this report. Habitat requirements for the aquatic focus species are described in Appendix C.

For each focus species, a determination was made whether water level fluctuations at the times of species occurrence in the affected habitat(s) are severe enough to have a potential effect on the required habitat. This was accomplished using maximum monthly fluctuations (Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3) identified for permanent and temporary gauges in the investigation area (as described in Section 2.2.1.4). It is important to note that for the upper and lower river the maximum monthly fluctuations are resource conservative estimates of the potential effects of water level fluctuations resulting from all causal factors identified through the analysis of water level data for 1995, 1997, and 2001. These factors are NYPA and OPG operations, “non-significant” storm events on Lake Erie, and local environmental conditions. This approach was taken because it is difficult to accurately determine the extent of water level fluctuation caused by each factor (Section 2.2.1.4 and Section 3.3.1). Water level fluctuations in Lewiston Reservoir are primarily due to normal operation of the Niagara Power Project. Water level fluctuations may affect aquatic focus species that use shallow water habitats for life stages that are unable to avoid dewatering. For fish, these would include spawning/egg incubation and early larval development for some species. Juvenile and adult fish would likely be able to move into and out of areas with changing water depths and are unlikely to be directly affected (e.g., stranded) by

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changes in water levels. Various life stages of benthic macroinvertebrates may be affected in these areas as adults and larval forms of some species are relatively immobile.

A list of aquatic focus species and life stages potentially affected by water level fluctuations was developed for each region of the investigation area (Table 5.2.1-1). This evaluation utilized species considered to be representative of the fish and wildlife communities of the investigation area or were of special interest to NYPA or stakeholder groups. Species that do not use the potentially affected depth zones for a vulnerable life stage were not identified as potentially affected species.

5.2.1 Potentially Affected Focus Species in the Upper Niagara River and Tributaries

Water level fluctuations in the upper Niagara River have the potential to affect the shallowest habitats used by fish for spawning, egg incubation, and development of larvae within the 0-2 foot zone and the extreme upper portions (the top 0.5 feet) of the 2-6 foot zone based on the estimated water level fluctuations for wet, typical, and dry years (Tables 2.2.1.4-1, 2.2.1.4-2, and 2.2.1.4-3.).

Thirteen species of fish were chosen as focus species for the upper Niagara River (Section 3.3.2.1). Habitat of adults and juveniles of all focus species would not be directly affected by water level and flow fluctuations. In the paragraphs below, the fish species are grouped by the water depth ranges the species use for spawning, and egg and larval rearing.

5.2.1.1 Emerald shiner

Water level fluctuations in the upper Niagara River do not directly affect spawning, egg and larval habitat of emerald shiner as emerald shiners are pelagic and their spawning, egg and larval habitat is in mid-water. Thus, their eggs and larvae are not typically found within these shallower, near shore areas where water level fluctuations from a number of sources occur.

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5.2.1.2 Lake Sturgeon and Lake Trout

The literature states that lake sturgeon spawn at water depths of 2 – 39 feet, over clean, large (i.e., gravel and larger) substrates in water velocities of ~0.3 – 2.3 fps. The depths influenced by water level fluctuations (<2.5 feet) are a small part of the depth of water they are documented to use for spawning. Spawning by lake sturgeon has not been documented in the upper Niagara River. Suitable spawning water velocities and depths are present in the upper river, especially around Strawberry Island where the water level fluctuations are almost always < 2 feet. Although substrates in this area contain gravel and cobble, they are intermixed with sand and pebble substrates, which are not suitable for lake sturgeon spawning and larval lifestages. Lake sturgeon were historically known to spawn upstream of the Peace Bridge, an area in which the water elevation is controlled by the outflow from Lake Erie (URS et al. 2005a). No other spawning areas have been documented in the upper river.

Lake trout require rocky ledges and shoals in lakes, and spawning in rivers is rare. Spawning depths throughout their range are 1 to 260 feet, with spawning in the Great Lakes documented to occur between ~9 to 260 feet. It is possible that lake trout in the Great Lakes do not spawn in water shallower than ~ 9 feet. In eastern Lake Superior, where the only documented native river-spawning populations in the Great Lakes exists, lake trout spawn over large boulders intermixed with coarse gravel. In eastern Lake Ontario, spawning has been documented to occur over mixed cobble-gravel substrates. Cobble and larger substrates are limited in the upper river, but where coarse gravel (likely the smallest substrate that lake trout would use for spawning) is present (western side of Grand Island), it occurs from the shoreline to depths of >20 feet.

While the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for lake sturgeon and lake trout is influenced by water level fluctuations from a number of sources, suitable habitat is present at greater depths and affords opportunities for these species' lifestages at depths that are not affected by water level fluctuations.

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5.2.1.3 Muskellunge, Largemouth Bass, Smallmouth Bass, Walleye and Yellow Perch

Muskellunge have been reported to spawn in the upper Niagara River in depths of 3-7 feet, and the literature indicates that, throughout their range, the spawning and larval lifestages of muskellunge require SAV and depths of 2-7 feet. SAV is generally not present at depths shallower than 2 feet, an observation that was made in 1928, 1955 and 2002. Documented muskellunge spawning areas are between Grand, Motor, and Strawberry Islands (May and June monthly water level fluctuations are generally 0.5 – 1.5 feet) and between Navy and Grand Islands (May and June monthly water level fluctuations are generally between 1.5 – 2 feet). Water depths in these areas in which muskellunge have been documented to spawn range from approximately 3 – 8 feet.

Largemouth bass generally spawn in May and June, have a spawning depth range of 0.5-26 feet, and they prefer water with little or no velocity. Areas of the upper river that are likely to be suitable for largemouth bass spawning are along the northern shore of Grand Island and near Woods Creek (monthly fluctuations in May and June are <2.5 feet and usually < 2 feet), the Big Six Mile Creek Marina (monthly fluctuations in May and June are <2 feet), and Gun and Woods Creeks (monthly fluctuations in May and June are <2.5 feet and usually < 2 feet).

Smallmouth bass spawn in water of 2-20 feet deep, preferably over gravel, in areas with little or no velocity. The substrate in the upper river where the depth is <20 feet is generally gravel, pebbles and sand. Where large areas of gravel are present (south of Navy Island and around Strawberry Island), the water depths extend from the shoreline to > 20 feet. Areas of <1.1 fps velocity exist along the shorelines of most of the upper river.

Walleye prefer to spawn at water depths of 2.5 – 5 feet (but will spawn in a range of water depths ranging from less than 1 foot up to 20 feet), in velocities of 2 – 3.6 fps, and over a gravel/cobble mix of substrate; however walleye will also spawn over gravel and sand. Gravel and sand substrates are common from the shoreline to depths of >20 feet in the upper river, and provide suitable habitat for the

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spawning, egg and larval lifestages of walleye. Gravel/cobble mixes are much less common in the upper river than in the lower river.

The preferred spawning habitat for yellow perch is at depths of 1.2 - 9 feet over mud or silt and SAV or submerged brush. They prefer areas with low velocities for spawning. Areas in the upper river that have these attributes are generally in areas protected from wind such as near the shoreline of the northern end of Grand Island (monthly water level fluctuations in April and May are <2.5 feet) and the mouth of Spicer Creek (monthly water level fluctuations in April and May are generally <1.5 feet, but were ~2.7 feet in April 1995).

Although the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for muskellunge, largemouth bass, smallmouth bass, walleye and yellow perch is influenced by water level fluctuations from a number of sources, suitable habitat is present at greater depths and affords opportunities for these species' lifestages at depths that are not affected by water level fluctuations.

5.2.1.4 Bluntnose Minnow, Brown Bullhead, and Greater Redhorse

Bluntnose minnows spawn in May and June and build nests under the surface of various objects such as stones and logs in water of 0.5-3 feet deep. Males guard the nest and the eggs hatch in 7-14 days. Suitable spawning, egg and larval habitat for bluntnose minnows occurs in areas of little or no velocity in the upper river, in the tributaries of Grand Island, and along the shorelines of Cayuga, Ellicott, and Tonawanda Creeks. Monthly fluctuations in these areas from May to August are < 2.5 feet, and usually < 2 feet.

Brown bullhead spawn in May and June, and build nests in shallow water of less than 4 feet deep. Their nests are usually in substrate of mud, sand, and gravel in areas of little or no velocity. Suitable spawning, egg and larval habitat for brown bullhead occurs in areas of little or no velocity in the upper

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river, in the tributaries of Grand Island, and along the shorelines of Cayuga, Ellicott, and Tonawanda Creeks. Monthly fluctuations in these areas in May and June are < 2.5 feet, and usually < 2 feet.

Greater redhorse spawn in May and June and in shallow water (0.3-3 feet deep), but generally in high gradient runs and riffles with moderate velocities and over gravel and cobble substrates. They appear to prefer coarse substrates (i.e., not fine substrates such as sand and mud). Areas in the upper river that contain habitat suitable for spawning greater redhorse are most likely found in the near shore areas upstream of Strawberry Island extending to south of the Peace Bridge. The area near Strawberry Island experiences monthly water level fluctuations in May and June of <1.5 feet. Upstream of Peace Bridge, water level fluctuations are controlled by the outflow of Lake Erie.

Although the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for bluntnose minnow, brown bullhead, and greater redhorse is influenced by water level fluctuations from a number of sources, suitable habitat for these species' lifestages is present at depths below the zone affected by water level fluctuations.

5.2.1.5 Northern Pike and White Sucker

Northern pike typically spawn in shallow (0.5-1.2 feet) vegetated areas (over SAV, EAV, or flooded terrestrial vegetation), but can spawn over a range of depths (~0.5 - 16 feet), with deeper areas selected later in the spawning period. In the deeper areas, spawning takes place over SAV, which occurs principally at depths >2 feet and is common throughout the upper river. Some sheltered areas in the river and its tributaries, however, may provide suitable SAV, EAV or flooded terrestrial vegetation for spawning. These sheltered areas are found in some sections of the tributaries of Grand Island, such as Woods and Gun Creeks. Although Burnt Ship Creek is relatively sheltered from wind, the vegetation is primarily cattails, which are not preferable spawning substrate for northern pike.

White suckers generally spawn at depths shallower than those used by northern pike for spawning. Spawning generally occurs in depths of 0.2-1 feet over pebble and gravel substrates. Areas in

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the upper river that contain these attributes are along the shorelines of most of the upper river. April-June monthly water level fluctuations in the upper river range from <1.5 feet to < 2.5 feet.

Although the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for northern pike is influenced by water level fluctuations from a number of sources, suitable habitat is present at greater depths and affords opportunities for northern pike lifestages at depths that are not affected by water level fluctuations. White suckers have the most limited spawning depth requirements (<1 foot deep) of all the focus species, and because of this, little spawning habitat exists at depths greater than 1 foot.

It is possible that any or all of the focus fish species may tend to avoid spawning in the absolute shallowest parts (<2 feet) of the river and tributaries as the water fluctuates daily from April to October, the time of year in which most of the fish species spawn (Tables 2.2.1.4–1, 2.2.1.4-2, 2.2.1.4-3 and URS et al 2005a). Nest building species (Table 5.2.1-1) generally require several days to construct the nest and defend their territory. Those species would experience daily water level fluctuations during each day of nest construction. Therefore, those species may avoid spawning in the shallowest parts of the river and tributaries where daily water level fluctuation occur. Such is the case with largemouth bass (a nest building species) in the tidal freshwater portions of the Hudson River. Largemouth bass spawn 0.5 – 3 feet below the 3 foot low tide elevation (Nack et al. 1993). This area of the Hudson River also supports viable reproducing populations of brown bullhead, smallmouth bass, yellow perch, and other species (Smith 1985).

5.2.1.6 Macroinvertebrates

Adult aquatic insect nymphs and eggs, such as *Hexagenia spp.* (mayfly), can be found at various depths and the nymphs prefer soft sediments. Generally, the upper river contains little habitat with soft sediments, while the tributaries on Grand Island and Cayuga, Ellicott, and Tonawanda Creeks have soft sediments in most areas. These tributaries experience water level fluctuations, but with the exception of Spicer Creek, little area is dewatered due to their rectangular bathymetry.

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Adult mussels such as the giant floater are relatively mobile and can avoid dewatering by following the receding waters. Another adaptive strategy for mussels is to close up and wait out periodic dewatering that may occur in some areas due to daily water level fluctuations in the upper Niagara River. Eggs of the giant floater are protected within the female, and the larvae are parasites that live on adult fish gills. These life stages would not be susceptible to changes in water levels. There is however, the potential for increased predation on stranded mussels by terrestrial predators such as muskrat and raccoon.

Adult crayfish use a variety of substrates ranging from fines such as silts and loams, to much coarser substrates such as cobble and boulders. Adult crayfish are the most mobile of the invertebrate focus groups and would be able to move in response to fluctuating water levels. Some species are strictly aquatic but are able to survive short periods of desiccation by burrowing into the soft sediments. Some burrowing crayfish create their own homes or "burrows" by digging into soft sediments in terrestrial areas until water is reached. Burrowing crayfish are adaptive to fluctuating water levels and rising and falling water levels often stimulate these animals to dig new burrows (Helfrich et al. 2001). Crayfish eggs and larvae are carried by the female and would not be as susceptible to changes in water level as would other less mobile groups. There may be increased predation by terrestrial predators on stranded individuals or on individuals that may move from burrow to burrow in response to water level changes.

5.2.2 Potentially Affected Focus Species in the Lower Niagara River

Water level fluctuations in the lower Niagara River have the potential to affect habitats used for spawning by fish, egg incubation, and development of larvae within the 0-2 foot zone and the shallower portions (the top 0.5 feet) of the 2-6 foot zone based on the temporary gauge data collected in 2002. These zones would most likely experience the greatest potential effects of water level fluctuations, although the extent of these zones in the lower Niagara River is limited due to the steep shore slopes.

Fourteen species of fish were chosen as focus species for the lower Niagara River (Section 3.3.2.1). Habitat of adults and juveniles of all focus species would not be directly affected by water level

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and flow fluctuations. In the paragraphs below, the fish species are grouped by the water depths ranges the species use for spawning, and egg and larval rearing.

5.2.2.1 Emerald Shiner

Water level fluctuations in the lower Niagara River do not directly affect spawning, egg and larval habitat of emerald shiner as emerald shiners are pelagic and their spawning, egg and larval habitat is in mid-water. Thus, their eggs and larvae are not typically found within these shallower, near shore areas where water level fluctuations from a number of sources occur.

5.2.2.2 Lake Sturgeon, Lake Trout and Chinook Salmon

The literature states that lake sturgeon spawn at water depths of 2 – 39 feet, over clean, large (i.e., gravel and larger) substrates in water velocities of ~0.3 – 2.3 fps. The depths influenced by water level fluctuations in the lower river (<2.5 feet) are a small part of the depth of water they are documented to use for spawning. Spawning by lake sturgeon has not been documented in the lower Niagara River, although there are several suspected spawning locations. The depths at which adult sturgeon were found in the suspected spawning locations was >15 feet (Appendix C), depths below the zone influenced by water level fluctuations. Suitable spawning water velocities, depth, and substrates are common in the lower river and extend from the shoreline to depths > 25 feet.

Lake trout require rocky ledges and shoals in lakes, and spawning in rivers is rare. Spawning depths throughout their range are 1 to 260 feet, with spawning in the Great Lakes documented to occur between ~9 to 260 feet. In eastern Lake Superior, where the only documented native river-spawning populations in the Great Lakes exists, lake trout spawn over large boulders intermixed with coarse gravel. In eastern Lake Ontario, spawning has been documented to occur over mixed cobble-gravel substrates. Cobble and larger substrates are common in the lower river, and occur from the shoreline to depths much greater than 20 feet.

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Chinook salmon spawn in September and October, at depths of about 1 foot to >20 feet, over gravel to large cobble substrates, in swift (1.4-2.5 fps) water. Water velocity is more important than water depth in the selection of spawning locations. Areas in the lower river downstream of the Robert Moses Power Plant tailrace in which spawning habitat occurs were found at all six transects. Suitable substrates are common at depths of about 2 feet to > 20 feet.

Although the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for lake sturgeon, lake trout, and Chinook salmon is influenced by water level fluctuations from a number of sources, suitable habitat is present at greater depths and affords opportunities for these species' lifestages at depths that are not affected by water level fluctuations.

5.2.2.3 Muskellunge, Largemouth Bass, Smallmouth Bass, Walleye and Yellow Perch

Muskellunge have been reported to spawn in the upper Niagara River in depths of 3-7 feet, and the literature indicates that, throughout their range, the spawning and larval lifestages of muskellunge require SAV and depths of 2-7 feet. SAV is not present at depths shallower than 2 feet in the lower river, an observation that was made in 1928 and 2002. There are no documented muskellunge spawning areas in the lower river, although young-of-the-year muskellunge have been collected from several locations there, all downstream of Lewiston Landing (NYSDEC 1996a) indicating that muskellunge likely spawn in or near these areas. These young-of-the-year were collected in water of 3 to 6 feet deep in SAV beds dominated by wild-celery, which was very similar to that found during young-of-the-year muskellunge surveys in the upper river (NYSDEC 1996b).

Largemouth bass generally spawn in May and June, have a spawning depth range of 0.5-26 feet, and they prefer water with little or no velocity. Areas of the lower river that are likely to be suitable for largemouth bass spawning are near Fort Niagara State Park (monthly water level fluctuations in June 2002 were 0.73 feet) and extend from the shoreline to depths >20 feet.

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Smallmouth bass spawn in water of 2-20 feet deep, preferably over gravel, in areas with little or no velocity, in May and June. Little spawning habitat exists in the lower river except in the shallow areas near the mouth and along some areas of the shoreline where slopes are less steep. Where spawning habitat occurs, it extends from the shoreline to >20 feet deep.

Walleye prefer to spawn in April and May at water depths of 2.5 – 5 feet within water depths ranging from less than 1 foot up to 20 feet, in velocities of 2 – 3.6 fps, and over a gravel/cobble mix of substrate; however walleye will also spawn over gravel and sand. Areas in the lower river that have these attributes are dispersed along the shoreline from the NYPA tailrace to near the mouth, and a long section along the northern part of the Town of Lewiston which has primarily gravel substrate. These areas occur from the shoreline to depths > 20 feet.

Yellow perch spawning habitat is at depths of 1.2 - 9 feet over mud or silt and SAV or submerged brush. They prefer areas with low velocities for spawning. Areas in the lower river that have these attributes are generally in areas protected from wind such as the shoreline near Fort Niagara State Park and areas along the shoreline from Youngstown to Lewiston that are less steep.

Although the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for muskellunge, largemouth bass, smallmouth bass, walleye and yellow perch is influenced by water level fluctuations from a number of sources, suitable habitat is present at greater depths and affords opportunities for these species' lifestages at depths that are not affected by water level fluctuations.

5.2.2.4 Bluntnose Minnow and Rainbow Smelt

Bluntnose minnows spawn in May and June and build nests under the surface of various objects such as stones and logs in water 0.5-3 feet deep. Males guard the nest and the eggs hatch in 7-14 days. Suitable spawning, egg and larval habitat for bluntnose minnows occurs in near shoreline areas with little or no velocity in the lower river, principally near the mouth near Fort Niagara State Park.

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Rainbow smelt spawn in April-May, in water depths of 0.3 - 4.3 feet, over sand and gravel substrates in fast (2-2.6 fps) water. Areas in the lower river that have these attributes are along the shoreline from Youngstown to Lewiston.

Although the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for bluntnose minnow and rainbow smelt are influenced by water level fluctuations from a number of sources, suitable habitat is present at greater depths and affords opportunities for these species' lifestages at depths that are not affected by water level fluctuations.

5.2.2.5 Northern Pike and White Sucker

Northern pike typically spawn in shallow (0.5-1.2 feet) vegetated areas (over SAV, EAV, or flooded terrestrial vegetation), but can spawn over a range of depths (~0.5 - 16 feet), with deeper areas selected later in the spawning period. In the deeper areas, spawning takes place over SAV, which occurs principally at depths >2 feet. Northern pike have not been documented to spawn in the lower river, and EAV and flooded terrestrial vegetation is nearly absent from the lower river. Therefore, the spawning and larval habitat of northern pike in the lower river is limited to areas with SAV. SAV occurs at depths of about 2 feet and extends to about 20 feet.

White suckers generally spawn at depths shallower than those used by northern pike for spawning. Spawning generally occurs in depths of 0.2-1 feet over pebble and gravel substrates. Areas in the lower river that contain these attributes are along the shorelines of most of the lower river.

Although the shallowest part (the top ~2.5 feet) of the areas that contain suitable spawning, egg, and larval habitat for northern pike is influenced by water level fluctuations from a number of sources, suitable habitat is present at greater depths and affords opportunities for northern pike lifestages at depths that are not affected by water level fluctuations. White suckers have the most limited spawning depth requirements (<1 foot deep) of all the focus species, and because of this, little spawning habitat exists at depths greater than 1 foot.

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It is possible that any or all of the fish focus species may tend to avoid spawning in the absolute shallowest parts (<2 feet) of the river and tributaries as the water fluctuates daily from April to October, the time of year in which most of the fish species spawn (Table 5.2.1-1 and URS et al 2005a). Nest building species (Table 5.2.1-1) generally require several days to construct the nest and defend their territory. Those species would experience daily water level fluctuations during each day of nest construction. Therefore, those species may avoid spawning in the shallowest parts of the river and tributaries where daily water level fluctuation occur. Such is the case with largemouth bass (a nest building species) in the tidal freshwater portions of the Hudson River. Largemouth bass spawn 0.5 – 3 feet below the 3 foot low tide elevation (Nack et al. 1993). This area of the Hudson River also supports viable reproducing populations of brown bullhead, smallmouth bass, yellow perch, and other species (Smith 1985).

5.2.2.6 Macroinvertebrates

The nymphs of *Hexagenia* mayflies prefer soft sediments. Because soft substrates are rare in the lower river, the nymphs of *Hexagenia* mayflies are not expected to be found there. Relatively little habitat exists for giant floater mussels in the lower river, as they also require mud or other soft bottom substrates with little or no velocity.

Adult crayfish use a variety of substrates ranging from silts and loams to cobble and boulders. Cobble and boulder substrates are common in the lower river. Adult crayfish are the most mobile of the invertebrate focus groups and would be able to move in response to fluctuating water levels. Some are strictly aquatic but are able to survive short periods of desiccation by burrowing into the soft sediments, although soft sediments are rare in the lower river. Some species of crayfish create their own homes or "burrows" by digging into soft sediments in terrestrial areas until water is reached. Burrowing crayfish are adaptive to fluctuating water levels and rising and falling water levels often stimulate these animals to dig new burrows (Helfrich et al. 2001). Crayfish eggs and larvae are carried by the female and would not be as susceptible to changes in water level as would other less mobile groups. There may be increased

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Benthic macroinvertebrates inhabiting the drawdown zone may potentially be affected. The drawdown zone is steep sided with large riprap armoring for substrate which is unsuitable habitat for two of the macroinvertebrate focus species, the giant floater mussel and *Hexagenia* mayflies. These two focus species prefer soft substrates such as silt and mud that are found only on the bottom of the reservoir. Some areas of the bottom of the reservoir are dewatered during normal operations.

Adult crayfish will use the large boulder riprap habitat found within the drawdown zone. However, they are the most mobile of the invertebrate focus groups and have the ability to move from those areas that become dewatered.

5.3 Water Level and Flow Fluctuation Effects on Wildlife Focus Species

This section reviews 15 wildlife focus species that may utilize habitats potentially affected by water level and flow fluctuations (as described in Section 5.1). These species were chosen because they 1) represent a wide range of species that use aquatic and/or terrestrial habitats in the investigation area for various life-stages; 2) and they were thought to be a useful assessment tool for determining the potential effects of water level fluctuations on habitats. Habitat requirements for the focus species are described in Appendix D. Suitable habitat for various life stages was identified by reviewing water depth information, general information on substrates, vegetation, average water velocities, and more detailed habitat data collected along the representative transects. For each focus species, a determination was made whether water level fluctuations at the times of species occurrence in the affected habitat(s) are severe enough to have a potential effect on the required habitat. This was accomplished using maximum monthly water level fluctuations (Tables 2.2.1.4.1, 2.2.1.4.2, 2.2.1.4.3, and 2.2.2.1) identified for permanent and temporary gauges in the investigation area (as described in Sections 2.2.1, 2.2.2 and 2.2.3). It is important to note that the upper and lower river maximum monthly fluctuations are conservative estimates of water level fluctuations resulting from all causal factors. This approach was taken because it was not possible to accurately determine the extent of water level fluctuation caused by each factor (Section 3.3.1). Water level fluctuations in Lewiston Reservoir are primarily due to normal operation of the Niagara Power Project.

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predation by terrestrial predators on stranded individuals or on individuals that may move from burrow to burrow in response to water level changes.

5.2.3 Potentially Affected Focus Species in the Lewiston Reservoir

The Lewiston Reservoir differs from the Niagara River in that the water levels are subject to both daily and weekly drawdown and recharge schedules, resulting in large daily, weekly, and seasonal water level fluctuations (URS et al. 2005a).

Four species of fish (emerald shiner, smallmouth bass, rock bass, and yellow perch) were chosen as focus species for the Lewiston Reservoir. Juvenile and adult fish are mobile and can avoid many of the potential effects associated with water level fluctuations.

Water level fluctuations in the Lewiston Reservoir do not directly affect spawning, egg and larval habitat of emerald shiner as emerald shiners are pelagic and their spawning, egg and larval habitat is in mid-water. Thus, their eggs and larvae are not typically found within these shallower, near shore areas where water level fluctuations occur.

The sides of the reservoir are comprised of large boulder riprap, which is unsuitable spawning, egg and larval habitat for smallmouth bass, rock bass, and yellow perch. Smallmouth bass prefer gravel substrate on which to construct their nests, and little gravel substrate occurs in the reservoir. Rock bass prefer gravel substrate and instream cover for construction of their nests, and little of either occurs in the reservoir. Substrates on the bottom of the reservoir were primarily clay, mud, muck and silt. Yellow perch prefer mud or silt substrates, and SAV or submerged brush for spawning. Although suitable substrates occur in the reservoir, SAV and submerged brush are uncommon. Spawning likely occurs in the Lewiston Reservoir only on a very limited basis with adult populations maintained primarily by the transport of fish from the upper Niagara River into the reservoir through the conduits and the Lewiston Pump Generating Plant (NYPA 1984). Studies have found evidence of only very limited spawning activity in the reservoir by yellow perch and rock bass (Ecological Analysts 1984).

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For wildlife species, water level fluctuations in the investigation area may directly affect both aquatic habitats (e.g., through dewatering of amphibian eggs) and terrestrial habitats (e.g., through flooding of bird nests). Water level fluctuations typically are not directed solely on aquatic habitats or solely on terrestrial habitats but instead tend to be distributed both above and below the median water elevation (i.e., the shoreline). This evaluation considered three scenarios for the upper river, lower river, and Lewiston Reservoir: (1) direct effects of monthly minimum water levels; (2) direct effects of monthly maximum water levels; and (3) indirect effects on foraging. When considering the potential direct effects of water levels on wildlife focus species, the lifestages of interest include reptilian hibernation and amphibian hibernation and breeding (minimum water levels), and shorebird and reptilian nesting (maximum water levels). Other wildlife focus species' lifestages are mobile and any potential direct effects are considered minimal. The exception to this is the discussion of potential direct effects on water-dependent furbearers (represented by the muskrat), which considers all lifestages because of information on habitat needs presented in the literature (i.e., the importance of water levels to major lifestages of this species).

5.3.1 Potentially Affected Focus Species in the Upper Niagara River and Tributaries

Potential effects of water level fluctuations on wildlife in the upper river and its tributaries were assessed using 15 focus species. These included four species of amphibians (common mudpuppy, northern spring peeper, green frog, and northern leopard frog), two reptiles (common snapping turtle, midland painted turtle), eight species of birds (great blue heron, mallard, canvasback, greater scaup, Virginia rail, American coot, Bonaparte's gull, and spotted sandpiper), and one mammal (muskrat). The following discussions concentrate on shallow aquatic, wetland, and upland shore habitats because water level fluctuations in the upper river are typically restricted to those habitats.

5.3.1.1 Direct Effects of Monthly Minimum (Low) Water Levels

Literature indicates that northern spring peeper, northern leopard frog, and green frog lay eggs in shallow water; however, no specific preferred depths are presented. Literature also indicates that

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common mudpuppy breed from September through November and lay eggs during the spring in nests in water from 0.33 to 9.8 feet deep (Petranka 1998). All of these species typically deposit their eggs from April through June; although green frogs can sometimes breed and deposit eggs as late as August. Maximum monthly fluctuations in the upper Niagara River during these time periods can range from 0.70 to 2.69 feet. Only the top portion of the common mud puppy breeding depth range is influenced by fluctuating water levels and there is breeding habitat available below this zone of influence. Based on Marsh Monitoring Program data from Buckhorn Marsh collected during the 1990s, the vast majority of spring peeper breeding occurs in woodland vernal pools located well above the zone influenced by fluctuating water levels in the Niagara River (Rosenburg unpublished data). Some of the suitable habitat for the egg and larval lifestages of the green frog and northern leopard frog is located in water depth zones that are influenced by water level fluctuations. Specifically, eggs and larvae of these species could be affected if they occur in the 0-2 foot water depth zone and the upper most portion of the 2-6 foot water depth zone. Effects could include desiccation of eggs and larvae from prolonged exposure to air and increased predation rates on stranded larvae. However, review of literature and physical habitat data collected in 2002 revealed that there is also suitable habitat for these lifestages at depths that are not influenced by water level fluctuations.

According to literature, the hibernation period for amphibians and reptiles occurs from November through March; although this period can be shorter or longer depending on seasonal conditions (Harding 1997). The maximum monthly fluctuations during November through March ranged from 0.62 (November 2001) to 2.56 (January 1997) feet in the upper river. Literature indicates that green frog, northern leopard frog, common snapping turtle, and midland painted turtle use a variety of submerged hibernacula including mud, debris, rocks, logs, and overhanging banks (Wright and Wright 1995; Harding 1997; Meeks and Ultsch 1990; Ernst et al. 1994). Other than the midland painted turtle, which hibernates in water ranging from 0-6 feet deep, no preferred water depths are presented for these species. It has been documented that the common snapping turtle sometimes hibernates in deep water areas and occasionally remains active during the winter. The northern leopard frog will hibernate in deep or running water that will not freeze or become anoxic (Monds 1995). Northern spring peepers hibernate in upland woodlands located above the influence of fluctuating water levels and common mudpuppy does not hibernate and is active throughout the winter (Petranka 1998). No preferred water depths are presented in the literature for

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the hibernation life-stage for green frog, northern leopard frog, or common snapping turtle. Some of the suitable overwintering habitat for the green frog, northern leopard frog, common snapping turtle, and midland painted turtle is influenced by water level fluctuations (0-2 foot water depth zone and the upper most portion of the 2-6 foot water depth zone). However, review of literature and physical habitat data indicates that there is also suitable habitat available for the hibernation lifestage of these species at depths that are not influenced by water level fluctuations. According to the water level duration analysis figures comparing the tourist and non-tourist water levels and the tables with upper river maximum and minimum and water level data for the years 1995, 1997 and 2001, minimum water levels during the non-tourist season are similar to water levels at the 50,000 cfs flow during the tourist season. During the winter, water levels in Grass Island Pool are held at a more constant level than during the tourist season in order to achieve the long-term average of 562.75 feet. The more constant water levels are not lowered below levels seen at the 50,000 cfs flow during the tourist season. If adult amphibians and their larvae begin hibernation at the end of the tourist season (when flows generally fluctuate between the 100,000 cfs and 50,000 cfs flows), it is possible that they will respond to the daily fluctuations and choose hibernation sites outside of the zone of fluctuation.

Muskrat primarily utilize marsh habitats, but may also be found in riverine habitats, slow-moving streams, lakes, ponds, and ditches. This rodent is active throughout the year and feeds primarily on the roots and basal portions of aquatic plants, with cattail and bulrush being the most important plants (Wilson and Ruff 1999). In addition, they also eat small amounts of meat from sources including crayfish, mussels, small fish, turtles, and frogs (Kurta 1995; Wilson and Ruff 1999). These food sources exist in the upper river and associated wetland habitats. According to Allen and Hoffman (1984), water depths of 1.5-4 feet are most suitable for the muskrat and the occurrence of only minor seasonal fluctuations in water levels (i.e., no seasonal drying) is an important characteristic for meeting the muskrat's year-round habitat requirements. This information suggests that sufficient food sources exist in the upper river and there is suitable water depth (minimum of 1.44 feet based on based on 1997 data) for muskrat below the zone that is influenced by fluctuating water levels.

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5.3.1.2 Direct Effects of Monthly Maximum (High) Water Levels

The breeding season for ground-nesting birds and turtles typically occurs from May through July. Maximum monthly fluctuations during this period range from 0.66 (July 1997) to 2.34 (May 1995) feet. Virginia rails, and American coot build nests in wet meadows or shallow emergent marsh habitats. Spotted sandpipers build nests on shores and the nests are often under shrubs or in tall grass (DeGraaf and Rudis 1986). Nesting birds are known to adapt to water level changes, particularly if these changes are short-term, not extreme, and cyclical, and try to avoid exposure to flooding by building nests outside of fluctuation zones, in vegetation above them, or on floating rafts of vegetation. If nests and eggs do become flooded, Ehrlich et al. (1988) indicates that many species will rebuild nests and lay more eggs two or more times during the nesting season. Mallards will nest in wet meadow or marshes, but generally prefer to nest in upland areas usually within 100 yards of water (Bellrose 1976). There is suitable mallard nesting habitat available in upland areas outside of zones influenced by water level fluctuations.

The midland painted turtle and the common snapping turtle build nests in well-drained upland areas with loamy or loose, sandy soils. Midland painted turtles typically dig nests within 200 meters of water, but sometimes build nests as far as 600 meters from water (Ernst et al. 1994). This suggests that nesting habitat is located above the zone influenced by fluctuating water levels. Water level fluctuation is relatively common along most waterbodies. As a result, wildlife species that use shoreline habitats have developed a number of adaptive strategies.

In marsh environments, the muskrat constructs lodges from mud and emergent plants. These lodges are about 6.6 feet in diameter and 3.3 feet high (Kurta 1995; Wilson and Ruff 1999) and are usually constructed in water not more than 2 feet deep (Whitaker and Hamilton 1998). In riverine habitats, dens are excavated into stream banks. Lodges and bank dens include an underground chamber located just above the waterline with one or more plunge holes beneath the water for ingress and egress (Kurta 1995; Wilson and Ruff 1999). Allen and Hoffman (1984) indicated that high water levels may negatively affect muskrats by forcing them out of their lodges and burrows. Weller (1981) documented that muskrats have developed an adaptive strategy to overcome this. This strategy involves the building

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of high and low level (elevation) dens and access tunnels in riverbanks to accommodate fluctuating water levels.

5.3.1.3 Indirect Effects on Foraging

Shifts in the horizontal distribution of water depth zones can encourage wildlife species using nearshore habitats to shift the locations of their feeding activities in response to the changing availability of food resources. For example, the mallard may shift its feeding activities from one SAV bed located close to shore to another located further from shore as water levels drop and submerged macrophytes that were formerly too deep become accessible. These shifts can have negative or positive effects. Some wildlife species may need to expend additional energy to shift foraging efforts between different areas in response to changes in food availability. However, a greater abundance and variety of microhabitats and increased prey availability can result from fluctuating water levels. For example, an "intertidal zone" of exposed shallow water substrates can provide excellent feeding opportunities for shorebirds. This may benefit summer resident shorebirds, such as the spotted sandpiper, as well as a broad variety of migrant shorebirds.

Fluctuating water levels can increase foraging opportunities for predacious birds that capture prey in shallow waters near shore (i.e., the 0 to 2-foot water depth zone). Examples include the great blue heron, Virginia rail, American coot, and spotted sandpiper. These birds may feed on aquatic insects, fish, and amphibian larvae that could become stranded on occasion due to drops in water levels.

The canvasback, greater scaup, and Bonaparte's gull feed primarily in deeper waters (6.6 to 29.5 feet deep for canvasback and 3.3 to 32.8 feet for greater scaup, Bonaparte's gull dips or dives into open water areas). Water level fluctuations have very little influence on these water depth zones, as discussed in Section 5.1.1. It is unlikely that water level fluctuations affect foraging opportunities for these species because the fluctuations result only in minor horizontal shifts in the distribution of water depth zones (see Section 5.1.1). The substrates where these birds feed are rarely, if ever, exposed based on the magnitude of water level fluctuation in the upper river and its tributaries. Evidence that water level fluctuations are

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having minimal effects on the foraging opportunities of these species is the abundance of waterfowl and gulls that spend the winter in ice-free areas of the upper river (as described in Beak 2002).

5.3.2 Potentially Affected Focus Species in the Lower Niagara River

The potential effects of water level fluctuations on wildlife in the lower river were assessed using 10 focus species. These included two species of amphibians (common mudpuppy, green frog), two reptiles (common snapping turtle, midland painted turtle), and six species of birds (great blue heron, mallard, canvasback, greater scaup, Bonaparte's gull, and spotted sandpiper). The following discussions concentrate on shallow aquatic and upland shore habitats because water level fluctuations in the lower river below the Robert Moses tailrace are restricted to those habitats.

5.3.2.1 Direct Effects of Monthly Minimum (Low) Water Levels

Literature indicates that the green frog lays eggs in shallow water; however, no specific preferred depths are presented. This species typically breeds and deposits its eggs from April through August. Literature also indicates that common mudpuppy breed from September through November and lay eggs during the spring in nests in water from 0.33 to 9.8 feet deep. Maximum monthly fluctuations during the breeding seasons for these two amphibian focus species do not exceed 2.65 feet. This indicates that only the top portion of the common mud puppy breeding depth range is influenced by fluctuating water levels and there is breeding habitat available below this zone of influence. Although no preferred breeding depths are presented in the literature for the green frog, eggs and larvae of these species could be affected if they occur in the in the 0-2 foot water depth zone and the upper most portion of the 2-6 foot water depth zone. Effects could include desiccation of eggs and larvae from prolonged exposure to air and increased predation rates on stranded larvae.

According to literature, the hibernation period for amphibians and reptiles occurs from November through March; although this period can be shorter or longer depending on seasonal conditions. The green frog, common snapping turtle, and midland painted turtle use a variety of submerged hibernacula

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including mud, debris, rocks, logs, and overhanging banks. The midland painted turtle hibernates in water ranging from 0-6 feet deep. No preferred water depths are presented for the green frog or snapping turtle. It has been documented that the common snapping turtle sometimes hibernates in deep water areas such as lake bottoms (Carr 1995). The common mudpuppy does not hibernate and is active throughout the winter.

Maximum monthly fluctuations during the hibernation period do not exceed 2.65 feet. The preferred habitat characteristics for common snapping turtle and midland painted turtle include slow moving water with soft substrates (mud or sand) and abundant aquatic vegetation. These habitat characteristics are uncommon in the lower river. Therefore it is likely that neither of these species occurs in the lower Niagara River to any great extent and effects of low water conditions on hibernating individuals are expected to be minimal. Also, there is habitat available below the zone influenced by water level fluctuations for the hibernation lifestage of the midland painted turtle as they can hibernate in water up to 6 feet deep. It is unlikely that the common mudpuppy would be affected by monthly minimal water levels because it is mobile throughout the winter, allowing it to adapt to fluctuating water levels.

5.3.2.2 Direct Effects of Monthly Maximum (High) Water Levels

Maximum monthly fluctuations during the breeding seasons for the applicable focus species do not exceed 2.65 feet. The breeding season for these ground-nesting birds and turtles typically occurs from May to July. The midland painted turtle and the common snapping turtle build nests in well-drained upland areas with loamy or loose, sandy soils. Midland painted turtles typically dig nests within 200 meters of water, but sometimes build nests as far as 600 meters from water (Ernst et al. 1994). This suggests that turtle nesting habitat is located above the zone influenced by typical fluctuating water levels.

The spotted sandpiper builds nests on shores and the nests are often under shrubs or in tall grass (DeGraaf and Rudis 1986). These nests are typically made from grass and are cup-shaped (Sibley 2001). Nesting birds adapt to water level changes, particularly if these changes are short-term, not extreme, and cyclical (similar to tides), and try to avoid exposure to flooding by building nests outside of fluctuation

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zones, in vegetation above them, or on floating rafts of vegetation. If nests and eggs do become flooded, Ehrlich et al. (1988) indicates that many species including sandpiper will rebuild nests and lay more eggs two or more times during the nesting season. Mallards will nest in wet meadow or marshes, but generally prefer to nest in upland areas usually within 100 yards of water (Bellrose 1976). Extensive wet meadow and marsh habitats are non-existent in the lower river and small areas of EAV are confined to the littoral fringes of the river. However, there is sufficient mallard nesting habitat available in upland areas outside of zones influenced by water level fluctuations.

5.3.2.3 Indirect Effects on Foraging

Shifts in the horizontal distribution of water depth zones can cause wildlife species using nearshore habitats to shift the locations of their feeding activities in response to the changing availability of food resources (as described in Section 5.3.1.3). These shifts may have an overall positive effect on foraging efficiency for wildlife focus species that feed in nearshore habitats of the lower river including great blue heron, mallard, and spotted sandpiper. Specifically, temporal shifting of the water depth zones increases foraging opportunities for these species by increasing the amount of area available for foraging when water levels are low.

The canvasback, greater scaup, and Bonaparte's gull feed primarily in deepwater areas which are defined as depths of >6 feet for purposes of this report. Water level fluctuations do not influence these water depth zones, as discussed in Section 5.1.1.2. It is unlikely that water level fluctuations affect the foraging efficiency of these three focus species because the fluctuations result in only minor horizontal shifts in the distribution of water depth zones (see Section 5.1.1.2). Evidence that water level fluctuations are having minimal effects on the foraging efficiencies of these species is the abundance of waterfowl and gulls that spend the winter in certain ice-free areas of the lower river (see Beak 2002). In fact, the Niagara River is internationally recognized as an Important Bird Area (IBA). Thousands of waterfowl and gulls use the river as a migratory staging area and forage in ice-free areas during the fall and winter.

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5.3.3 Potentially Affected Focus Species in the Lewiston Reservoir

Six focus species were chosen to analyze the potential effects of water level fluctuations on wildlife in the Lewiston Reservoir. These included one amphibian (common mudpuppy), one reptile (common snapping turtle), and four species of birds (great blue heron, canvasback, greater scaup, and spotted sandpiper). The following discussions concentrate on deepwater and shallow aquatic habitats and upland shore areas (riprapped interior wall of the reservoir) because water level fluctuations in the Lewiston Reservoir affect those habitats.

5.3.3.1 Direct Effects of Monthly Minimum (Low) Water Levels

Fluctuations in Lewiston Reservoir occur on a weekly cycle and the monthly minimum and maximum ranges of fluctuation for the period of record were 31.44 (March) and 38.39 feet (August), respectively (Table 2.2.2-1). Literature indicates that the common snapping turtle prefers to hibernate in mud or debris on the bottom of a water body and additional cover, such as vegetation, brush, muskrat den, or overhanging banks (Meeks and Ultsch 1990). Although it is not known if the common snapping turtle attempts to hibernate within the reservoir, it has been documented that suitable (i.e., fine) substrates and hibernacula are lacking at shallow water depths. During the winter, substrates at shallow water depths are primarily composed of riprap. Mudpuppy are mobile and active throughout the year and likely unaffected by low water fluctuations in the Lewiston Reservoir.

5.3.3.2 Direct Effects of Monthly Maximum (High) Water Levels

The great blue heron builds large stick nests in trees and, to lesser degree, in shrubs near water. There are no trees or shrubs in Lewiston Reservoir and no known nesting areas for great blue heron. According to literature, canvasback breed primarily in northwestern and central Canada and greater scaup breed in western Alaska. These species do not breed in the Niagara River corridor (Bellrose 1976). Monthly water level fluctuations during the spotted sandpiper breeding season (May through July) range from 37.55 to 38.09 feet. This species builds nests on shores and nests are often constructed under shrubs

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or in tall grass (DeGraaf and Rudis 1986). These nests are typically made from grass and are cup-shaped (Sibley 2001). Riprap similar to that found on the interior wall of Lewiston Reservoir is not documented to be preferred nesting habitat for spotted sandpiper. In addition, in the reservoir interior there is no shrub habitat under which to construct nests or tall grass from which to build the cup-shaped nests typically constructed by the spotted sandpiper. Therefore, review of scientific literature suggests that nesting by this species in Lewiston Reservoir is limited by a lack of preferred nesting habitat.

Common snapping turtle nest in well-drained loamy or loose sandy soils. Based on field data collected during this study and literature-based information on preferred nesting habitat, in the interior of Lewiston Reservoir the only potential nesting habitat for common snapping turtle is found at the top of the interior wall between the riprap and the reservoir dike perimeter road. This area is outside of the influence of water level fluctuations.

5.3.3.3 Indirect Effects on Foraging

Shifts in the horizontal distribution of water depth zones can cause wildlife species using nearshore habitats to shift the locations of their feeding activities in response to the changing availability of food resources (as described in Section 5.3.1.3). These shifts may have an overall positive effect on foraging efficiency for wildlife focus species that feed in nearshore habitats of the Lewiston Reservoir including great blue heron and spotted sandpiper. Temporal shifting of the water depth zones increases foraging opportunities for these species by increasing the amount of area available for foraging. Specifically, when water levels in the reservoir are lowered below the bottom of the steep, riprapped interior wall, an extensive amount of shallow water forage habitat is temporarily available to wading and shore birds. Also, forage areas that function similarly to inter-tidal mudflats are sometimes temporarily available. This occurs because the bottom of the reservoir is relatively flat and water level fluctuations in this area have a marked effect on the spatial extent of water depth zones.

Large numbers of greater scaup use the Lewiston Reservoir in the fall and during ice-free periods in the winter (Beak 2002). Greater scaup feed primarily in deepwater areas (3-30 feet). Even though the

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reservoir exhibits large fluctuations in water levels, water depths of 10-20 feet are found in most areas of the reservoir during the typical foraging period for this species (during the fall and winter) (Section 5.1.1.3). It is unlikely that water level fluctuations affect the foraging efficiency of this species because the fluctuations result in only minor horizontal shifts in the distribution of water depth zones (see Section 5.1.1).

The canvasback occurs only sporadically on the Lewiston Reservoir. This is probably due more to potential indirect effects of water level fluctuations on forage habitat (i.e., SAV) than to potential effects on foraging efficiency. The large swings in water level that are characteristic of the reservoir appear to inhibit extensive establishment of SAV such that it is restricted to a few small areas that meet minimal requirements for these plants, as described in Section 5.1.4.3.

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TABLE 5.2.1-1

POTENTIALLY AFFECTED FISH FOCUS SPECIES HABITAT PREFERENCES

Species	Life Stage[1]	Time Period	Strategy[2]	Depth (feet)	Velocity (fps)	Substrate	Vegeta -tion
Bluntnose minnow	S	May-Aug	N	0.5-3.0	Slow	Rock/Objects	No
	F	May-Aug	-	0.5-3.0	Slow	-	No
Brown bullhead	S	May-Jun	N	<4.0	0	Mud-gravel	No
	F	May-Jun	-	<1.0	0	Fines	Yes
Chinook Salmon	S	Aug-Oct	N	>1.0	1.5-2.4	Gravel	No
	F	Spring	-	>0.5	<1.6	Gravel	No
Emerald shiner	S	May-Aug	B, P	>3	Unk[1]		
	F	May-Aug					
Greater redhorse	S	May-Jul	B	0.3-3.0	0.1-3.8	Gravel/Cobble	No
	F	May-Jul	-	>0.7	0.69	Gravel/Cobble	No
Lake sturgeon	S	May-Jun	B	2.0-25.0	0.32-2.29	Gravel/Cobble	No
	F	May-Jun	D	-	-	Gravel/Cobble	No
Lake trout	S	Sep-Nov	B	1-120	-	Rock/Boulder	No
	F	Jan-Mar	-	1-120	-	Rock/Boulder	No
Largemouth bass	S	May-Jun	N	0.5-26	0.0-0.09	Gravel	No
	F	May-Jun	-	>3.3	0.0-0.02	-	Yes
Muskellunge	S	May-Jun	B	3.0-7.0	-	-	Yes
	F	May-Jun	-	3.3	0.0	-	Yes

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TABLE 5.2.1-1 (CONT.)

POTENTIALLY AFFECTED FISH FOCUS SPECIES HABITAT PREFERENCES

Species	Life Stage[1]	Time Period	Strategy[2]	Depth (feet)	Velocity (fps)	Substrate	Vegeta -tion
Northern pike	S	Mar-May	B	0.5-16	-	-	Yes
	F	Mar-May	A	1-16	-	-	Yes
Rainbow smelt	S	Mar-Apr	B	0.3-4.3	2.0-2.6	Sand-Gravel	No
	F	May-Aug	D	-	-	Sand-Gravel	No
Rainbow trout	S	Apr-Jun	N	1.0-8.0	1.6-3.0	Gravel	No
	F	May-Aug	-	0.8-1.6	0.0-.05	Gravel	Yes
Rock bass	S	May-Jun	N	2.0-4.0	0	Gravel	Yes
	F	May-Jun	-	2.0-4.0	0	Gravel	Yes
Smallmouth bass	S	May-Jul	N	2-20	0.0-1.1	Gravel	No
	F	May-Jul	-	<2.4	<0.5	Gravel/Cobble	No
Walleye	S	Apr-May	B	2.5-5.0	2.5-3.0	Gravel/Cobble	No
	F	Apr-May	D	1.0-12.0	<0.25	Silt-Gravel	-
White sucker	S	Apr-Jun	B	0.2-1.0	1.0-2.0	Gravel	No
	F	Apr-Jun	-	>1.0	<0.3	-	-
Yellow perch	S	Apr-May	B	1.2-3.0	<0.25	Fines/Brush	Yes
	F	May-Jul	P	>0-20.0	-	Fines	Yes

[1]S=Spawning, F=Fry; [2]A=Attached (to vegetation), B=Broadcast, D=Drift, N=Nest, P=Pelagic.

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6.0 CONCLUSIONS

The potential effect of water level fluctuations on aquatic and terrestrial habitat and the habitat used by representative species was assessed in the upper and lower Niagara River and Lewiston Reservoir. This was done by collecting habitat information along representative transects, analyzing water level fluctuation information, and reviewing the habitat needs of representative species during various life stages. There are several factors that affect water level fluctuations in the Niagara River. The influence of these factors on water levels is interrelated and dynamic. Because the water level in the Niagara River at any location at any time is a complex function of natural and manmade factors, distinguishing the exact amount of water level fluctuation attributable to each factor is difficult. In the upper river, the effect was assessed using monthly minimum and maximum water level data from permanent water level gauges for a typical, wet and dry year. To narrow the list of factors that affect water level fluctuations, all "significant" storm events were removed from the dataset of the upper Niagara River. For the lower river, monthly minimum and maximum water levels from temporary gauges in 2002 were used (the water level elevation of the lower Niagara River is a complex function of Lake Ontario level, discharge from the Robert Moses and Canadian plants, and flow rate over Niagara Falls, and there are no permanent water level elevation gauges in the lower Niagara River downstream of the Robert Moses tailrace). For the Lewiston Reservoir, monthly minimum and maximum water levels from 1991-2002 were used; Niagara Power Project operations determine the water level of Lewiston Reservoir, and Project operations react to the demand for energy and the Niagara River flow. The approach used for this investigation provides a resource conservative assessment of the potential effects due to NYPA and OPG operations.

From the analyses of the water level fluctuations coupled with the habitat that is present in the upper and lower Niagara River and Lewiston Reservoir, the following conclusions are made:

- The general distribution and species composition of SAV in the upper Niagara River has been similar since 1928. According to a survey conducted in 1955, SAV was never common in water less than ~1.5 - 2 feet deep,

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except in protected areas. In 2002, SAV was present at depths of ~2 to 20 feet in most areas, and in water < 2 feet deep in protected areas;

- The distribution and species composition of SAV in the lower Niagara River has been similar since 1928. According to a survey conducted in 1928, SAV was not common in water less than 3 feet deep. In 2002, SAV was present at depths of ~2 to 20 feet in most areas. The dominant SAV species were the same in 1928 and 2002;
- The sides of the Lewiston Reservoir are large boulder riprap, which is unsuitable substrate for the establishment of SAV. Most of the bottom of the reservoir contains substrate suitable for SAV establishment, but extensive SAV establishment is likely precluded by water level fluctuations. If the water were held at a constant elevation at full reservoir depth, the water depth would be too great for the establishment of SAV;
- Water level fluctuations in the upper river and Grand Island tributaries could result in changes in coastal wetland habitat structure, distribution, and species composition. Literature indicates that this is consistent with the effect of water level fluctuations on coastal wetlands throughout the Great Lakes and is not unique to the investigation area. Coastal wetlands are dynamic ecosystems that typically require water level fluctuations and both high and low water levels to maintain habitats and the diversity of plant and animal species (Maynard and Wilcox 1996; USGS 2003). These fluctuations have varying sources, magnitudes, frequencies, timing, and duration, each with different effects on wetlands, and are important to the maintenance of coastal wetlands (Maynard and Wilcox 1996). Daily water level fluctuations resulting from American and Canadian hydroelectric operations do not appear to have a direct effect on coastal wetlands. These daily fluctuations in the Chippawa-Grass Island Pool (the portion of the upper Niagara River most influenced by hydroelectric operations) are generally 1.5 feet or less from April 1 to October 31 of each year, and 0.5 feet or less the remainder of the

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year. Distribution of wetland vegetation is likely not significantly altered by daily fluctuations and no stressed or dying vegetation was observed during field surveys. This is likely due to the adaptation of coastal wetlands to the cyclical and generally consistent extent and frequency of daily water level fluctuations. Paralells can be drawn between the adaptation of tidal freshwater marshes as described by Odum et al. (1984) and coastal wetlands subjected to the daily water level fluctuations that occur in the investigation area;

- Regulation of water levels that result in dampening of fluctuations can affect coastal wetlands. Where water-level regulation has significantly reduced the occurrence of extreme high and low water levels, disruption of the natural fluctuation cycle favors species intolerant of water-depth change and associated stresses, and/or excludes species requiring periodic exposure of fertile substrates, potentially leading to a reduction of species diversity (Maynard and Wilcox 1996; Minc and Albert 2001). For example, the dominance of cattails in many Lake Ontario marshes suggests a trend toward reduced species diversity following a reduction in the amplitude of natural water level fluctuations (Wilcox and Meeker 1992; Minc and Albert 2001, USGS 2003). The NYSDEC and NYSOPRHP, concerned about a lack of occurrence of high water levels in Buckhorn Marsh due to water-level regulation, initiated a restoration project. Earthen berms and two water-control weirs were constructed to raise and stabilize water levels in the marsh. Water level data indicate that the weirs were successful at increasing and stabilizing water levels in the marsh (URS et al. 2005a). In the spring, water levels inside the water control weirs were typically about 1.0 foot higher than in the west side of the marsh and these levels were much more constant than in the portions of Burnt Ship Creek and Woods Creek open to the Niagara River (URS et al. 2005a). These data suggest that the water levels in the marsh between the weirs are largely independent of the Niagara

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River and the marsh restoration project appears to have been successful at keeping these water levels higher and more stable than they were previously;

- In the upper river, seasonal and daily fluctuations in water levels may influence the portion of the nearshore zone affected by waves by exposing a wider area of this zone to wave action than if there were no fluctuations. Energy associated with waves may be an important factor affecting the local extent of EAV in nearshore habitats, physically uprooting and removing EAV and creating bands of coarser substrates in exposed nearshore habitats (Maynard and Wilcox 1996);
- Coastal wetland habitats are not found in the lower river because of the relatively steep upland slopes leading down to the water, the lack of shallow water areas with flat bathymetry, and fast water flows. These combined factors are not conducive to the development of coastal wetlands, and these habitats likely have never existed in the lower river to any great extent. There are no areas of coastal wetland in the lower river that could be affected by water level fluctuations;
- The steep, riprapped interior walls of Lewiston Reservoir are not conducive to the development of coastal wetland habitat. There are no areas of coastal wetland in Lewiston Reservoir that could be affected by water level fluctuations;
- Water level fluctuations in the upper and lower Niagara River and the Lewiston Reservoir do not affect the spawning, egg and larval habitat of emerald shiner, as emerald shiner are pelagic and their spawning, egg and larval habitat is in mid-water. Water level fluctuations in the lower Niagara River do not affect burrowing mayfly nymphs and eggs, and giant floater mussels.
- Water level fluctuations have the potential to affect the spawning, egg and larval habitat used by lake sturgeon, lake trout, muskellunge, largemouth

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bass, smallmouth bass, walleye, yellow perch, bluntnose minnow, and crayfish (in both the upper and lower Niagara River), brown bullhead, greater redhorse, burrowing mayfly nymphs and eggs, and giant floater mussels (in the upper Niagara River only), and Chinook salmon and rainbow smelt (in the lower Niagara River only). These potential effects are somewhat mitigated by the fact that suitable habitat exists at greater depths and affords opportunities for these species' lifestages at depths that are not affected by water level fluctuations;

- Water level fluctuations in the upper and lower Niagara River have the potential to affect the spawning, egg and larval habitat used by northern pike. Northern pike are documented to spawn in shallow (<1.2 feet deep) water on SAV and EAV, but are also documented to spawn over SAV in water up to 16 feet deep. SAV is common throughout the upper and lower Niagara River and along the shorelines of the lower river in water up to ~20 feet deep, and provides suitable spawning, egg and larval habitat at depths that are not affected by water level fluctuations. EAV is nearly absent from the lower Niagara River; therefore, northern pike in the lower river may spawn only over SAV, which is generally below the depth affected by water level fluctuations;
- Water level fluctuations in the upper and lower Niagara River have the potential to affect the spawning, egg and larval habitat used by white sucker. Of the aquatic focus species, white sucker have the narrowest range of spawning depths (0.2 – 1 foot);
- The large boulder riprap sides of the Lewiston Reservoir are not suitable substrate for the spawning of smallmouth bass, rock bass, and yellow perch. The substrate of the bottom of the reservoir is not suitable for smallmouth bass and rock bass spawning. Although the substrate of the bottom of the reservoir is suitable for yellow perch spawning, there is little SAV and submerged brush, which is preferred habitat for yellow perch spawning;

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- In the upper Niagara River and associated tributaries, some of the suitable habitat for the egg and larval lifestages of the green frog, northern leopard frog, and common mudpuppy is located in water depth zones that are influenced by water level fluctuations. However, review of literature and physical habitat data collected in 2002 revealed that there is suitable habitat for these species' lifestages at depths that are not influenced by water level fluctuations. This may somewhat mitigate any effects resulting from water level fluctuations. A similar situation exists in the lower Niagara River for the egg and larval lifestages of the common mudpuppy and green frog;
- In the upper Niagara River and associated tributaries, some of the suitable habitat for the overwintering (hibernation) lifestage of the green frog, northern leopard frog, common snapping turtle, and midland painted turtle is located in water depth zones that are influenced by water level fluctuations. However, review of literature and physical habitat data collected in 2002 revealed that there is suitable habitat for this lifestage in habitats that are not influenced by water level fluctuations. This may somewhat mitigate any effects resulting from water level fluctuations. A similar situation exists in the lower Niagara River for the overwintering lifestage of the green frog, common snapping turtle, and midland painted turtle. During the winter, water levels in Grass Island Pool are held at a more constant level than during the tourist season (when they also fluctuate daily because of the change between the 100,000 and 50,000 cfs flows) in order to achieve the long-term average of 562.75 feet. The more constant water levels are not lowered below levels seen at the 50,000 cfs flow during the tourist season. If adult amphibians and their larvae begin hibernation at the end of the tourist season (when flows generally fluctuate between the 100,000 cfs and 50,000 cfs flows), it is possible that they will respond to the daily fluctuations and choose hibernation sites outside of the zone of fluctuation;

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- Some of the suitable nesting habitat of the Virginia rail, American coot, and spotted sandpiper is located in areas influenced by water level fluctuations in the upper river. However, literature indicates that nesting birds are known to adapt to water level changes by employing various nest building strategies and/or by laying multiple clutches of eggs during the nesting season. A similar situation exists in the lower river for the nesting lifestage of the spotted sandpiper;
- There is muskrat habitat (all lifestages) in the upper river that is influenced by water level fluctuations. However, review of literature and biological data of the upper river indicate that sufficient food sources exist and there is suitable water depth for muskrat below the zone that is influenced by fluctuating water levels. In addition, literature also indicates that muskrats can build high and low level (elevation) dens and access tunnels in river banks to accommodate fluctuating water levels. There is suitable habitat available for the muskrat in areas not influenced by water level fluctuations (i.e., between the weirs at Buckhorn Marsh);
- Preferred substrates and hibernacula for the common snapping turtle are absent form Lewiston Reservoir and suitable nesting habitat is found outside the zone of water level fluctuations. The great blue heron, canvasback, and greater scaup do not nest in the reservoir. The common mudpuppy is likely unaffected by water level fluctuations in Lewiston Reservoir as they are mobile and active throughout the year;
- Water level fluctuations can have an overall positive effect on the foraging opportunities of wildlife focus species that feed in nearshore habitats of the upper and lower rivers. Temporal shifting of the water depth zones can increase foraging opportunities for these species by increasing the amount of area available for foraging when the water is low. Conversely, foraging opportunities can be diminished when water levels are high;

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- Foraging opportunities for the great blue heron and spotted sandpiper would likely be enhanced during low water levels in the reservoir because of the increased availability of forage area and easier access to prey. Conversely, the foraging efficiency of canvasback is potentially indirectly affected by water level fluctuations because the extreme weekly fluctuations in Lewiston Reservoir preclude the development of extensive SAV beds. The effects on the foraging efficiency of greater scaup are expected to be minimal because this species forages in a wide range of water depths (similar to those found in the reservoir). During the time that this species typically occurs on the reservoir to any significant extent (fall and winter), water depths in most areas of the reservoir are at least 10 feet or greater.

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