APPENDICES

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APPENDIX A - PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECTS

Transect 1
Transect 2
Transect 3
Transect 4
Transect 5
Transect 6
Transect 7
Transect 8
Transect 9
Transect 10
Transect 11
Transect 12
Transect 13
Transect 14
Transect 15
Transect 16
Transect 17
Transect 18
Transect 19
Transect 20
Transect 21
Transect 22
Transect 23
Transect 24
Cayuga Creek Transect 1
Cayuga Creek Transect 2
Cayuga Creek Transect 3
Ellicott Creek Transect 1
Ellicott Creek Transect 2
Ellicott Creek Transect 3
Tonawanda Creek Transect 1
Tonawanda Creek Transect 2
Tonawanda Creek Transect 3

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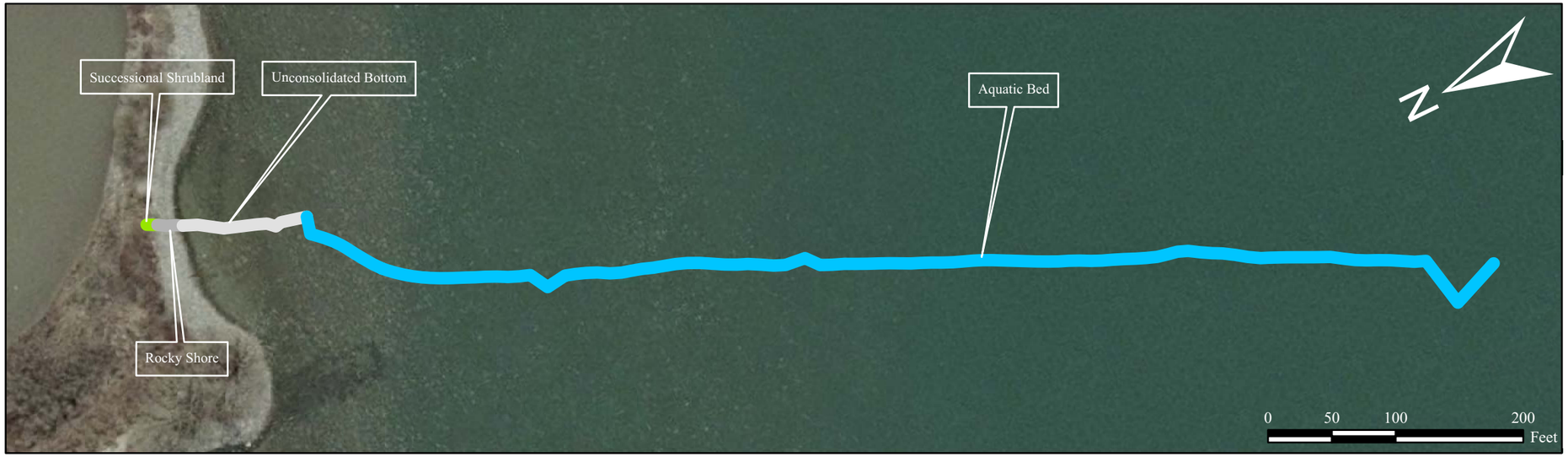
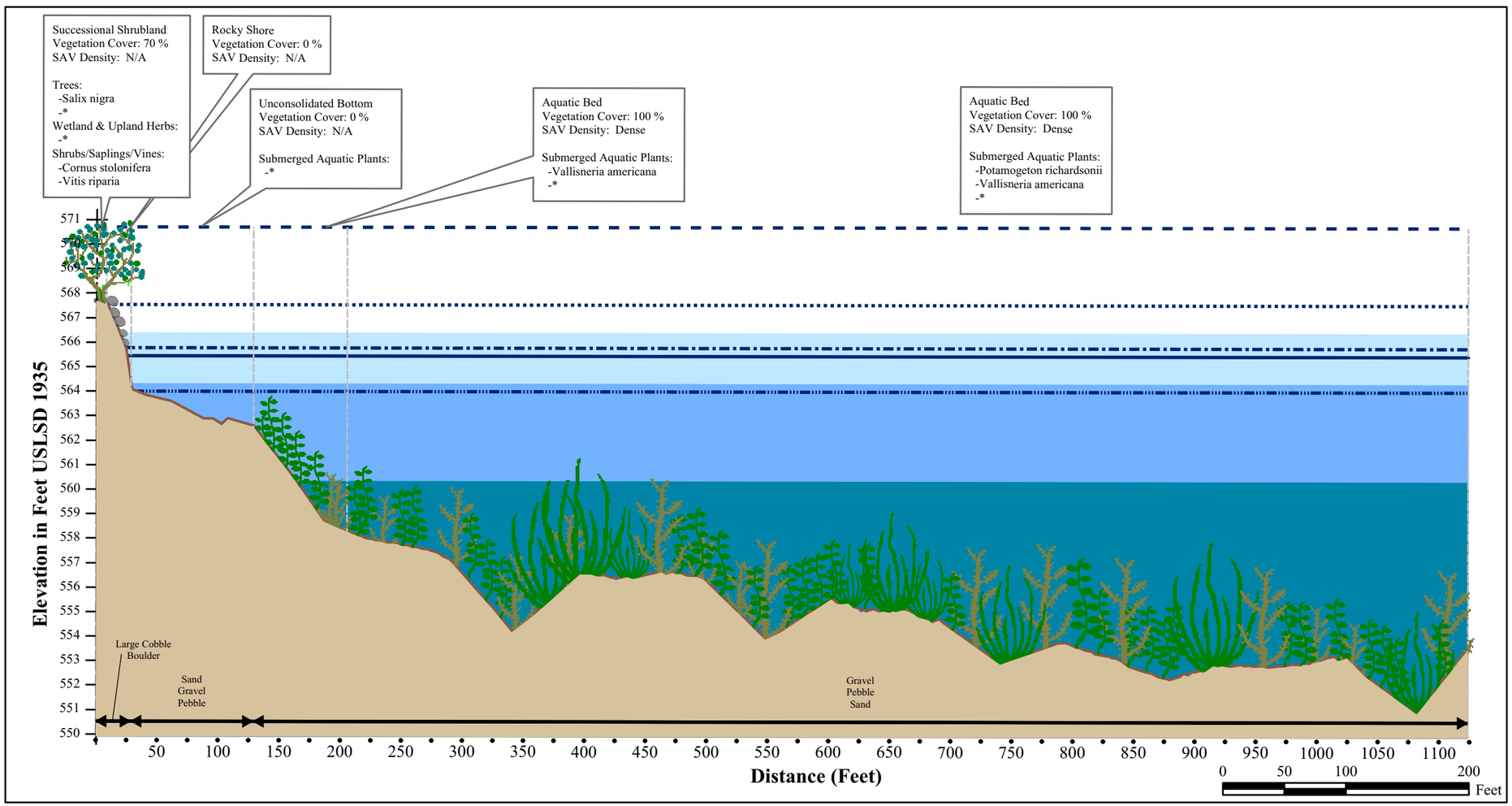




NEW YORK POWER AUTHORITY
NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 1

LEGEND

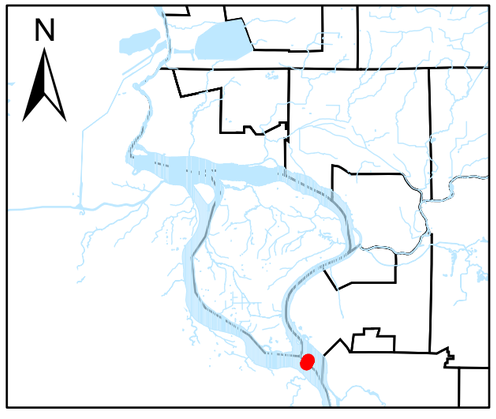
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (08/23/02 14:16)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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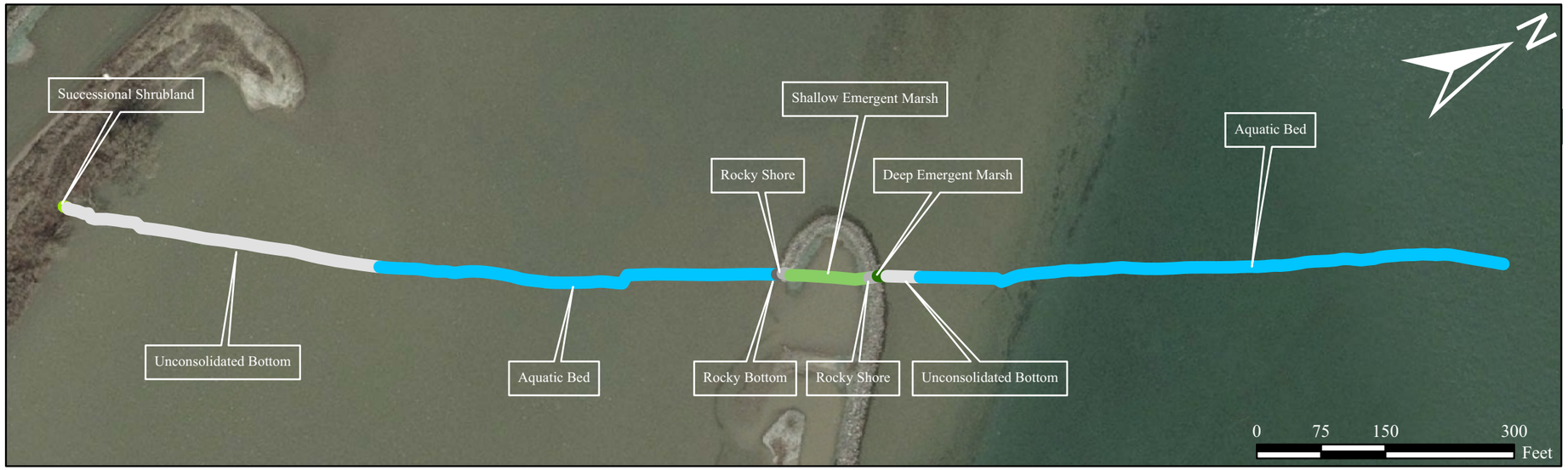
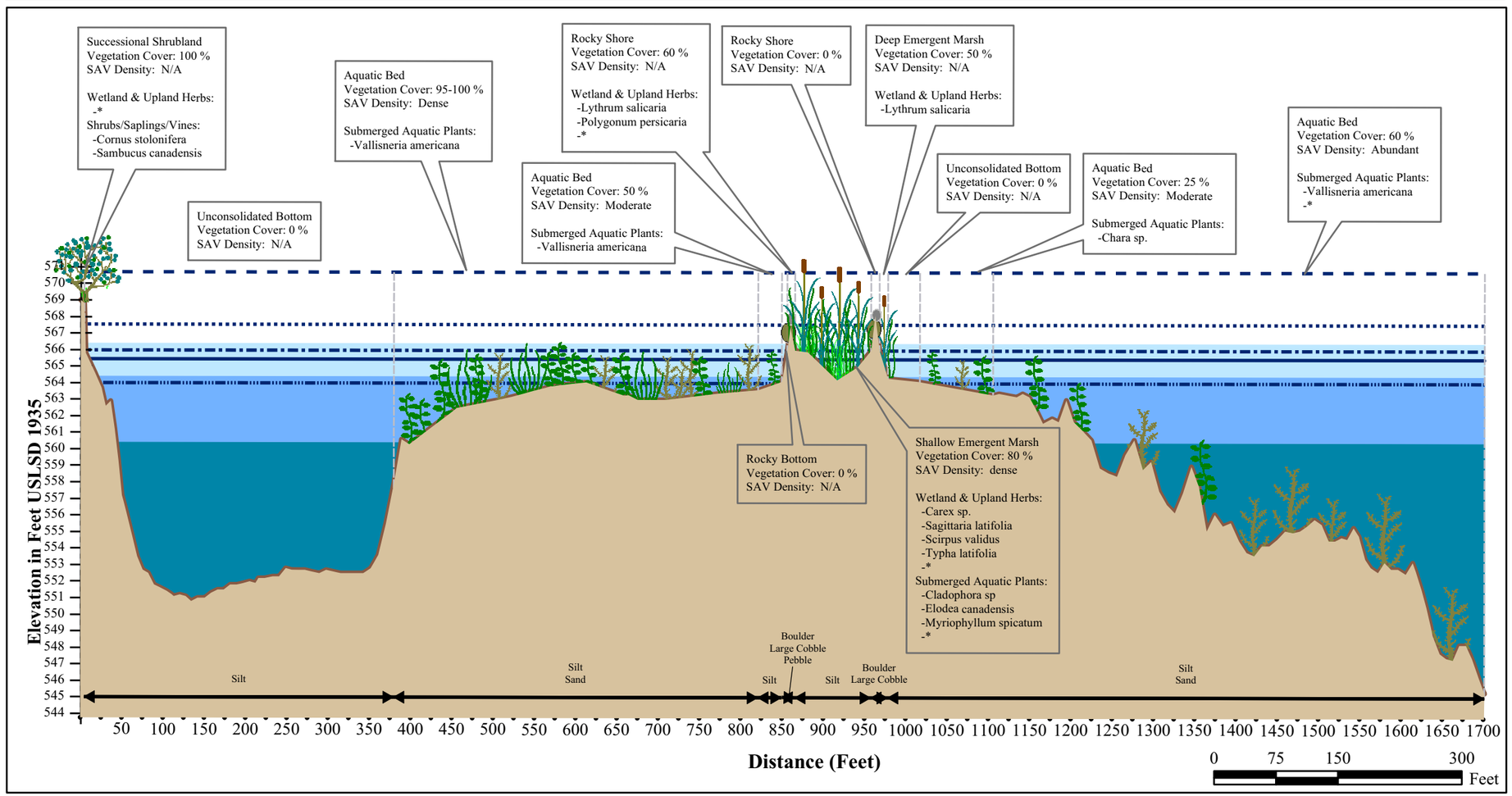
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 2





LEGEND

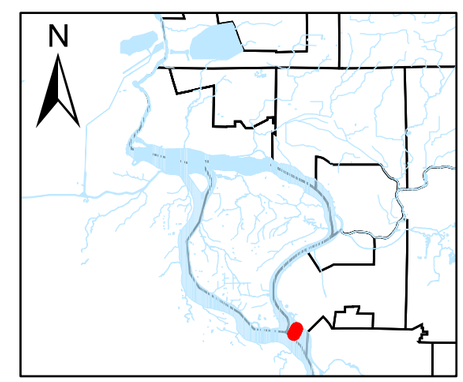
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (08/26/02 12:48)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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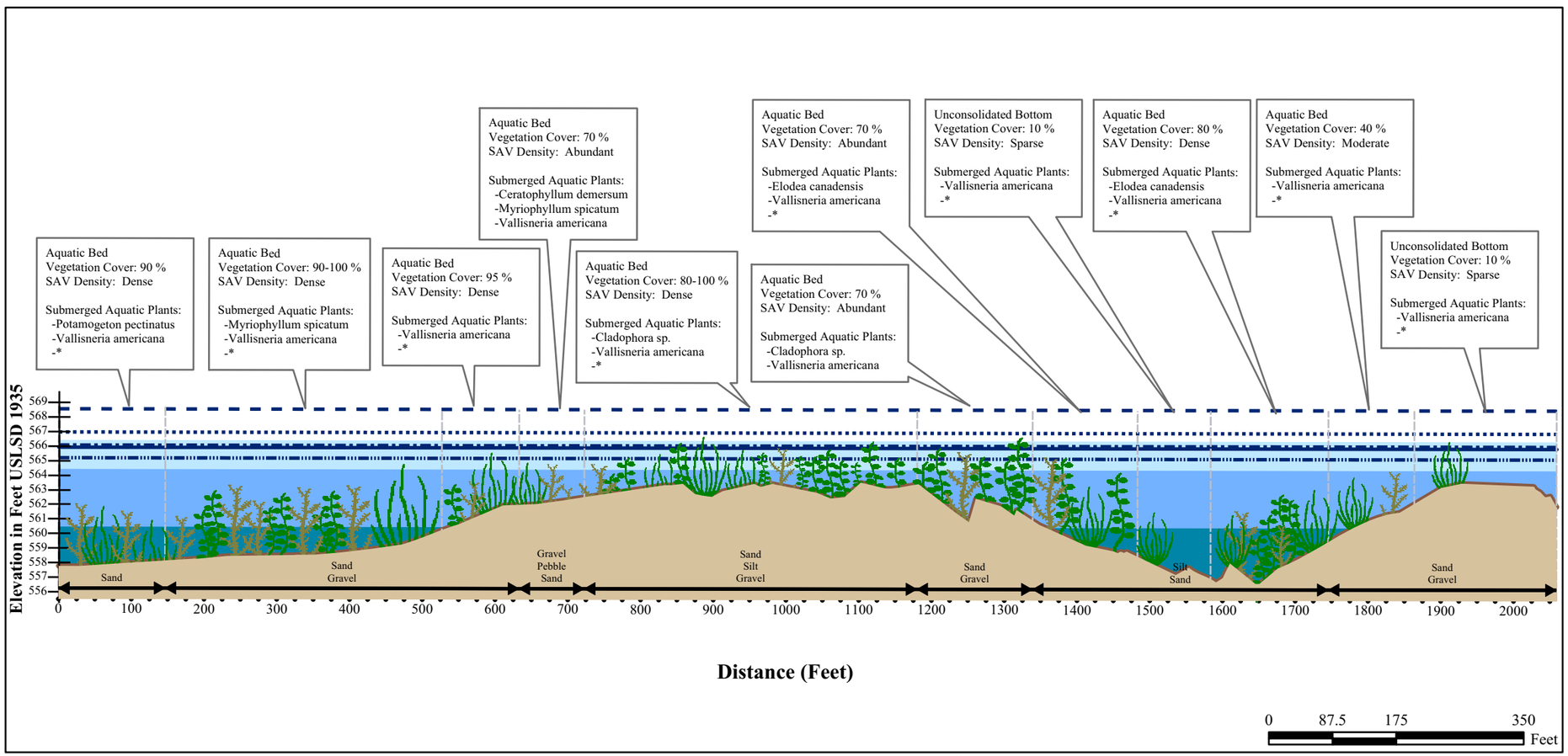

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 3

LEGEND

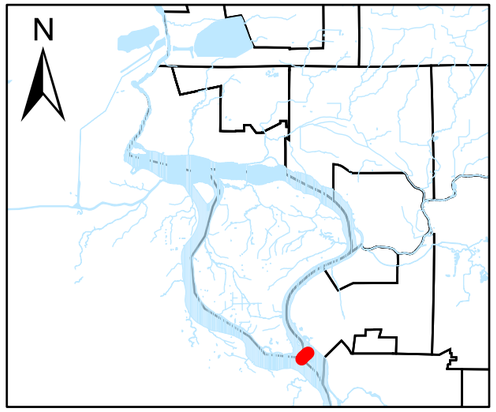
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (08/30/02 10:33)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



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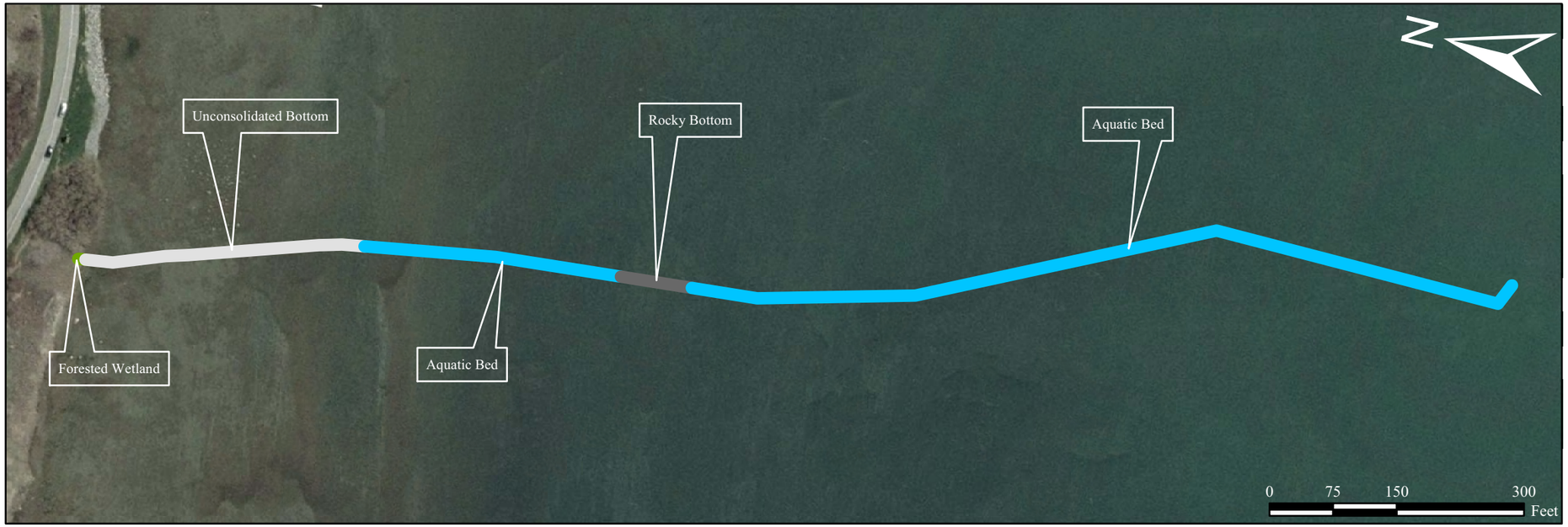

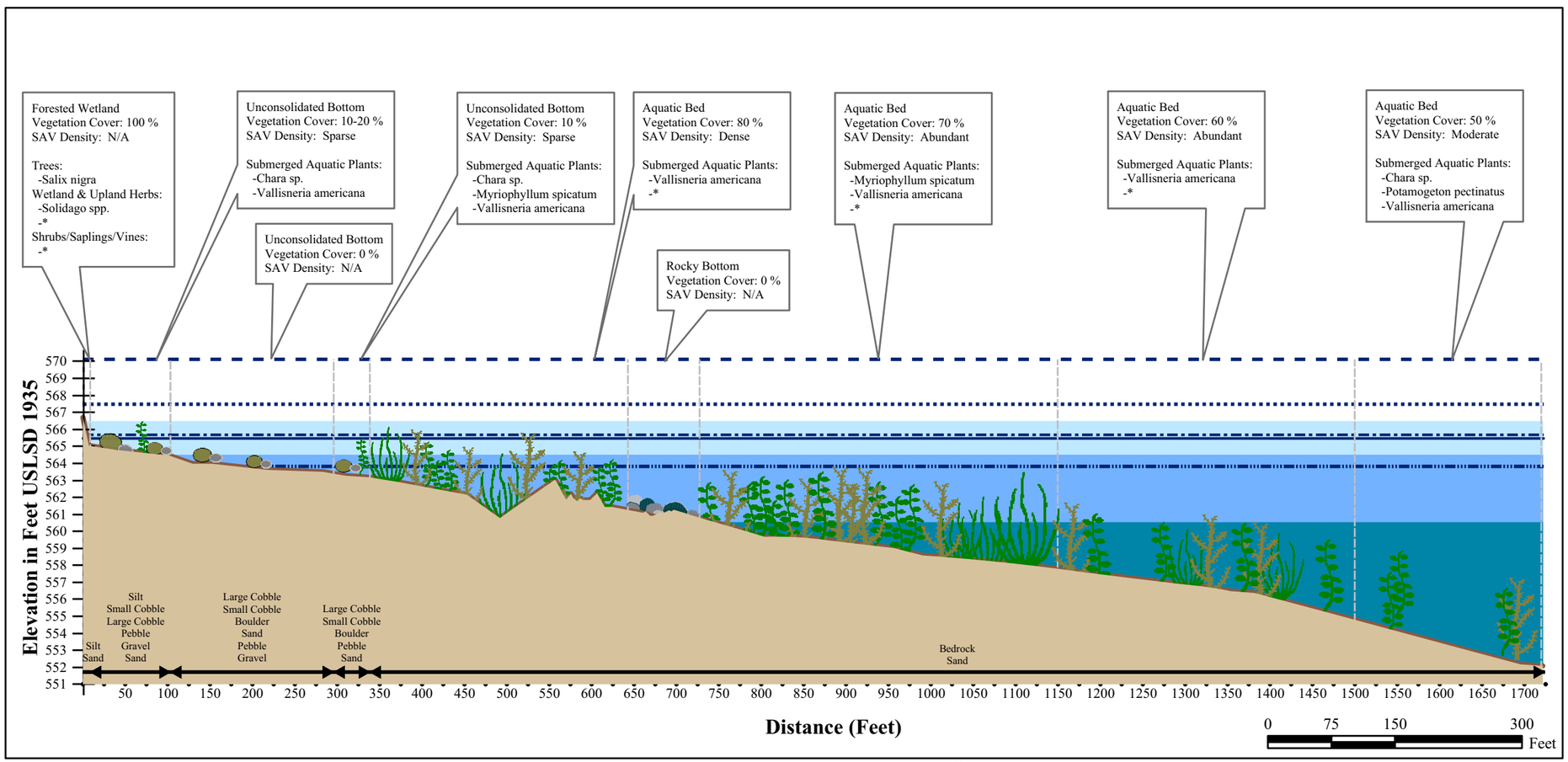

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 4

LEGEND

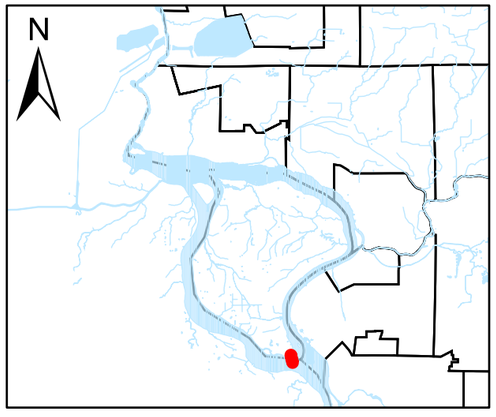
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (08/28/03 11:30)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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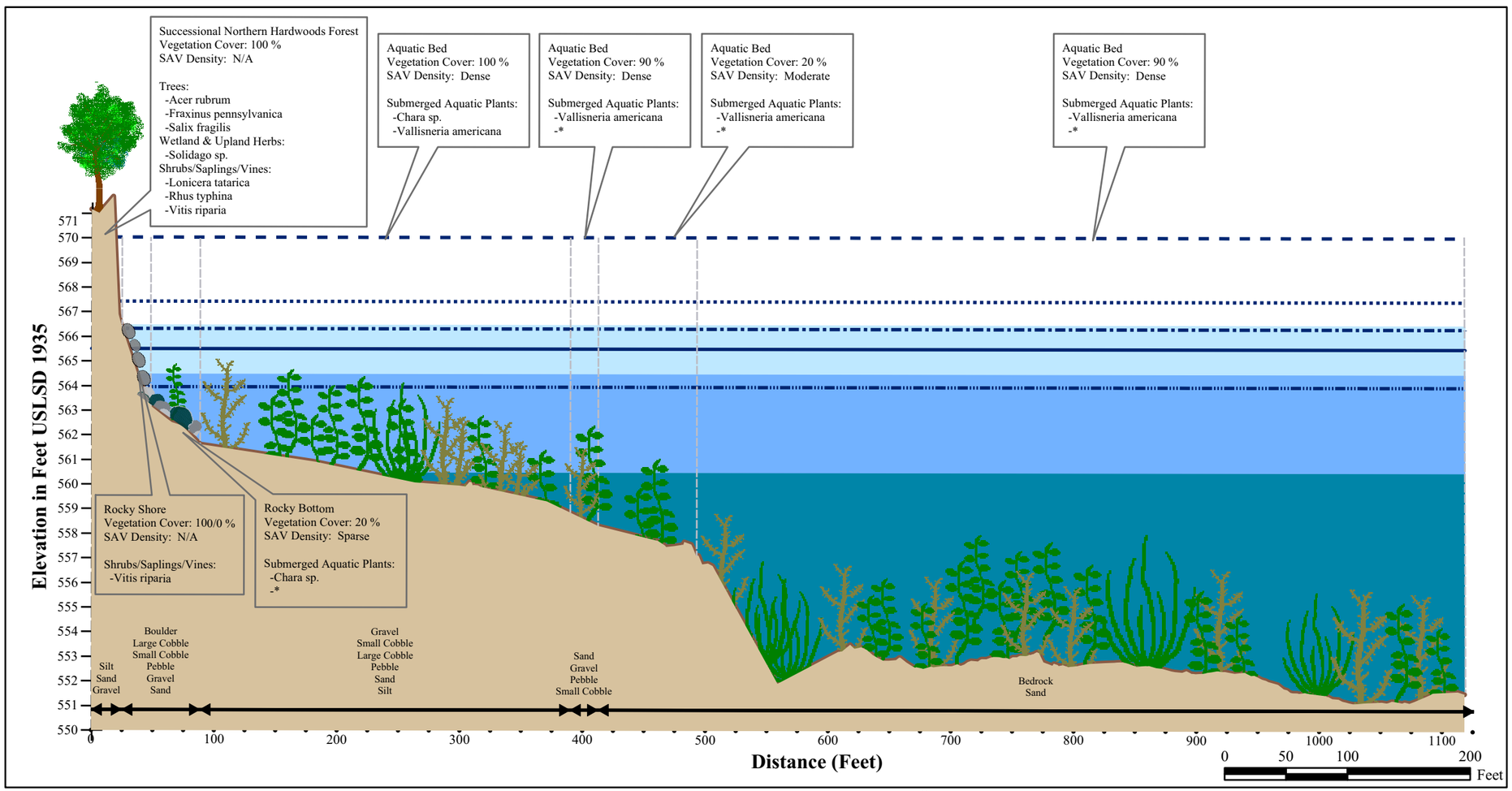

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 5

LEGEND

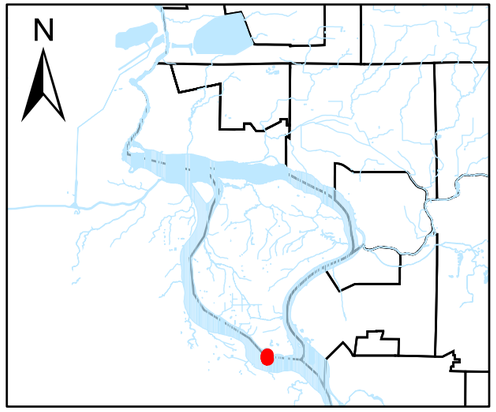
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/04/02 11:00)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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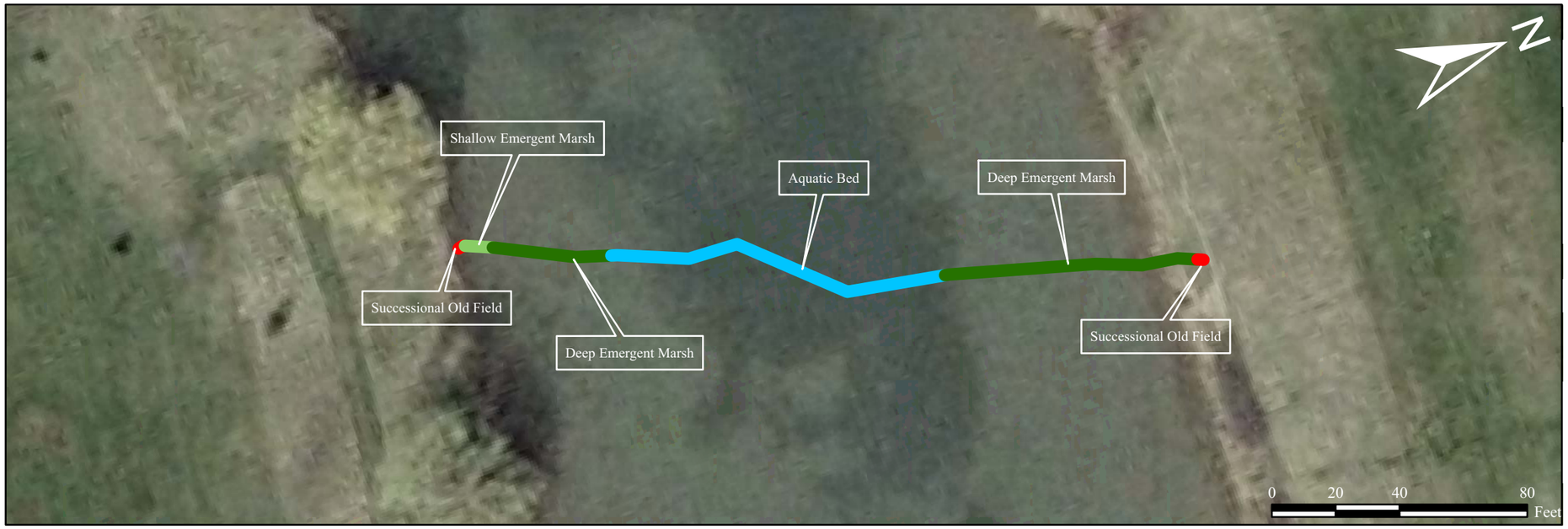

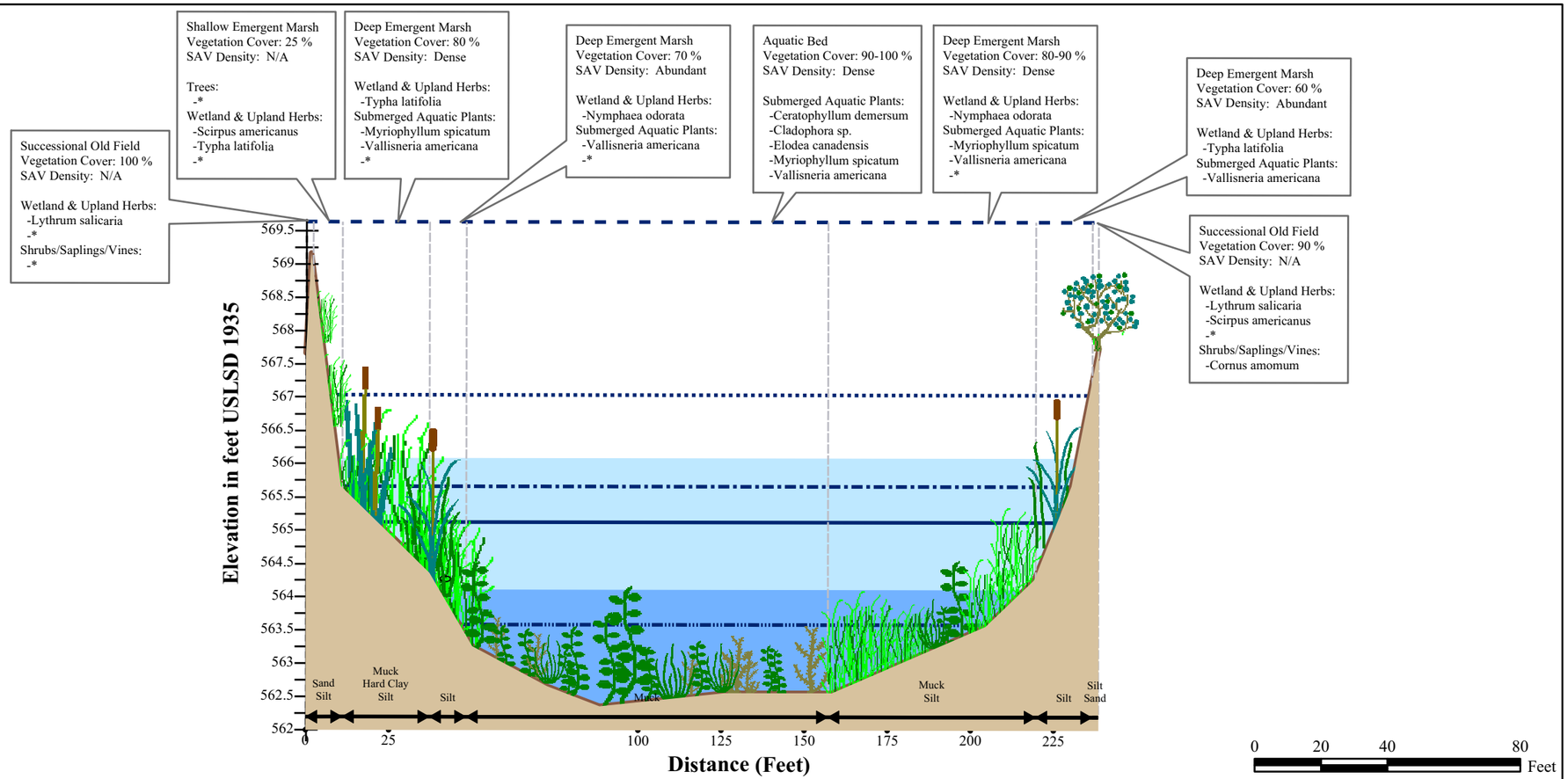

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 6

LEGEND

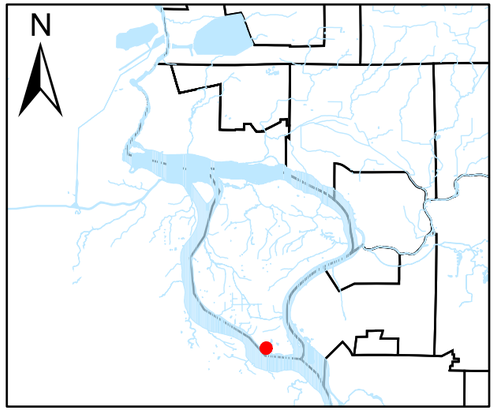
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey(08/30/02 13:06)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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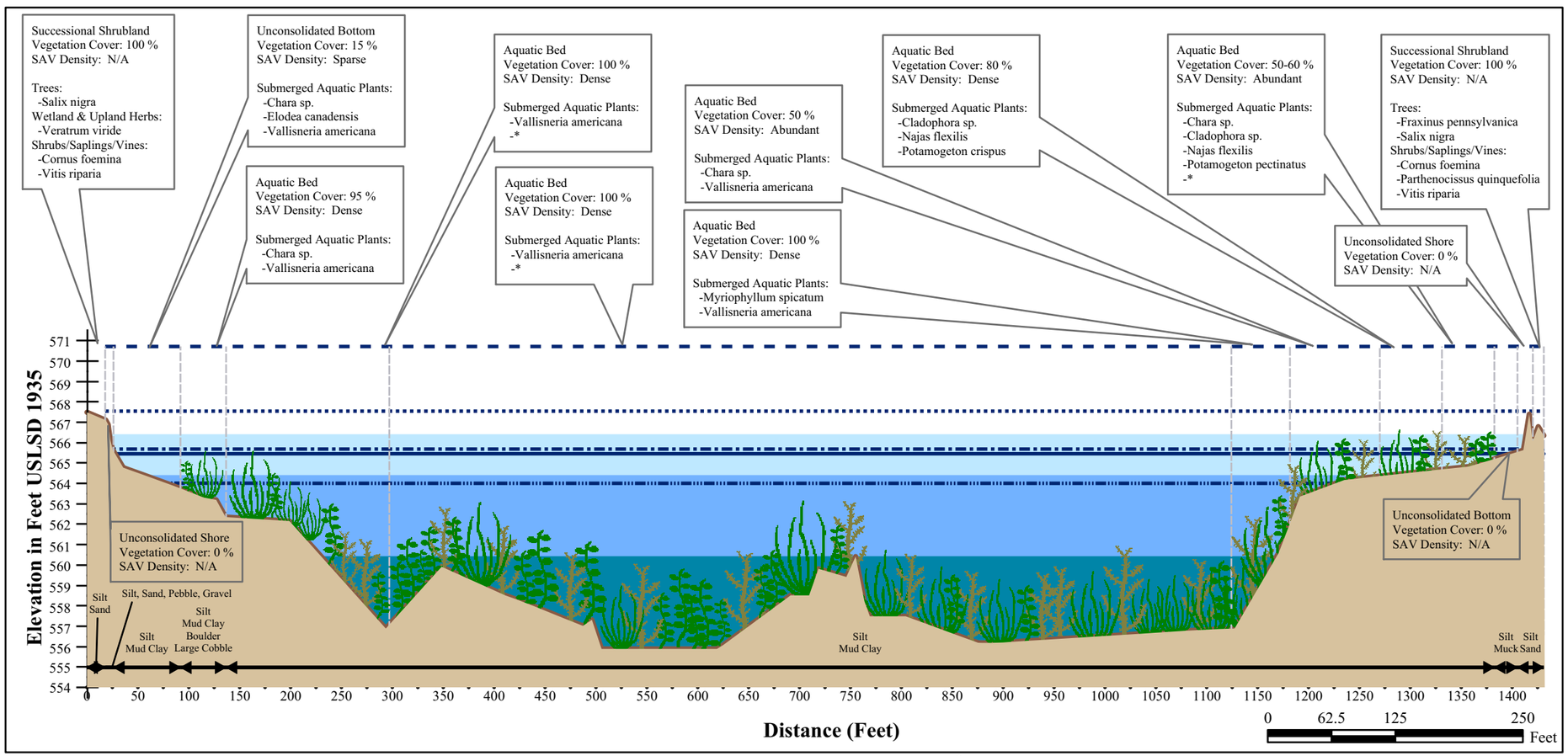

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 7

LEGEND

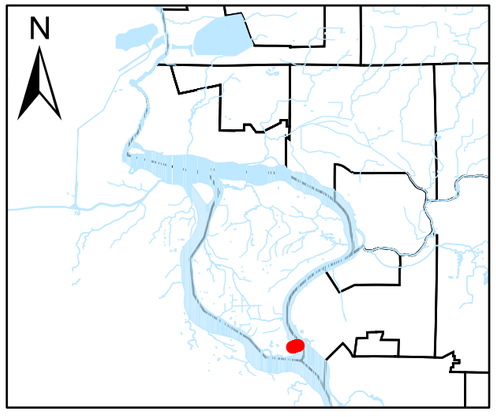
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (08/27/02 11:02)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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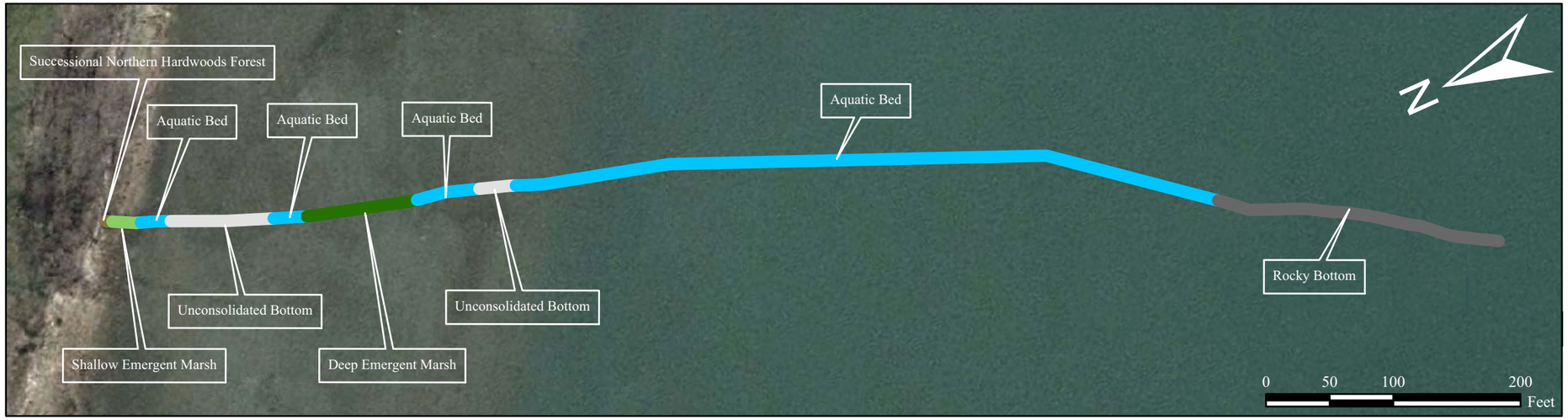

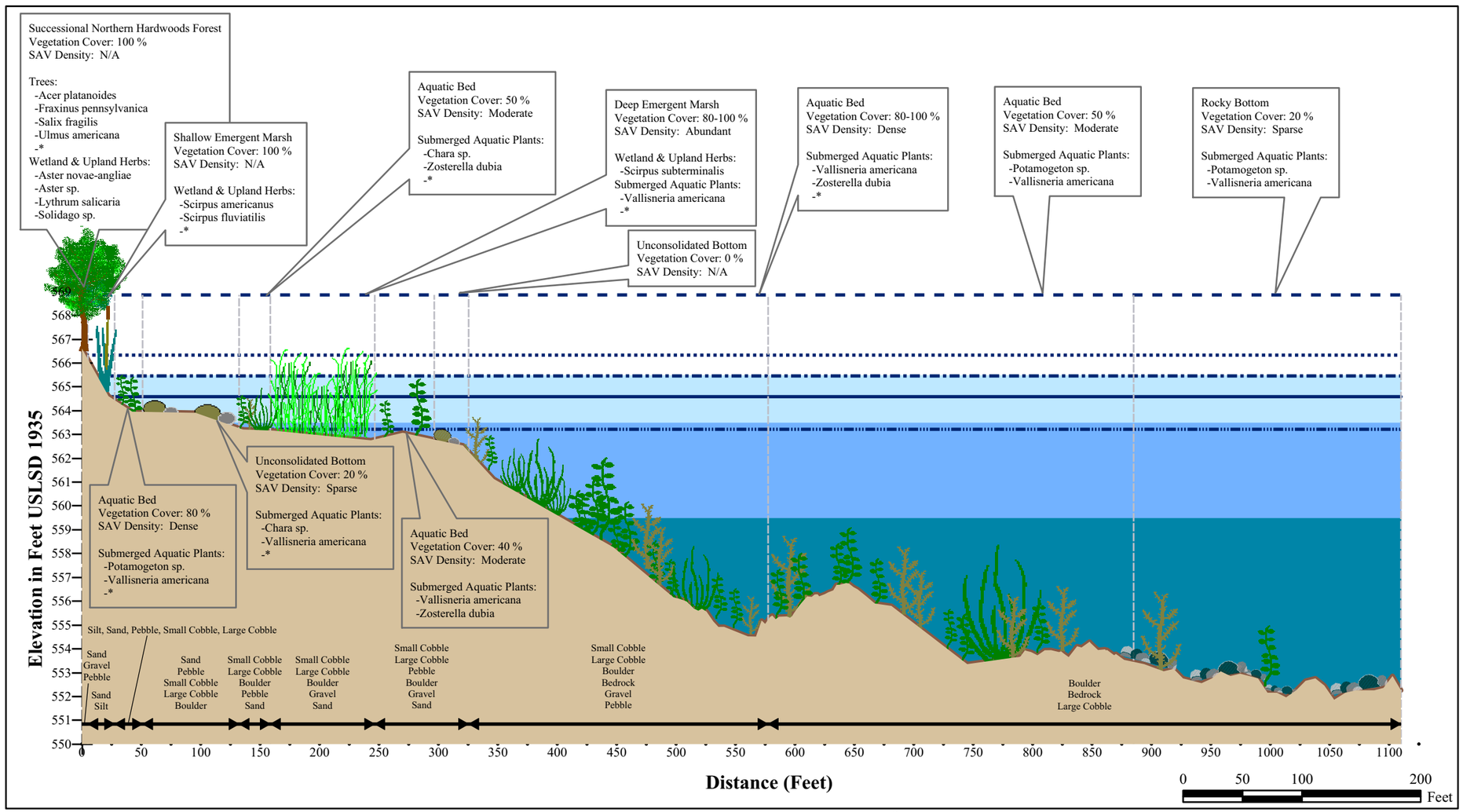

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 8

LEGEND

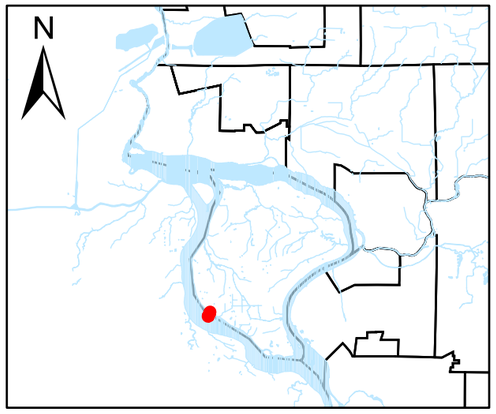
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/06/02 13:51)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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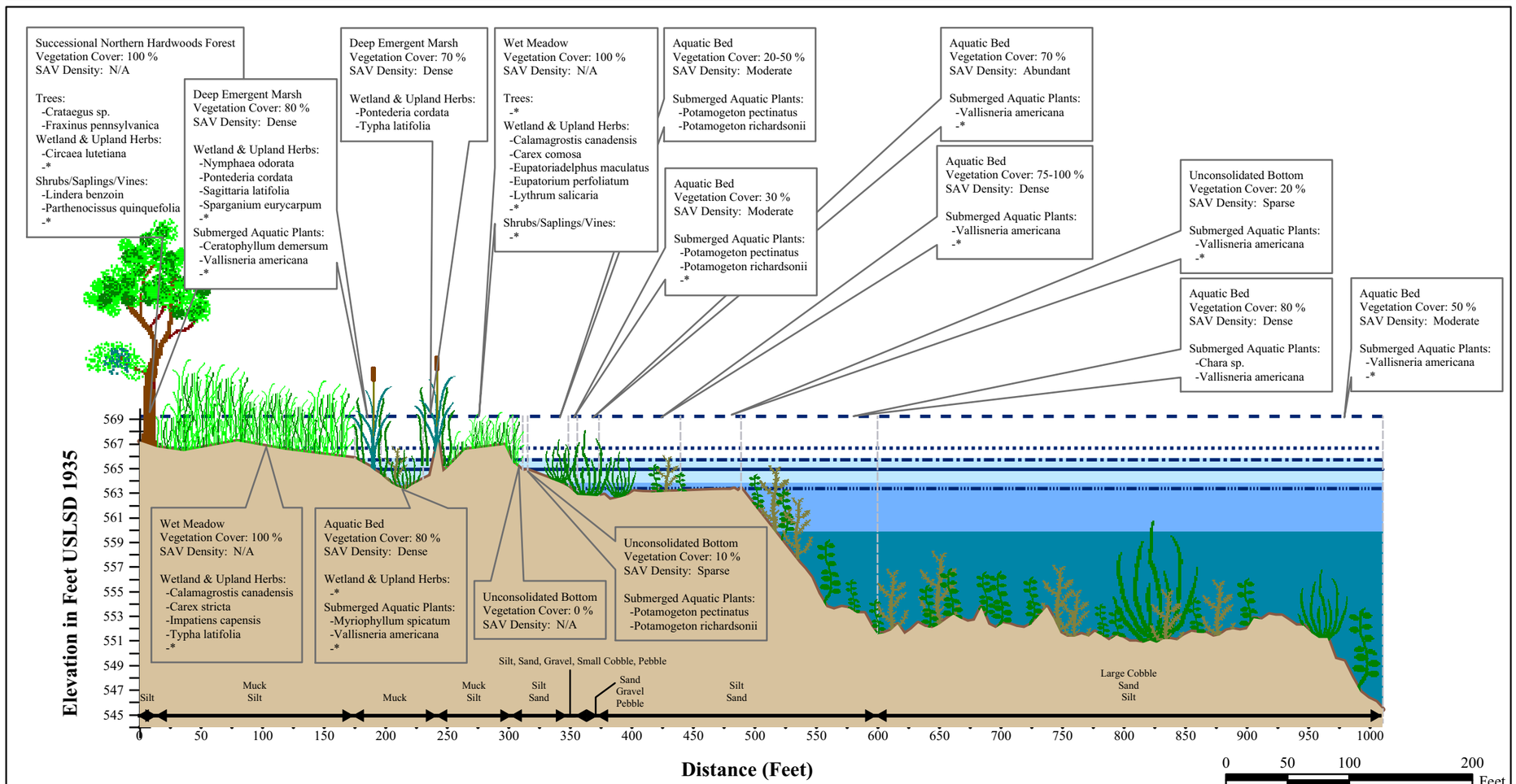

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 9

LEGEND

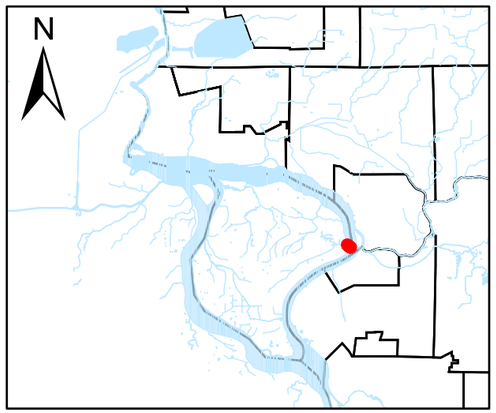
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (05/21/02 12:00, 08/15/02, 09/04/02 13:15)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:10

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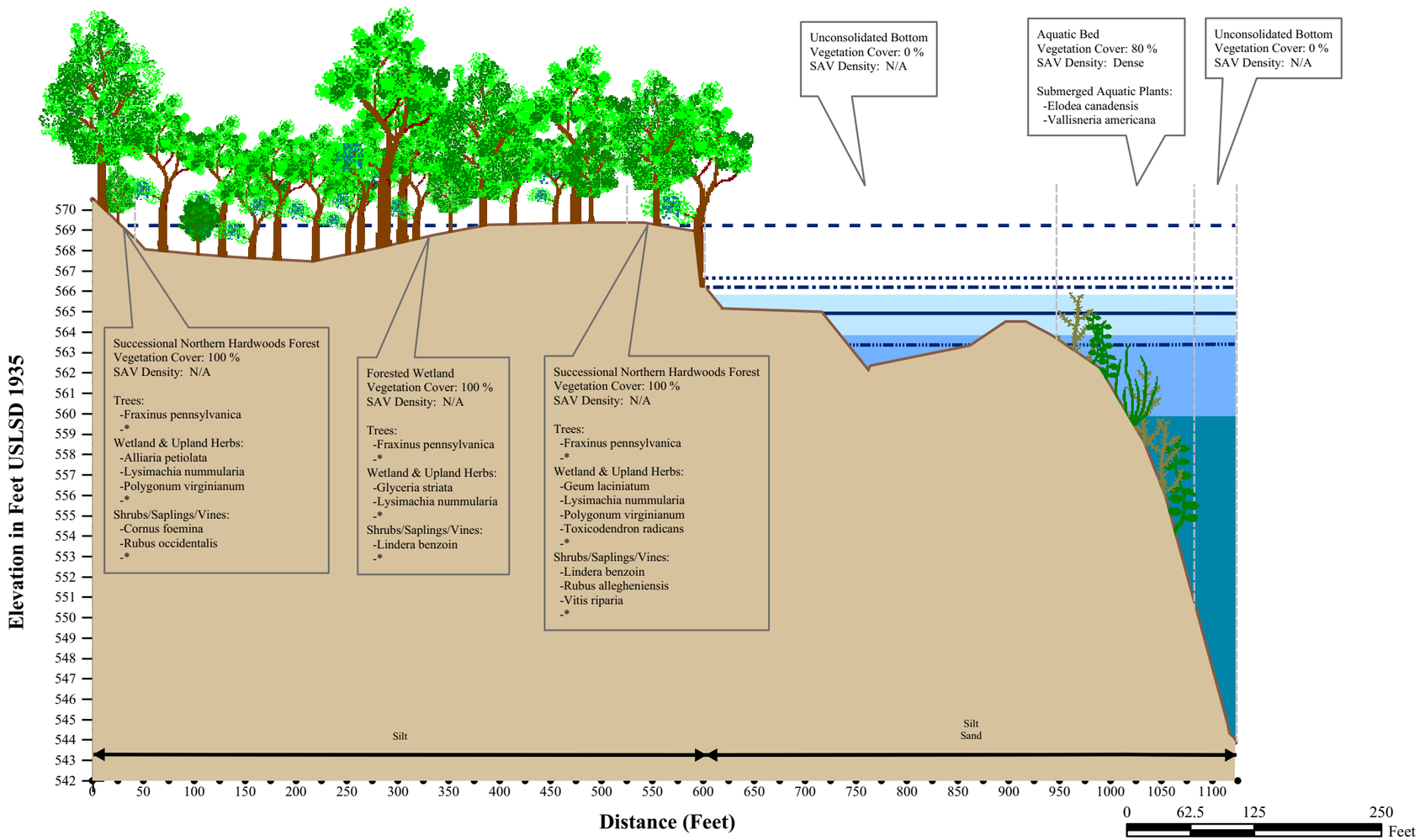

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 10

LEGEND

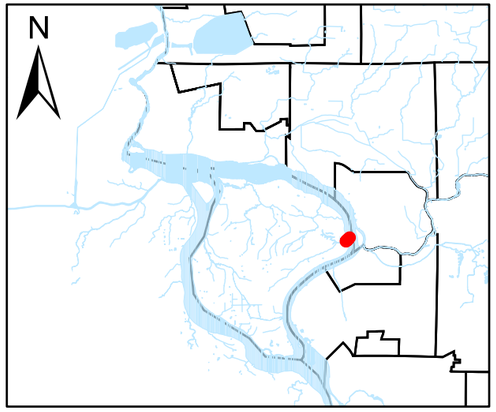
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (05/21/02 9:30, 08/15/02, 09/04/02 15:00)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



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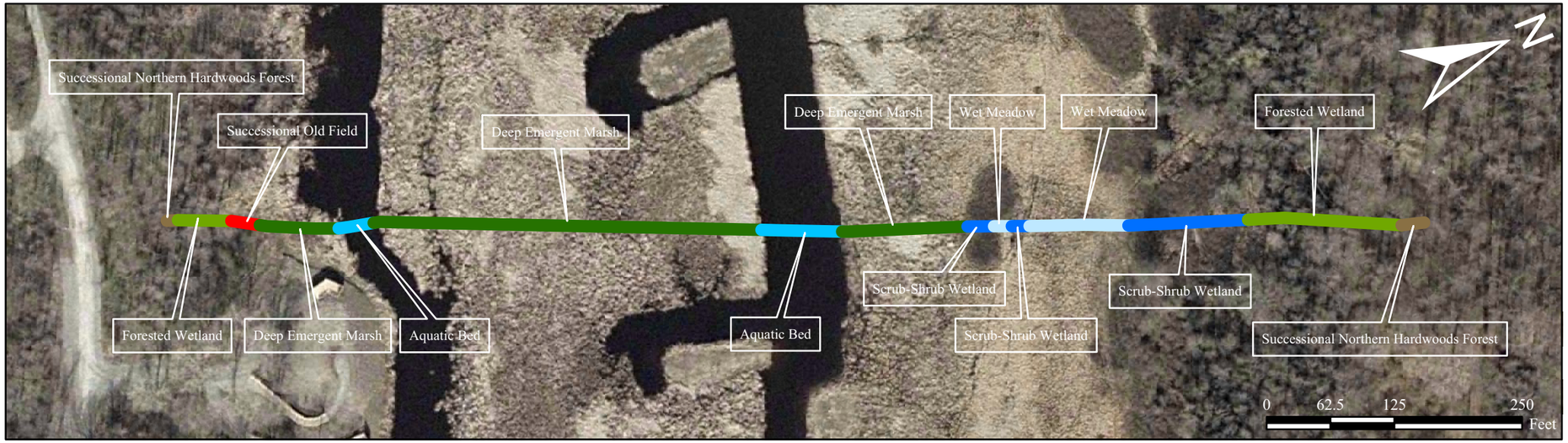


Successional Northern Hardwoods Forest
Vegetation Cover: 100 %
SAV Density: N/A

Trees:
-Fraxinus pennsylvanica
-*
Wetland & Upland Herbs:
-Geum laciniatum
-Parthenocissus quinquefolia
-Toxicodendron radicans
-*
Shrubs/Saplings/Vines:
-Rubus occidentalis
-*

Forested Wetland
Vegetation Cover: 100 %
SAV Density: N/A

Trees:
-Fraxinus pennsylvanica
Wetland & Upland Herbs:
-Carex comosa
-*
Shrubs/Saplings/Vines:
-Fraxinus pennsylvanica

Successional Old Field
Vegetation Cover: 100 %
SAV Density: N/A

Wetland & Upland Herbs:
-Solidago altissima
-*
Shrubs/Saplings/Vines:
-Salix fragilis
-*

Deep Emergent Marsh
Vegetation Cover: 100 %
SAV Density: N/A

Wetland & Upland Herbs:
-Typha latifolia
-*

Aquatic Bed
Vegetation Cover: 100 %
SAV Density: Dense

Wetland & Upland Herbs:
-*
Submerged Aquatic Plants:
-Ceratophyllum demersum
-Nymphaea odorata
-*

Deep Emergent Marsh
Vegetation Cover: 100 %
SAV Density: Dense

Wetland & Upland Herbs:
-Typha latifolia
-*

Aquatic Bed
Vegetation Cover: 100 %
SAV Density: Dense

Wetland & Upland Herbs:
-*
Submerged Aquatic Plants:
-Ceratophyllum demersum
-Nymphaea odorata
-*

Deep Emergent Marsh
Vegetation Cover: 100 %
SAV Density: N/A

Wetland & Upland Herbs:
-Typha latifolia
-*

Wet Meadow
Vegetation Cover: 100 %
SAV Density: Dense

Wetland & Upland Herbs:
-Calamagrostis canadensis
-Carex stricta
-*
Shrubs/Saplings/Vines:
-*

Scrub-Shrub Wetland
Vegetation Cover: 100 %
SAV Density: Dense

Wetland & Upland Herbs:
-*
Shrubs/Saplings/Vines:
-Rosa palustris

Scrub-Shrub Wetland
Vegetation Cover: 100 %
SAV Density: Dense

Wetland & Upland Herbs:
-Carex comosa
-*
Shrubs/Saplings/Vines:
-Cornus foemina
-Rosa palustris
-*

Wet Meadow
Vegetation Cover: 100 %
SAV Density: Dense

Wetland & Upland Herbs:
-Calamagrostis canadensis
-Carex stricta
-*
Shrubs/Saplings/Vines:
-*

Scrub-Shrub Wetland
Vegetation Cover: 100 %
SAV Density: Dense

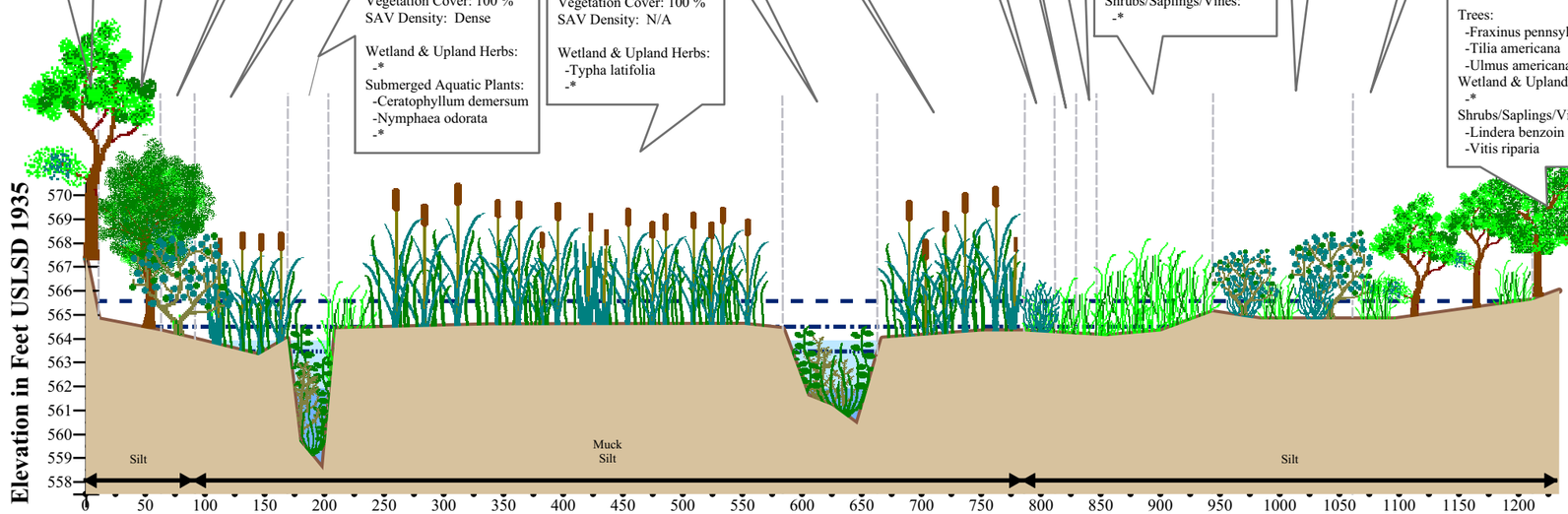
Wetland & Upland Herbs:
-Carex comosa
-*
Shrubs/Saplings/Vines:
-Cornus foemina
-Rosa palustris
-*

Forested Wetland
Vegetation Cover: 100 %
SAV Density: Dense

Trees:
-Fraxinus pennsylvanica
-Quercus palustris
-*
Wetland & Upland Herbs:
-Boehmeria cylindrica
-Lysimachia nummularia
-*
Shrubs/Saplings/Vines:
-Lindera benzoin
-*

Successional Northern Hardwoods Forest
Vegetation Cover: 100 %
SAV Density: Dense

Trees:
-Fraxinus pennsylvanica
-Tilia americana
-Ulmus americana
Wetland & Upland Herbs:
-*
Shrubs/Saplings/Vines:
-Lindera benzoin
-Vitis riparia



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PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 11

LEGEND

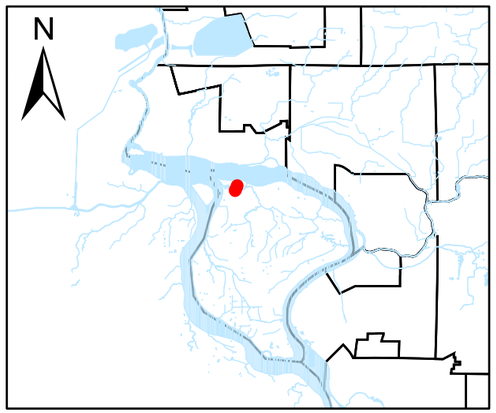
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (5/20/02 10:00, 8/16/02 9:00)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

Appendix A-11

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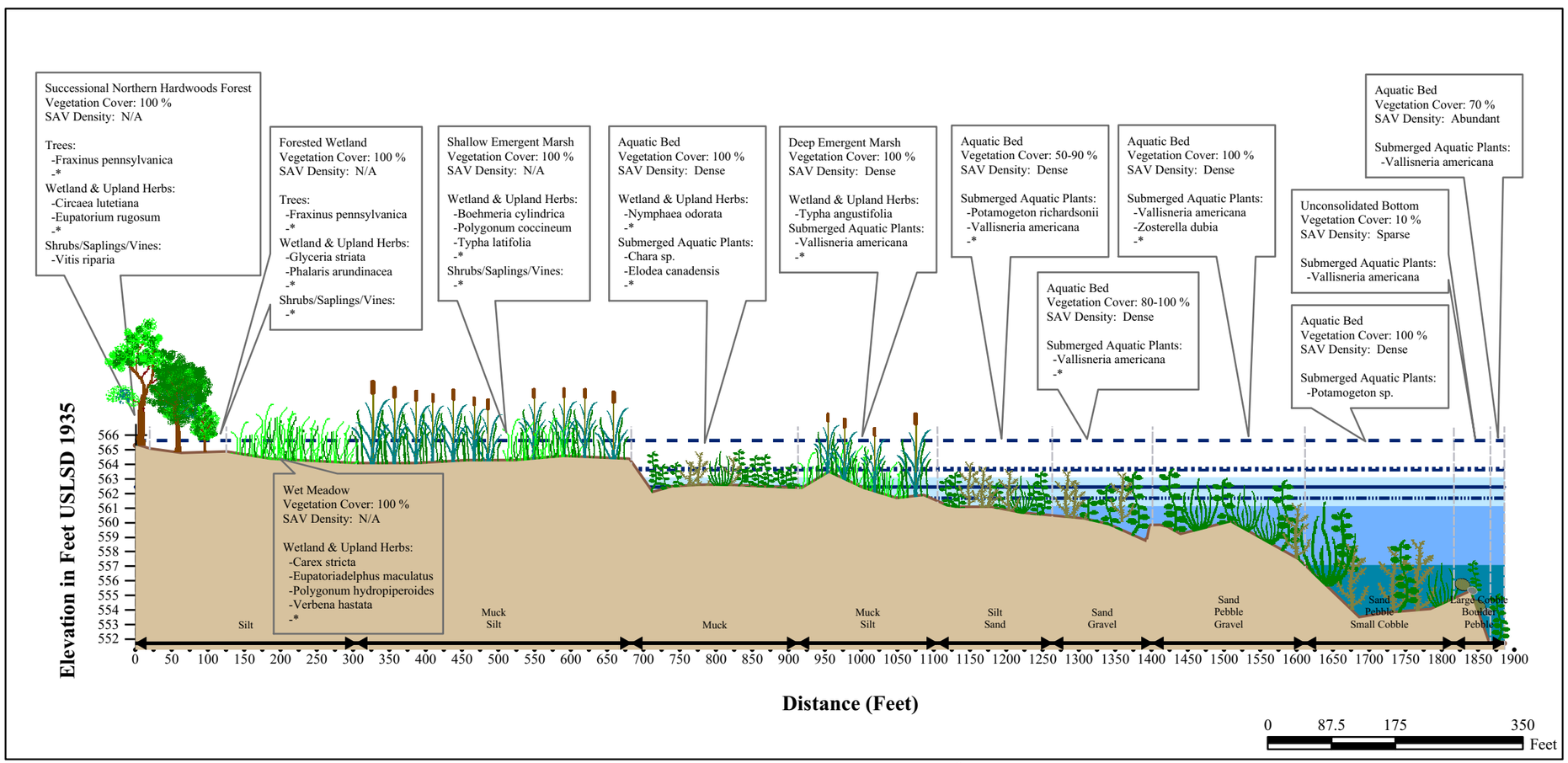


NEW YORK POWER AUTHORITY
NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 12

LEGEND

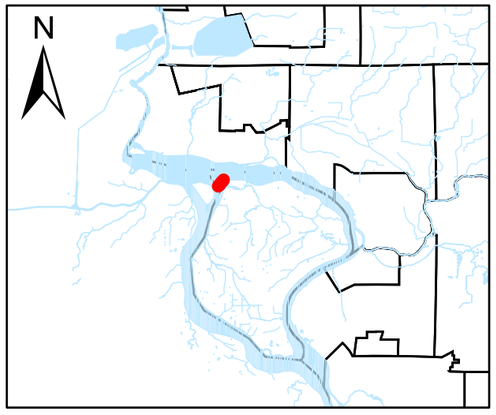
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (5/22/02 10:00, 8/29/02 11:00, 9/6/02 10:40)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

Appendix A-12

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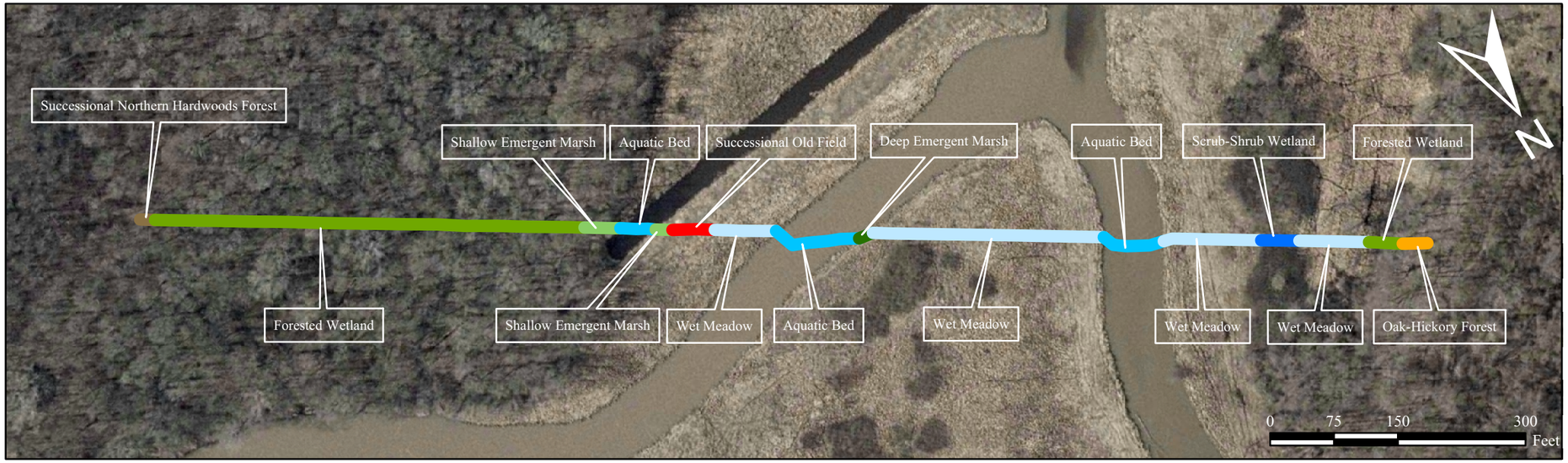
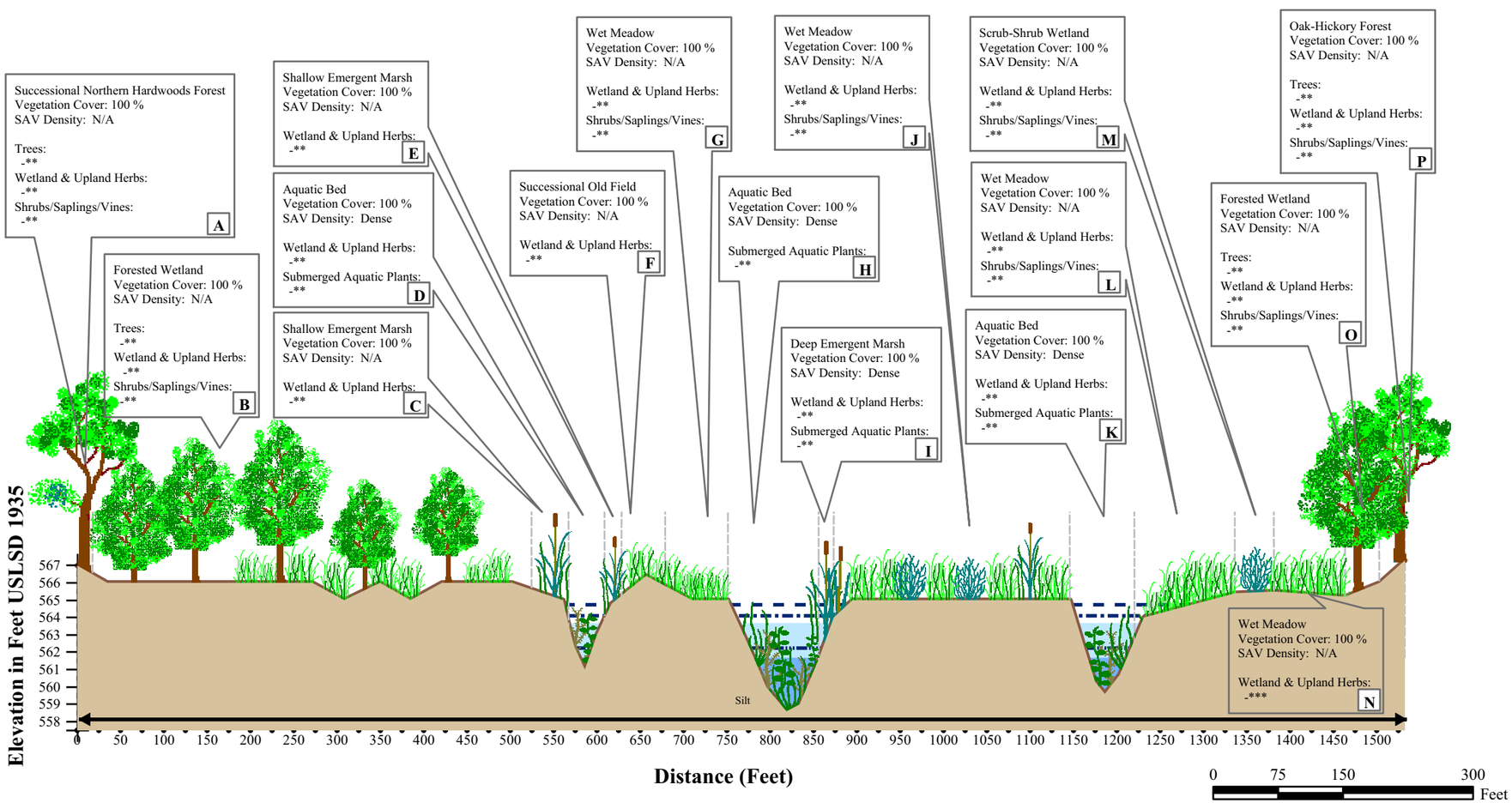




NEW YORK POWER AUTHORITY
NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 13

LEGEND

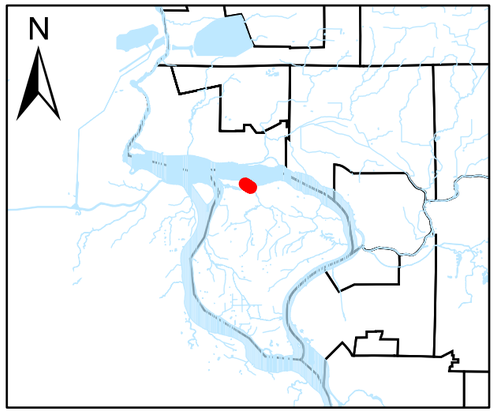
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (05/17/02 11:30, 08/16/02, 09/05/02 15:25)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

** See Appendix A-13A for species list

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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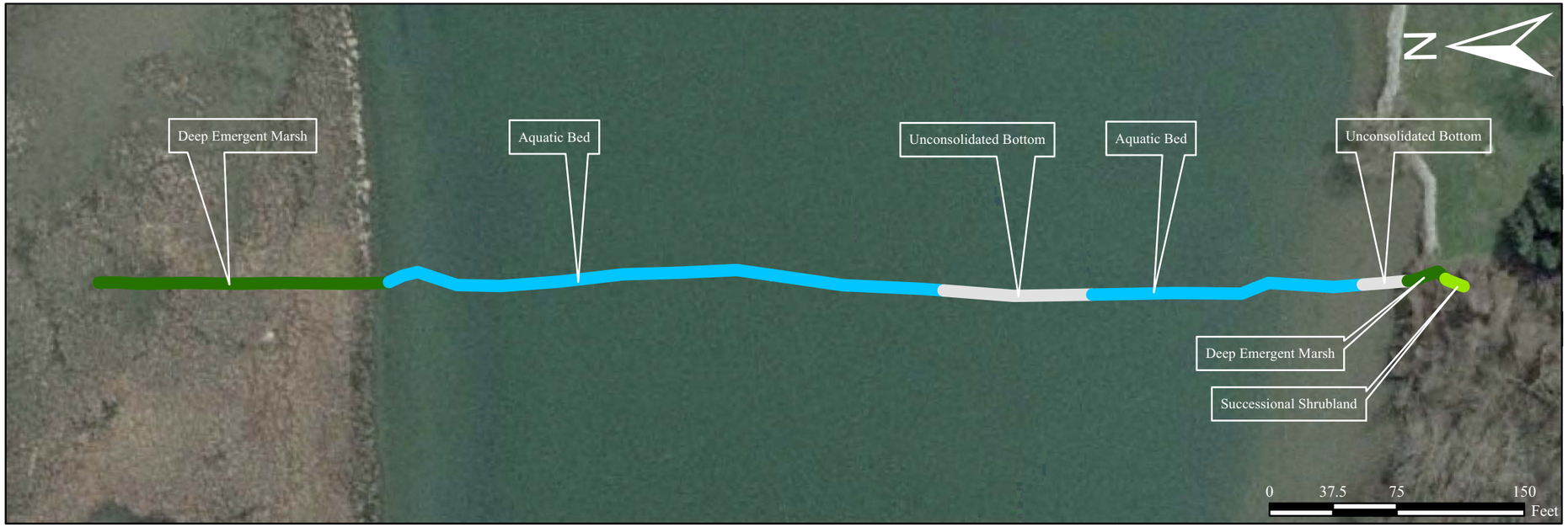
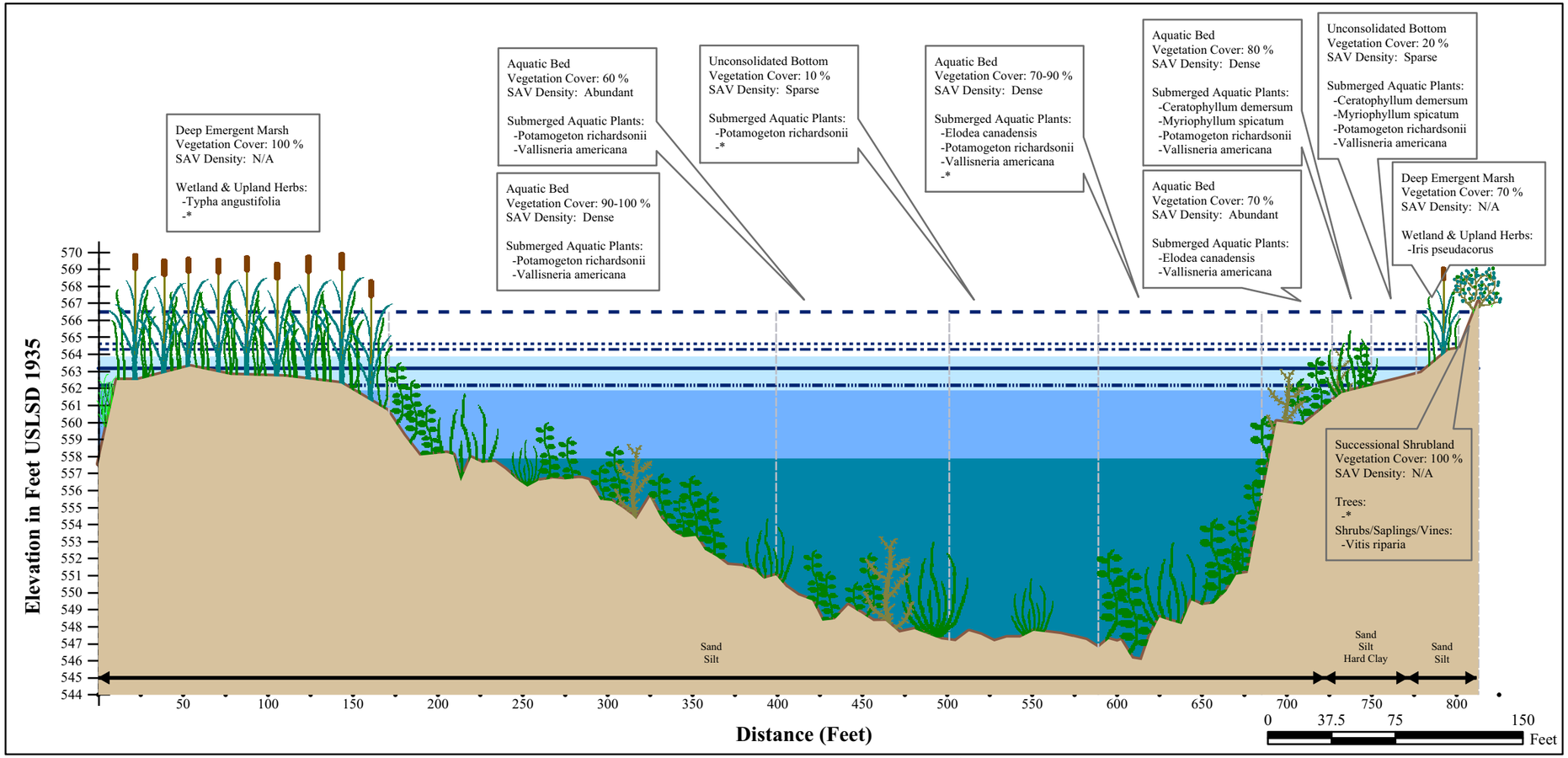




NEW YORK POWER AUTHORITY
NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 14

LEGEND

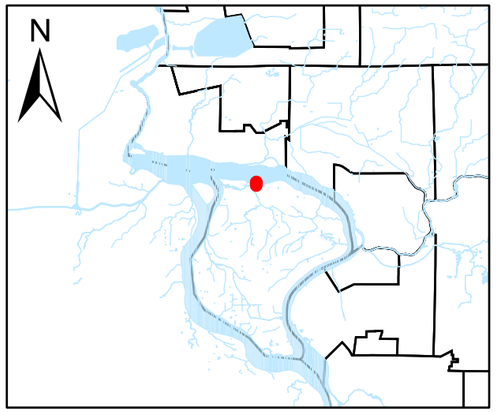
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (08/29/02 14:30, 09/05/02 10:00)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:10

Appendix A-14

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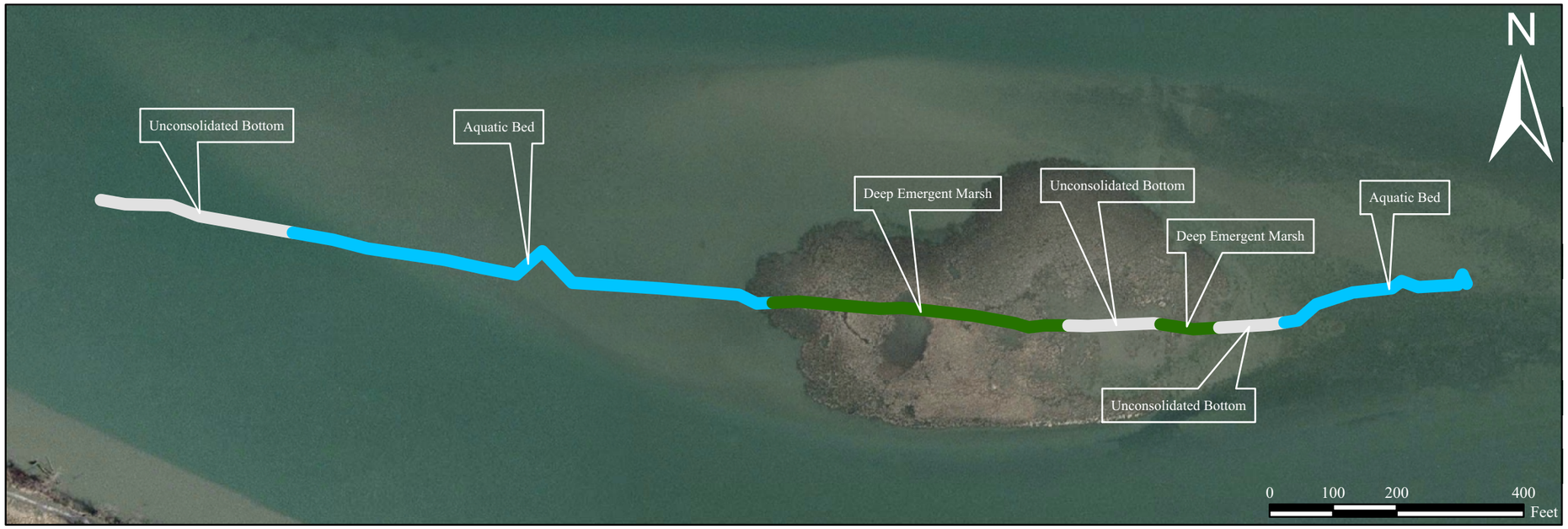
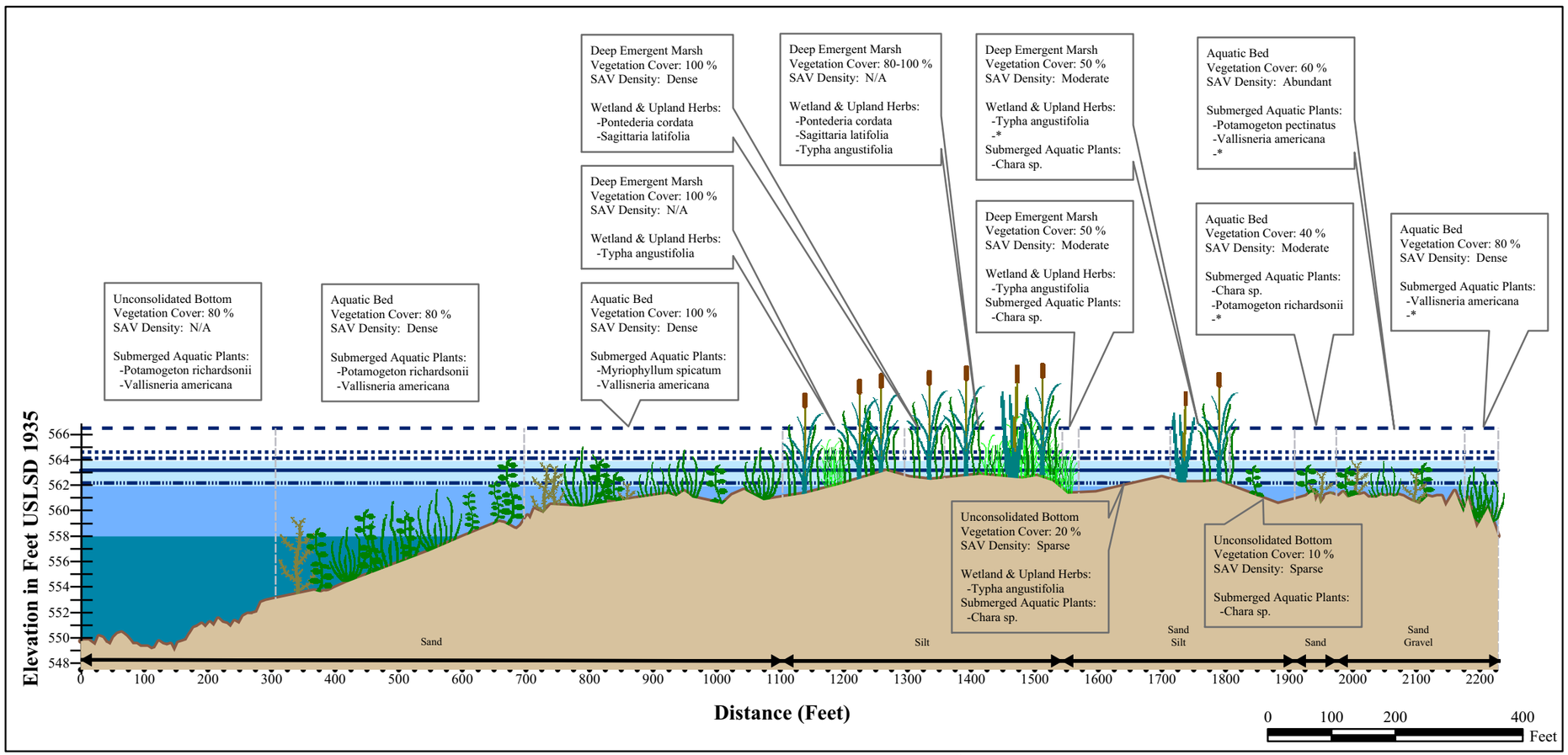
NEW YORK POWER AUTHORITY
NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 15





LEGEND

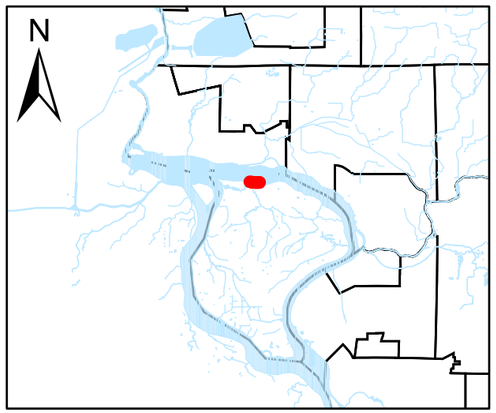
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/05/02 10:00)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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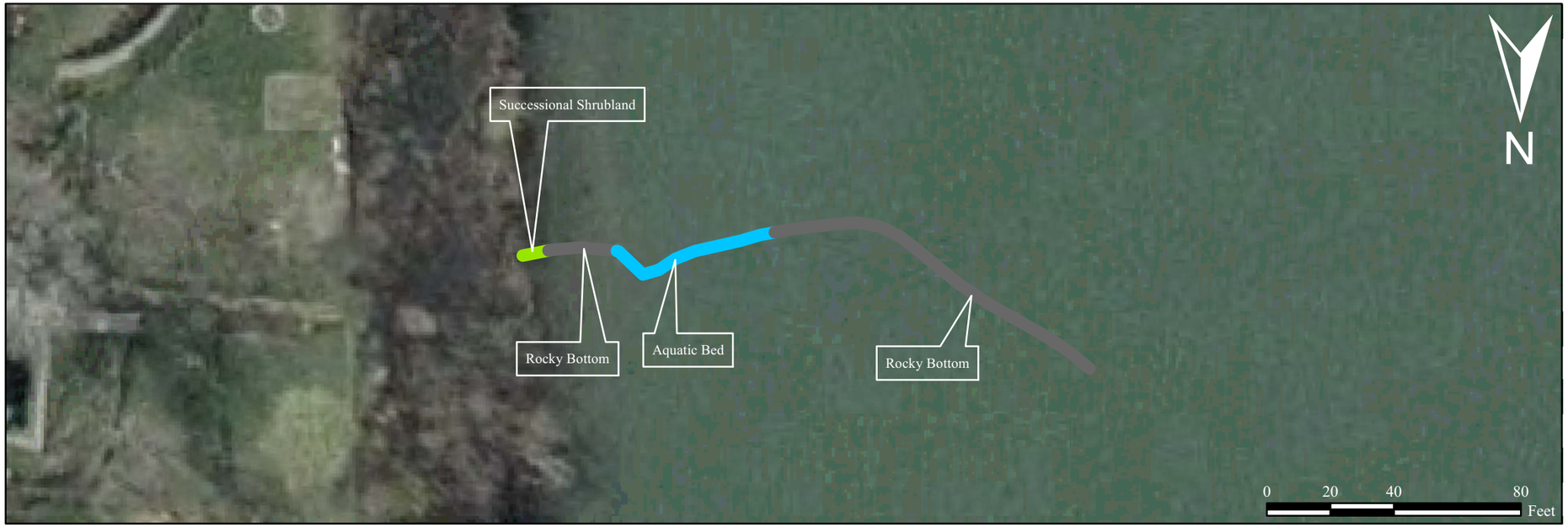

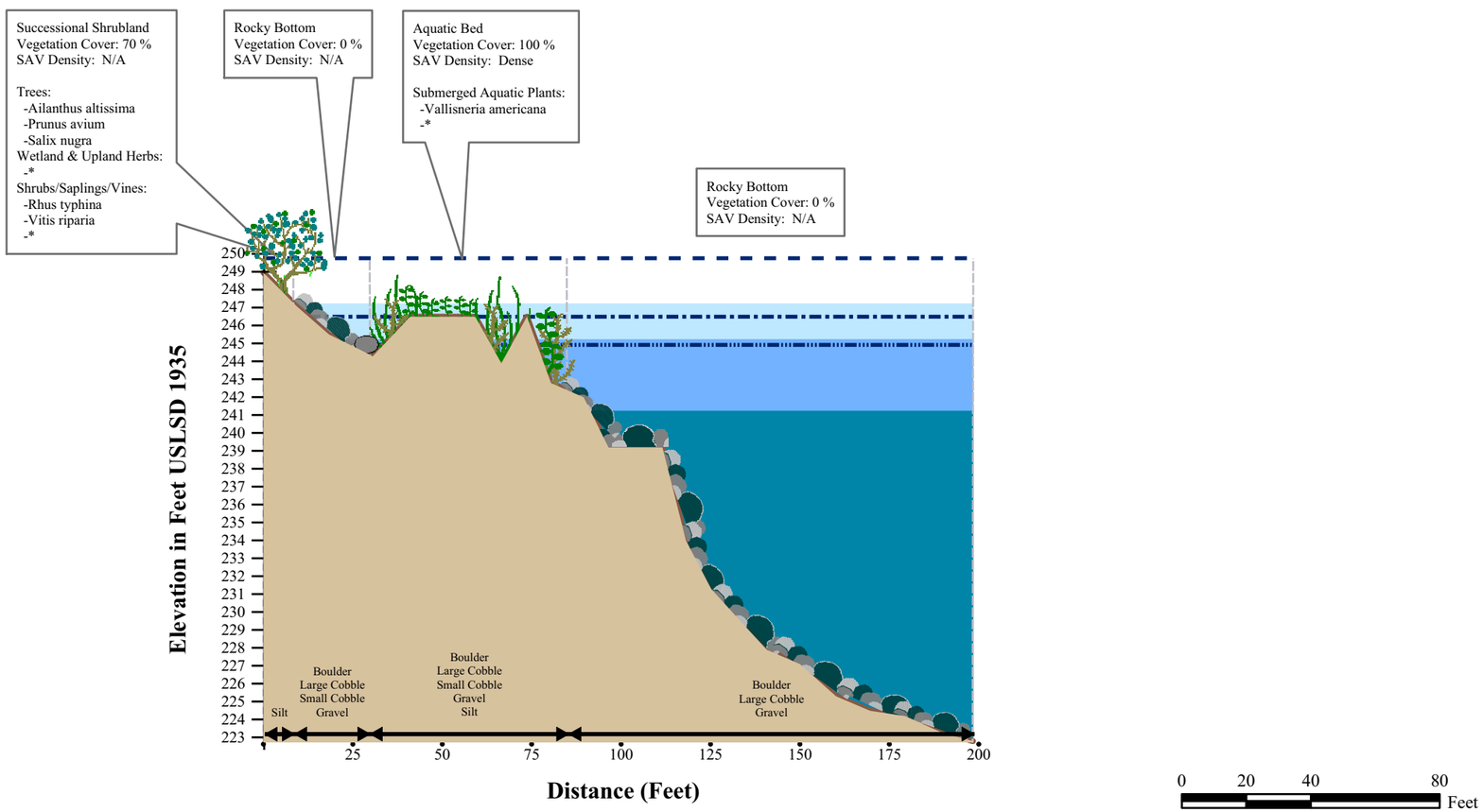

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 16

LEGEND

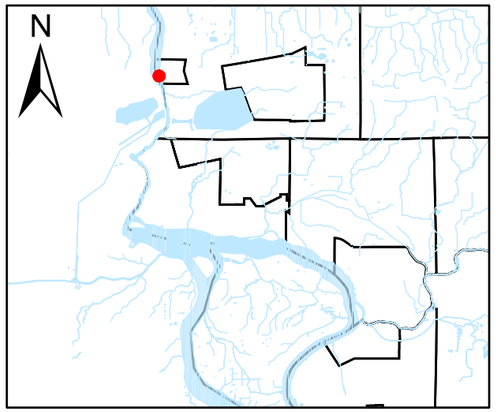
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/12/02 11:00)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:5

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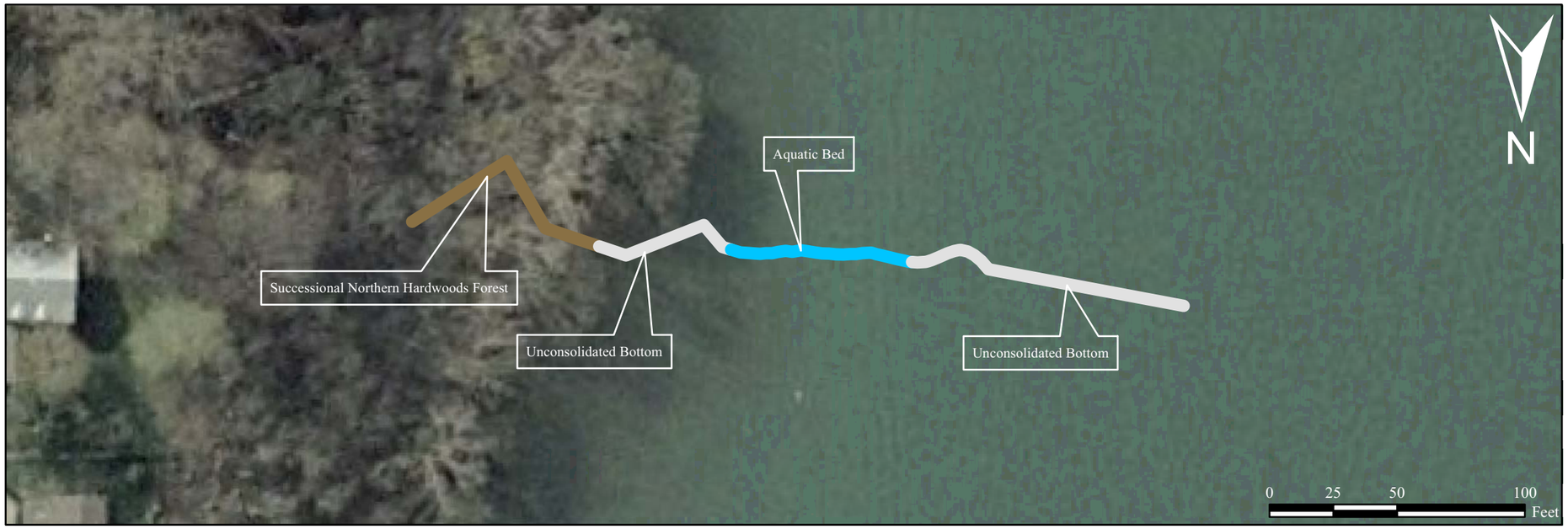

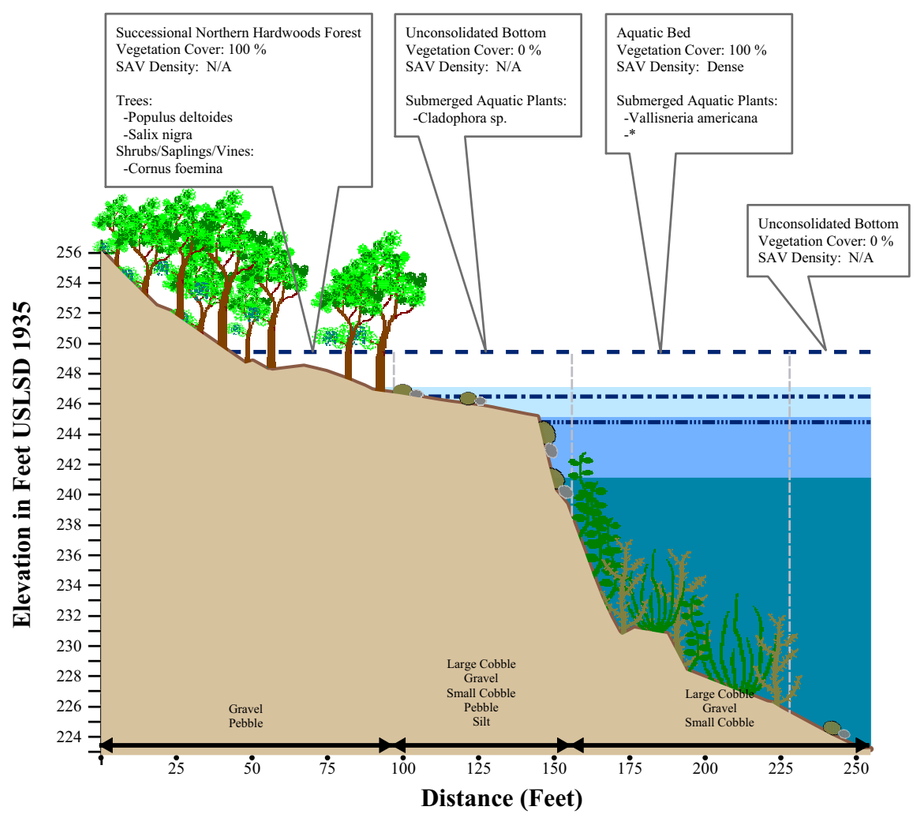

0 25 50 100
Feet

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 17

LEGEND

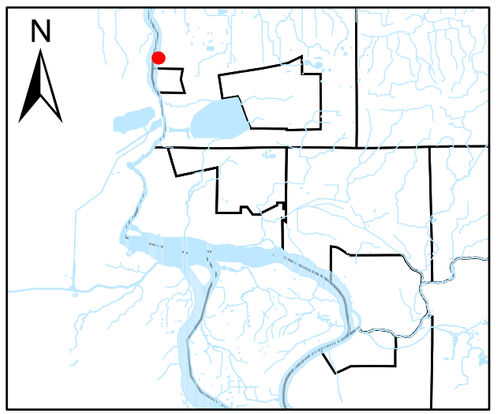
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/12/02 12:16)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:5

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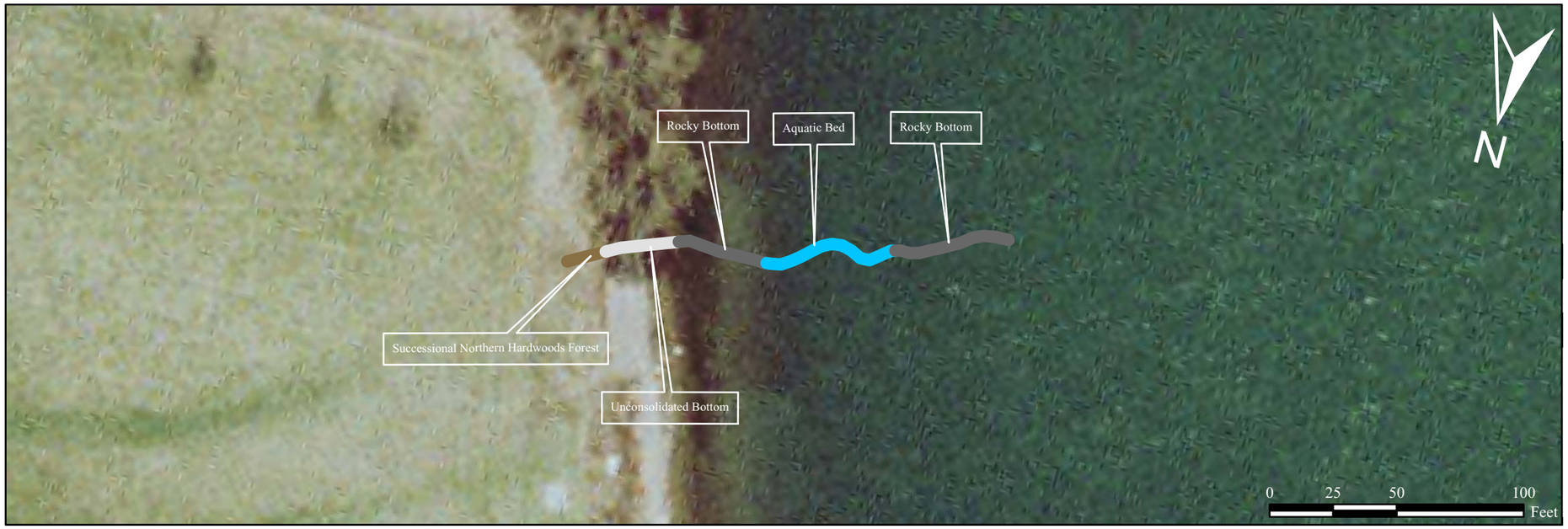

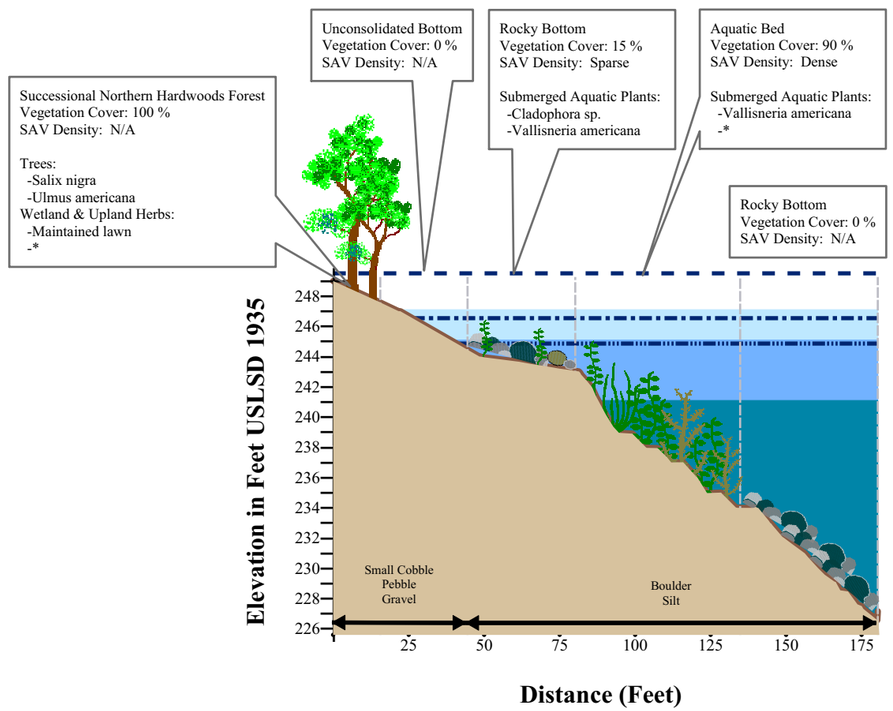

0 25 50 100
Feet

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 18

LEGEND

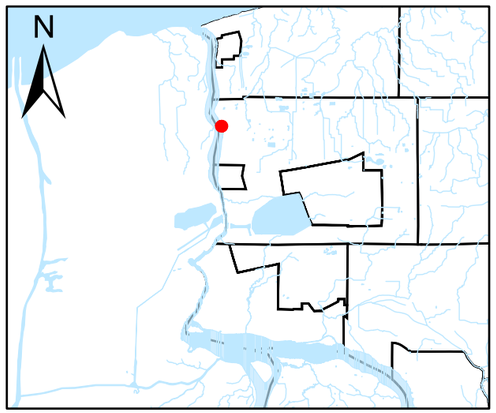
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/12/02 13:51)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:5

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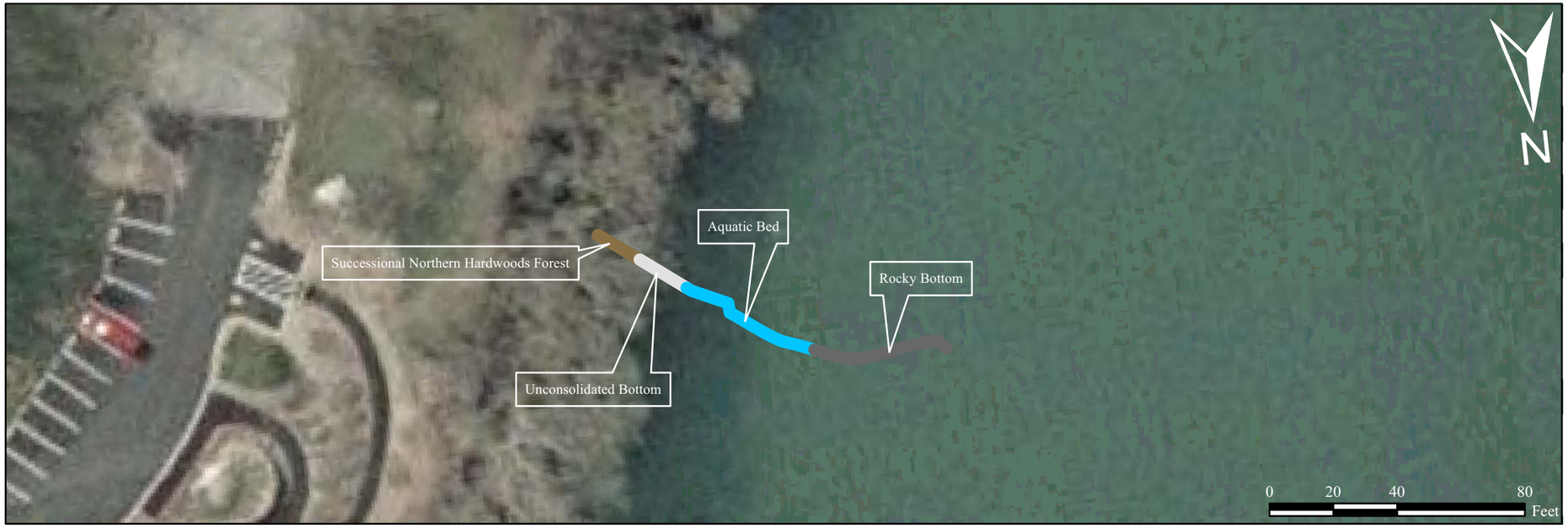

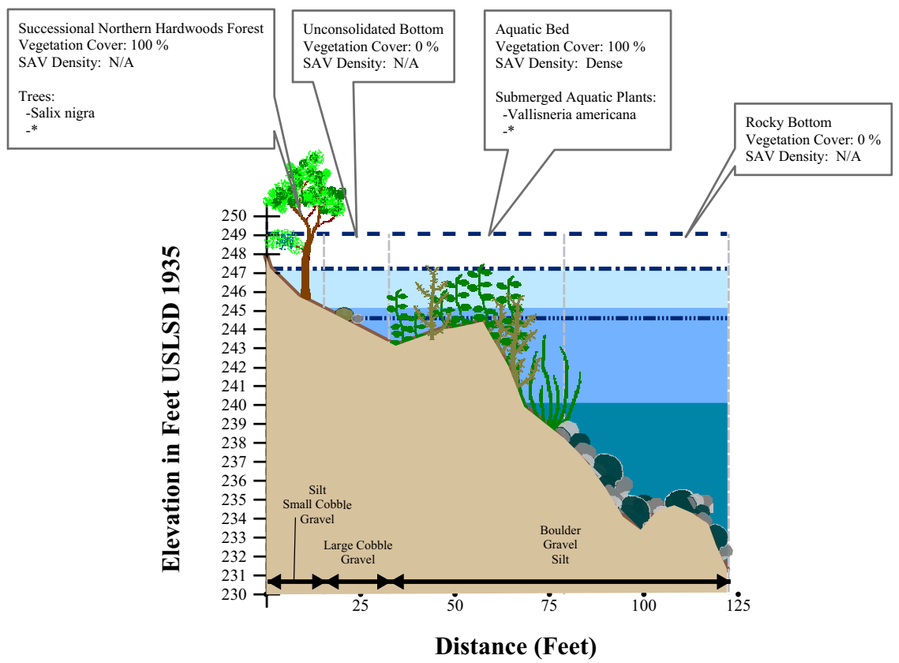

0 20 40 80
Feet

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 19

LEGEND

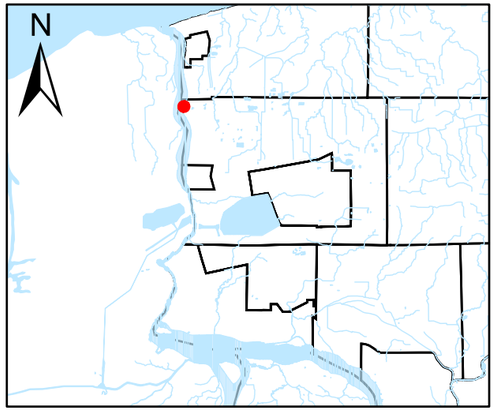
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/12/02 15:10)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:5

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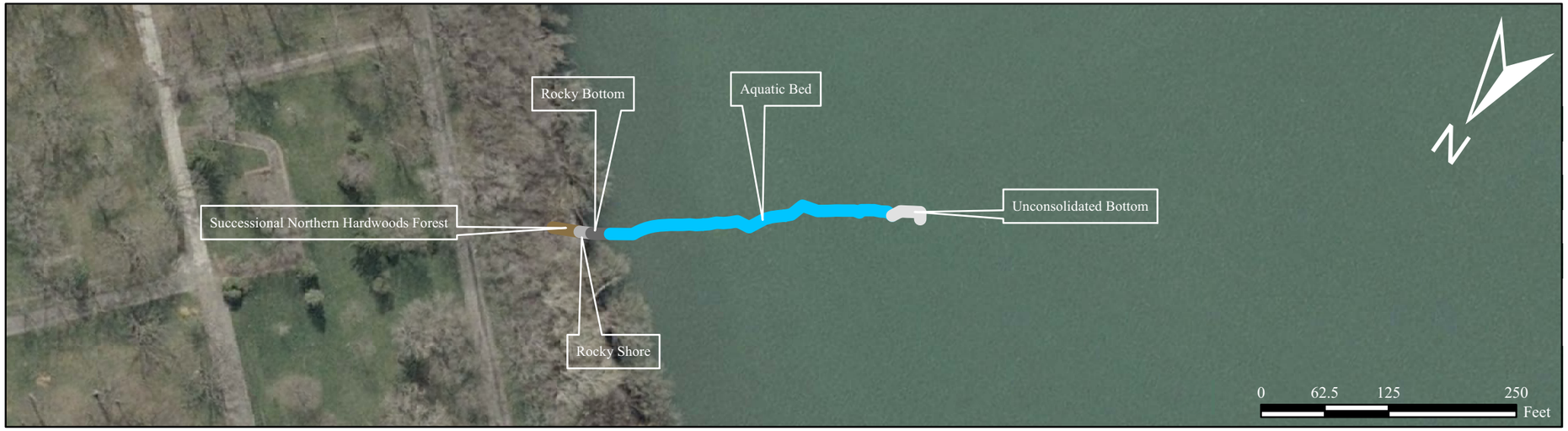

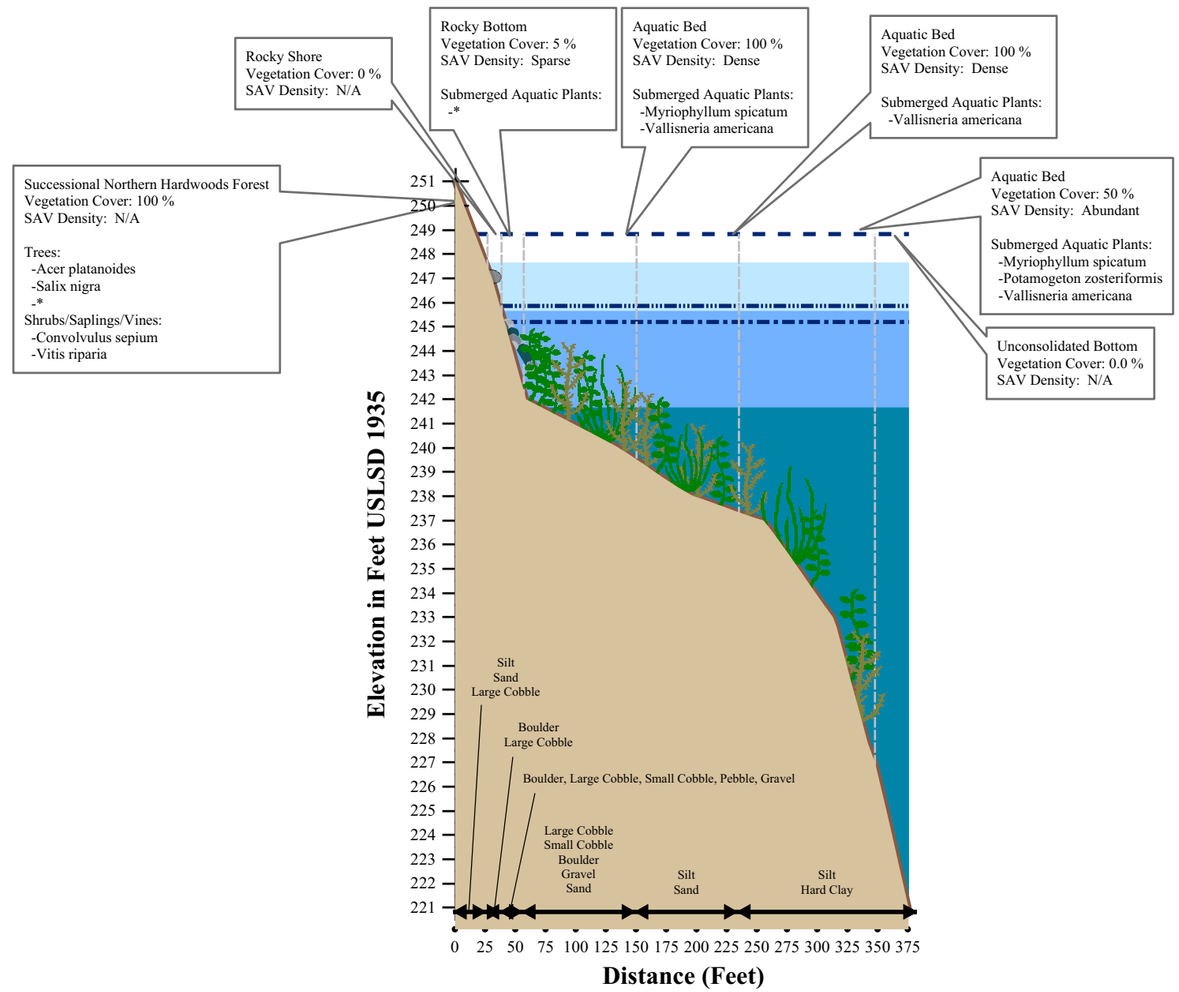

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 20

LEGEND

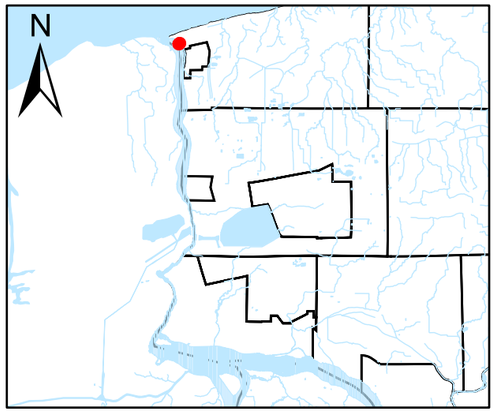
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/17/02 11:00)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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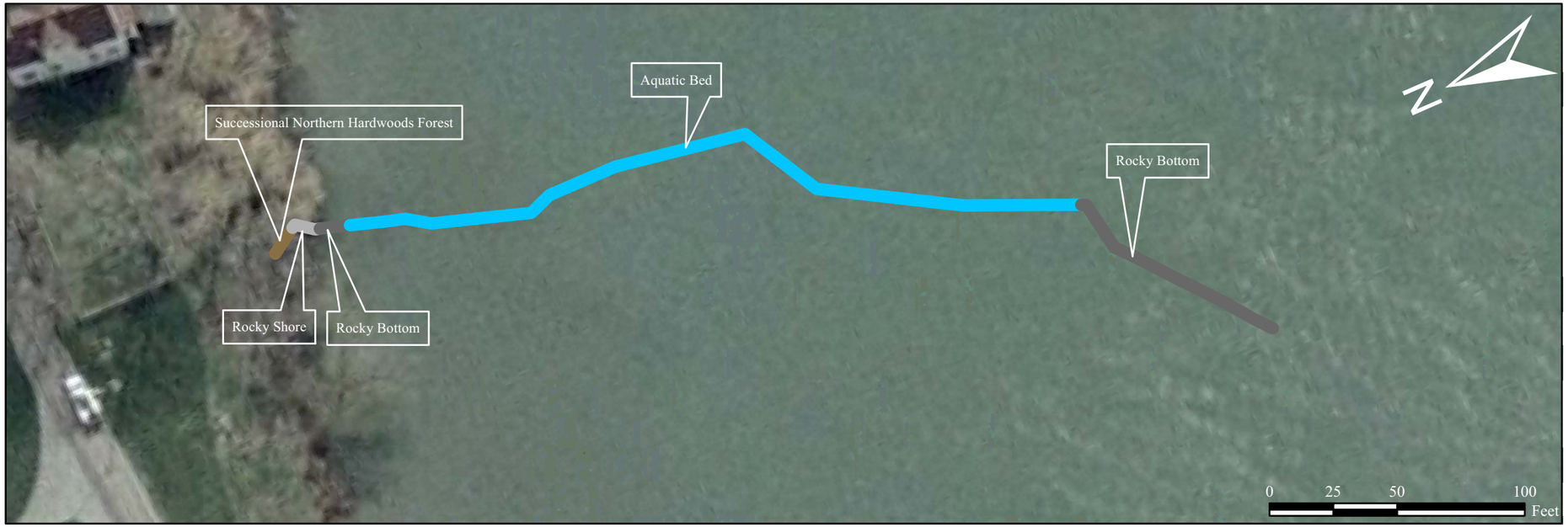

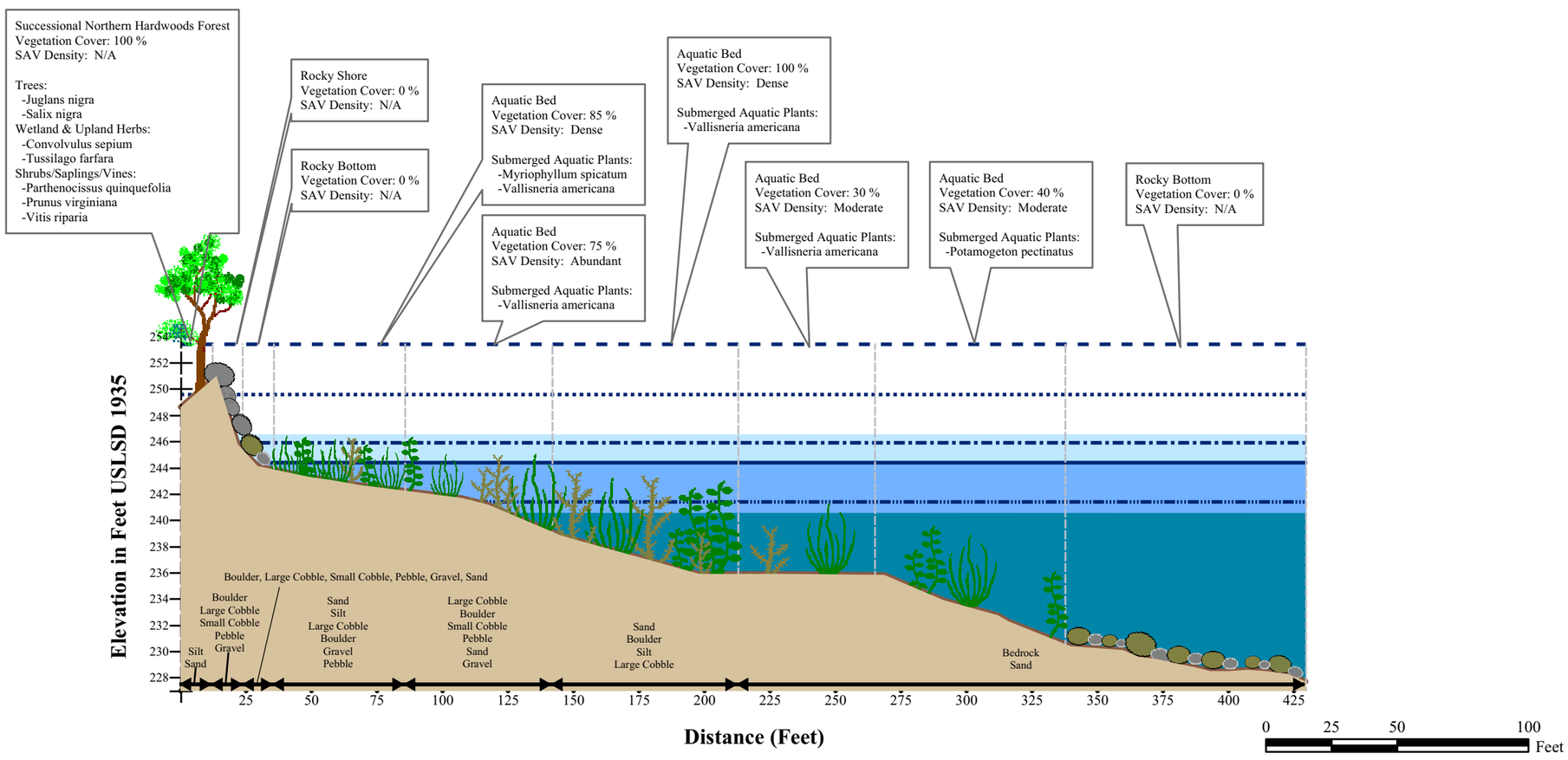

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 21

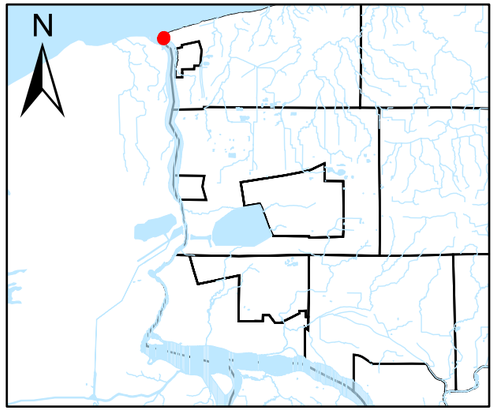
LEGEND

Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/17/02 12:25)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:5

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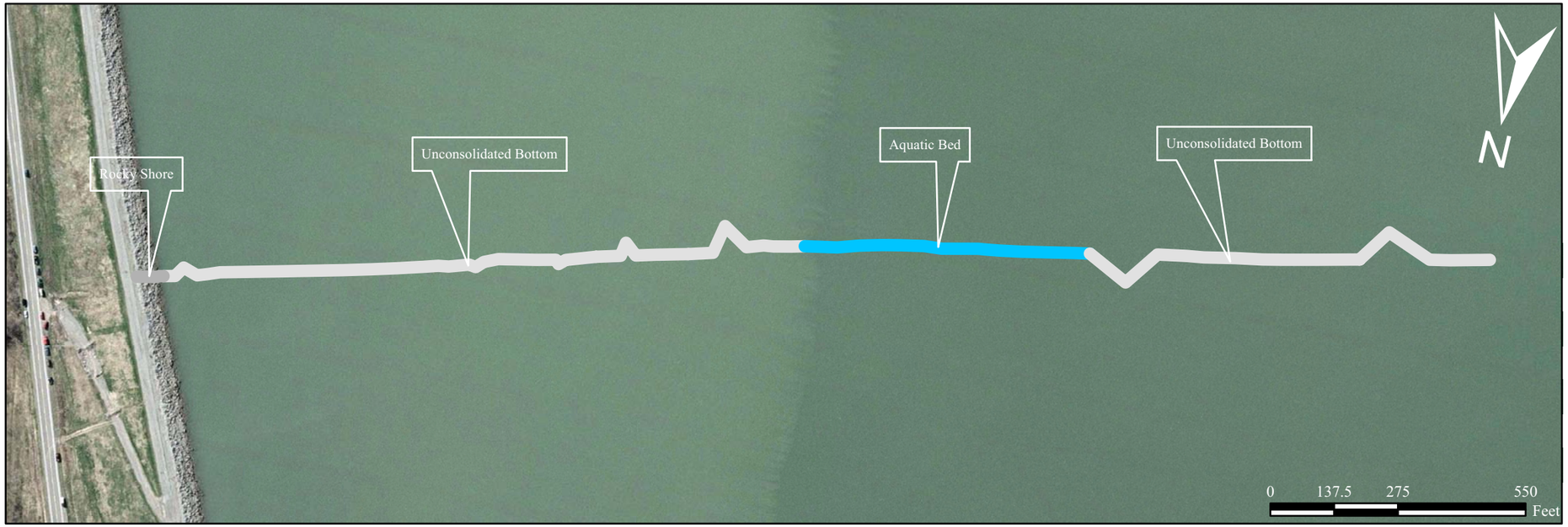

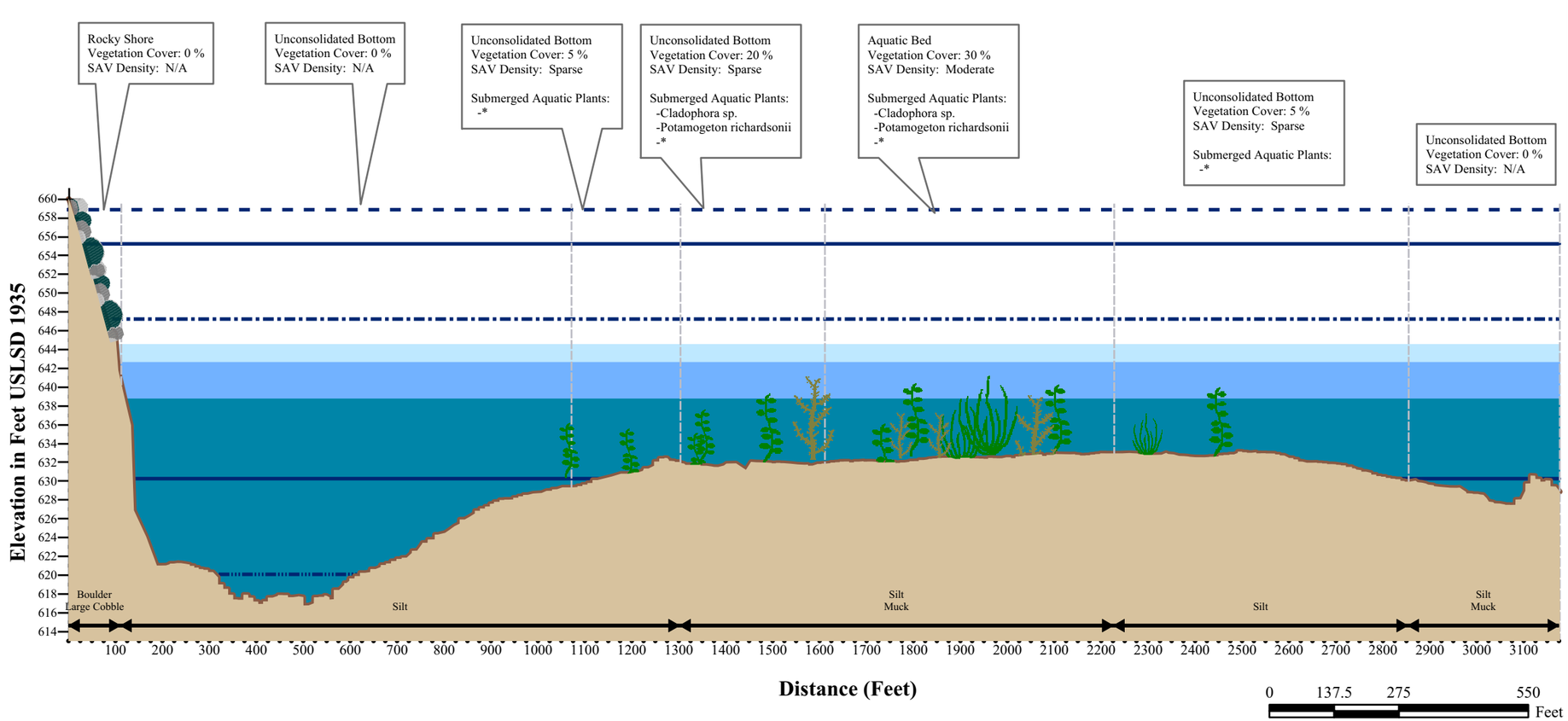

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 22

LEGEND

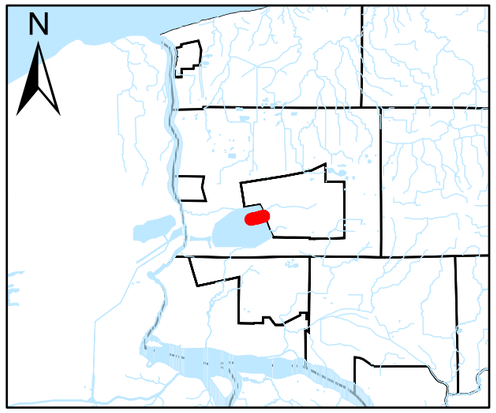
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (10/03/02 9:25)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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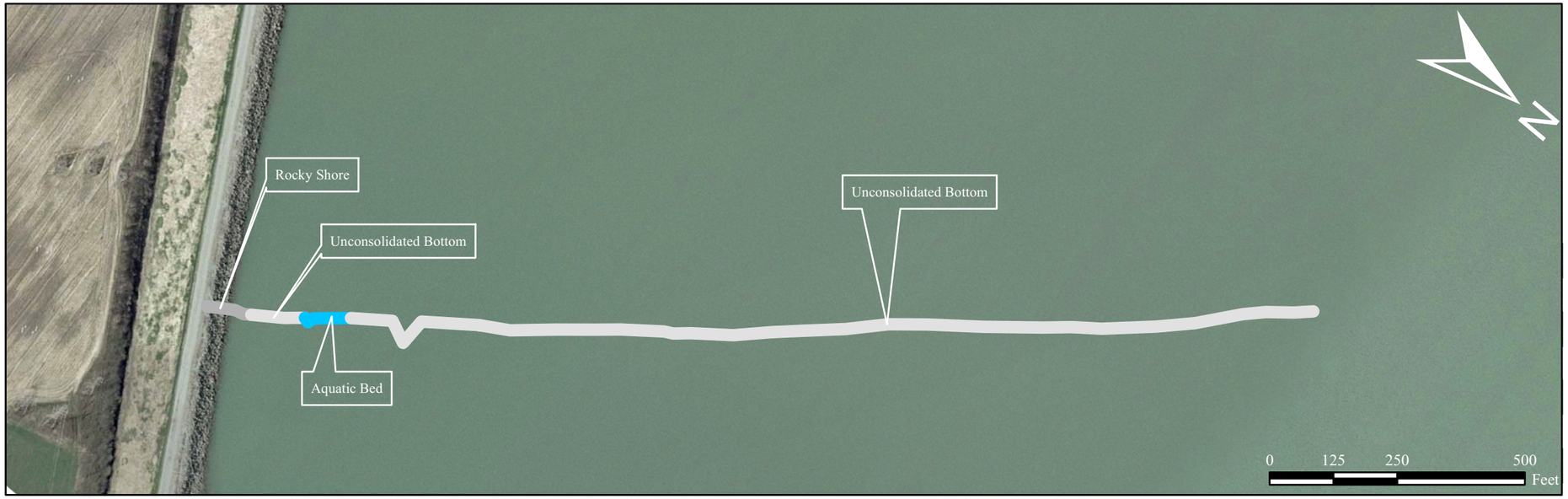
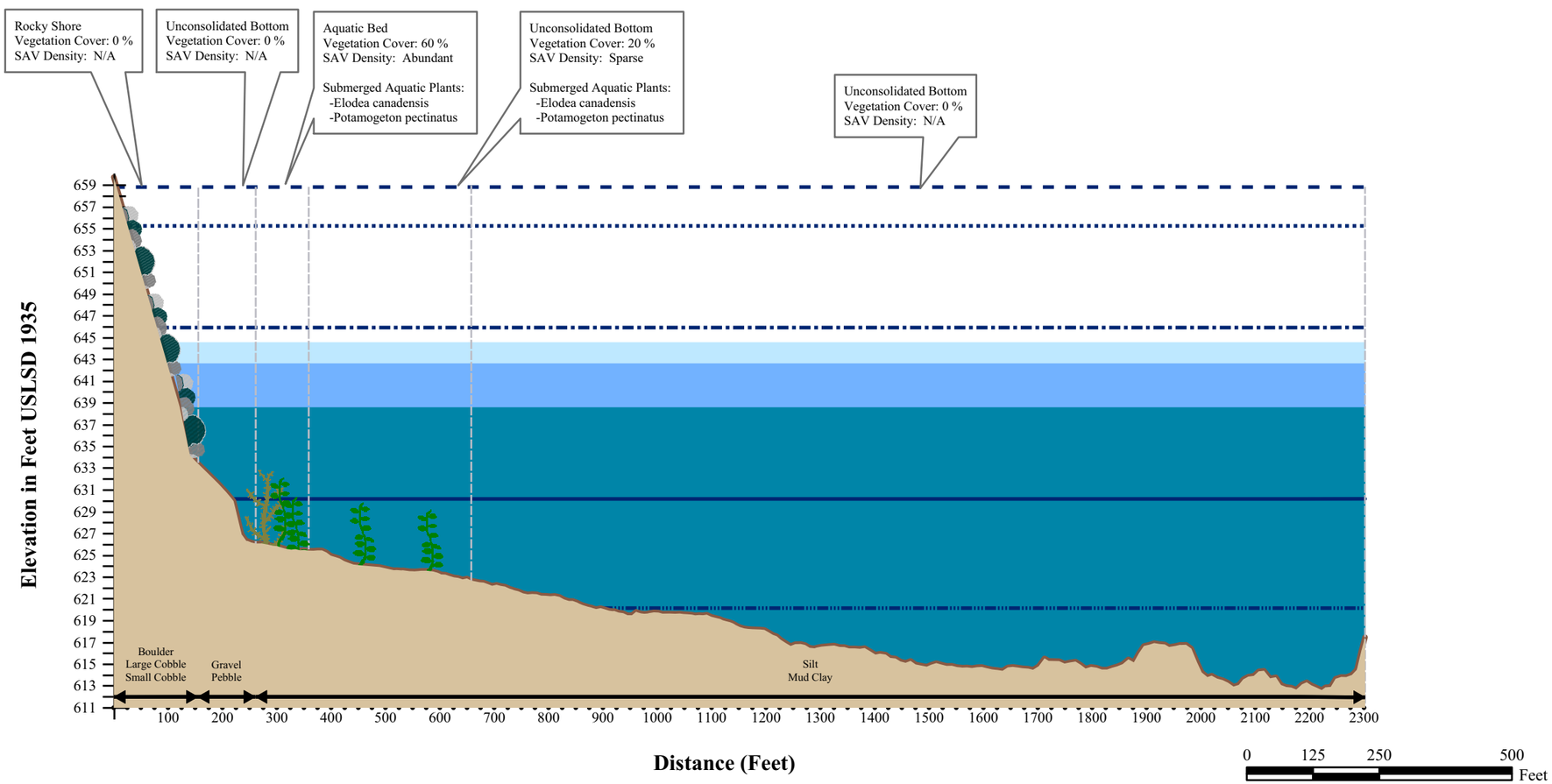




NEW YORK POWER AUTHORITY
NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 23

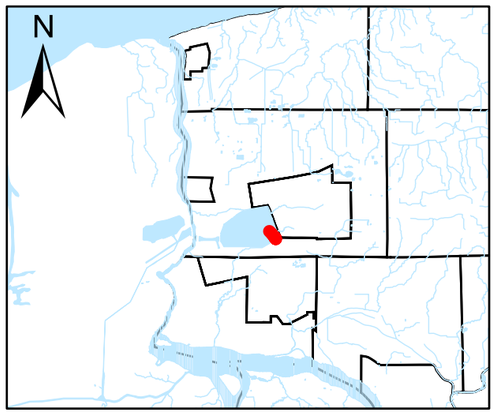
LEGEND

Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (10/03/02 11:55)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

Appendix A-23

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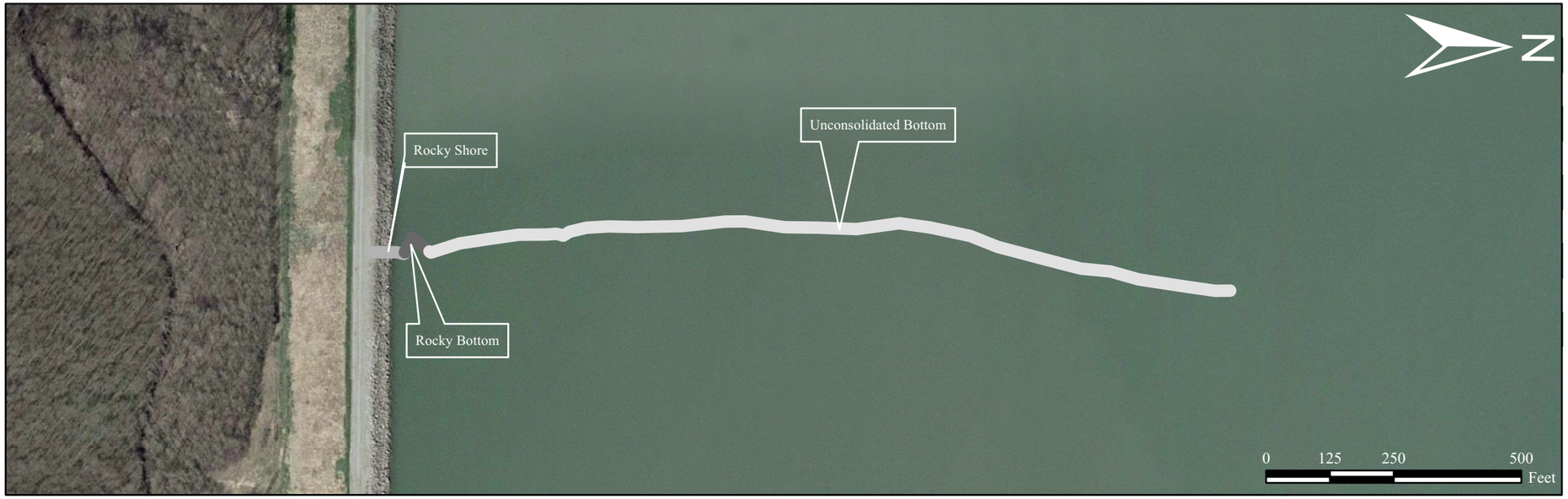

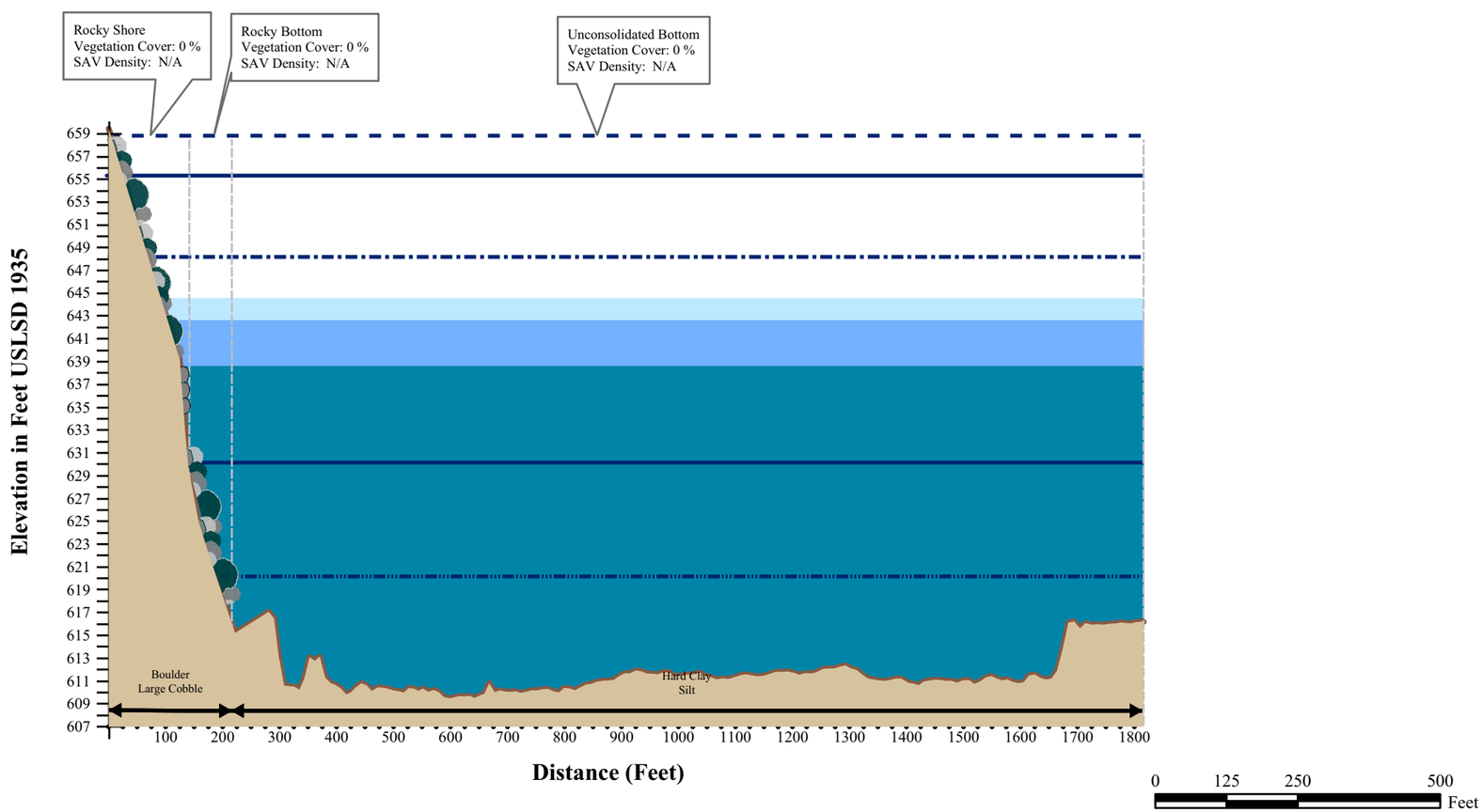

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TRANSECT 24

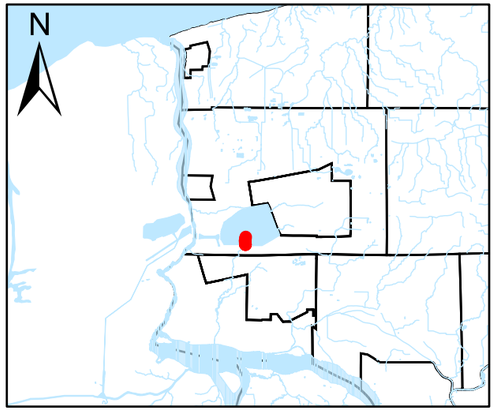
LEGEND

Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (10/03/02 13:30)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

Appendix A-24

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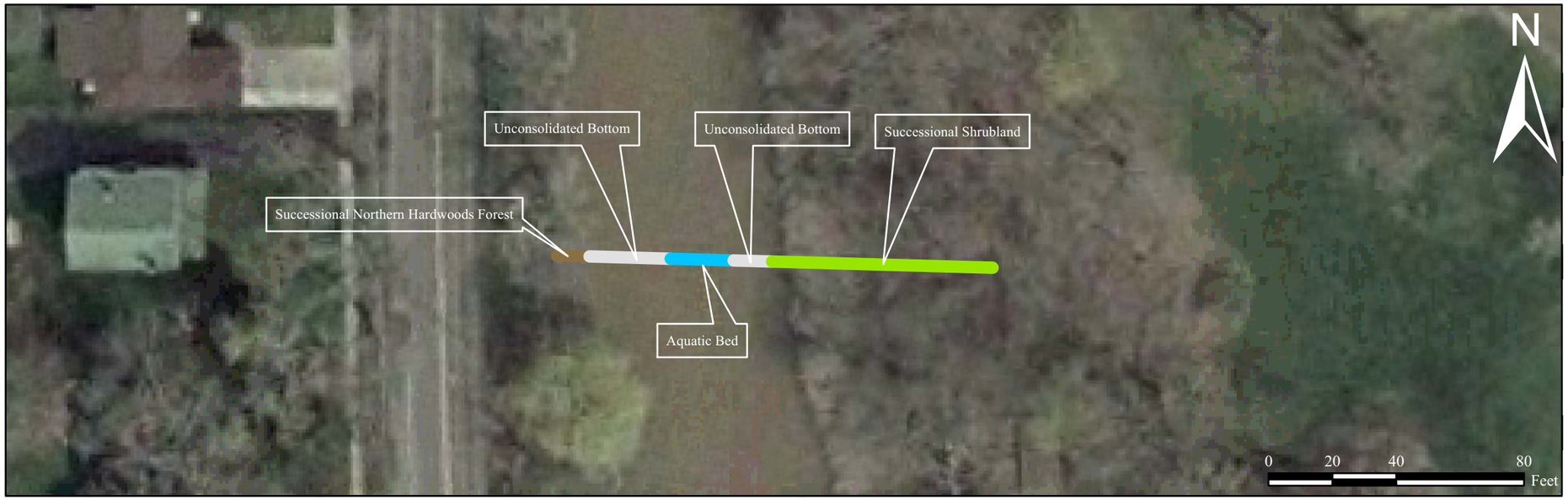

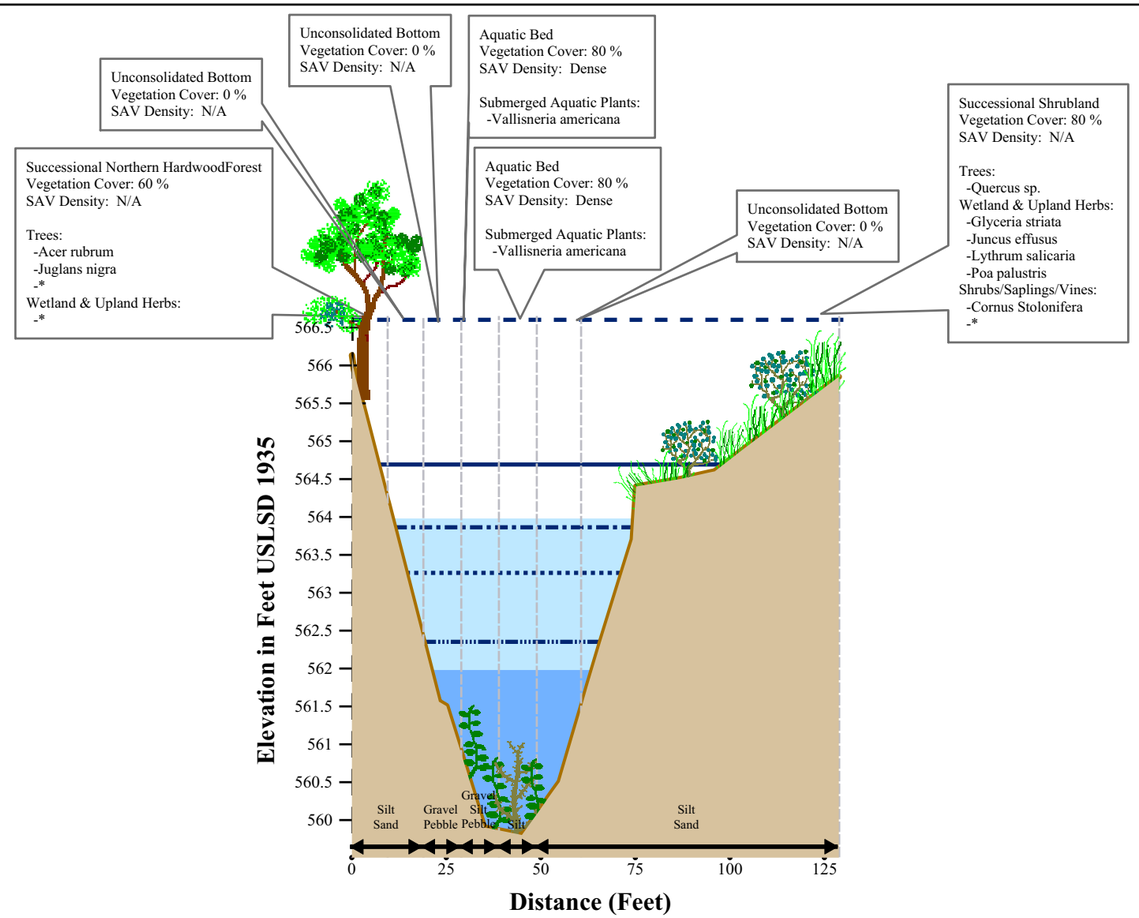

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF CAYUGA CREEK TRANSECT 1

LEGEND

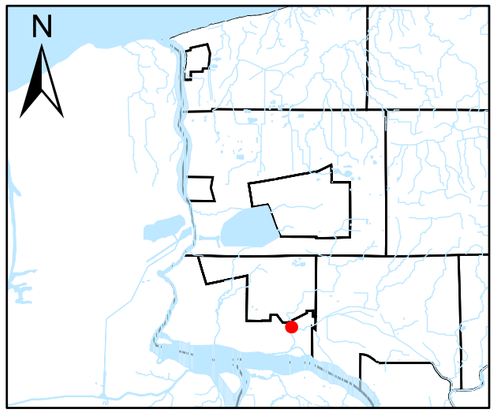
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/18/02 13:15)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

Appendix A-CC1

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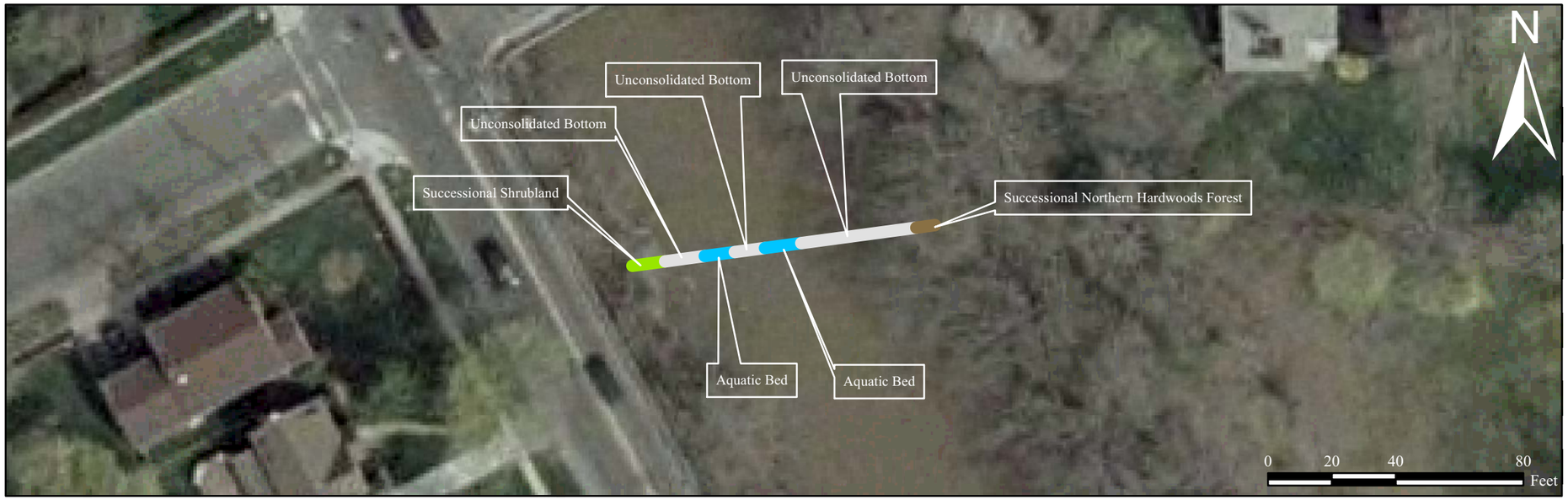

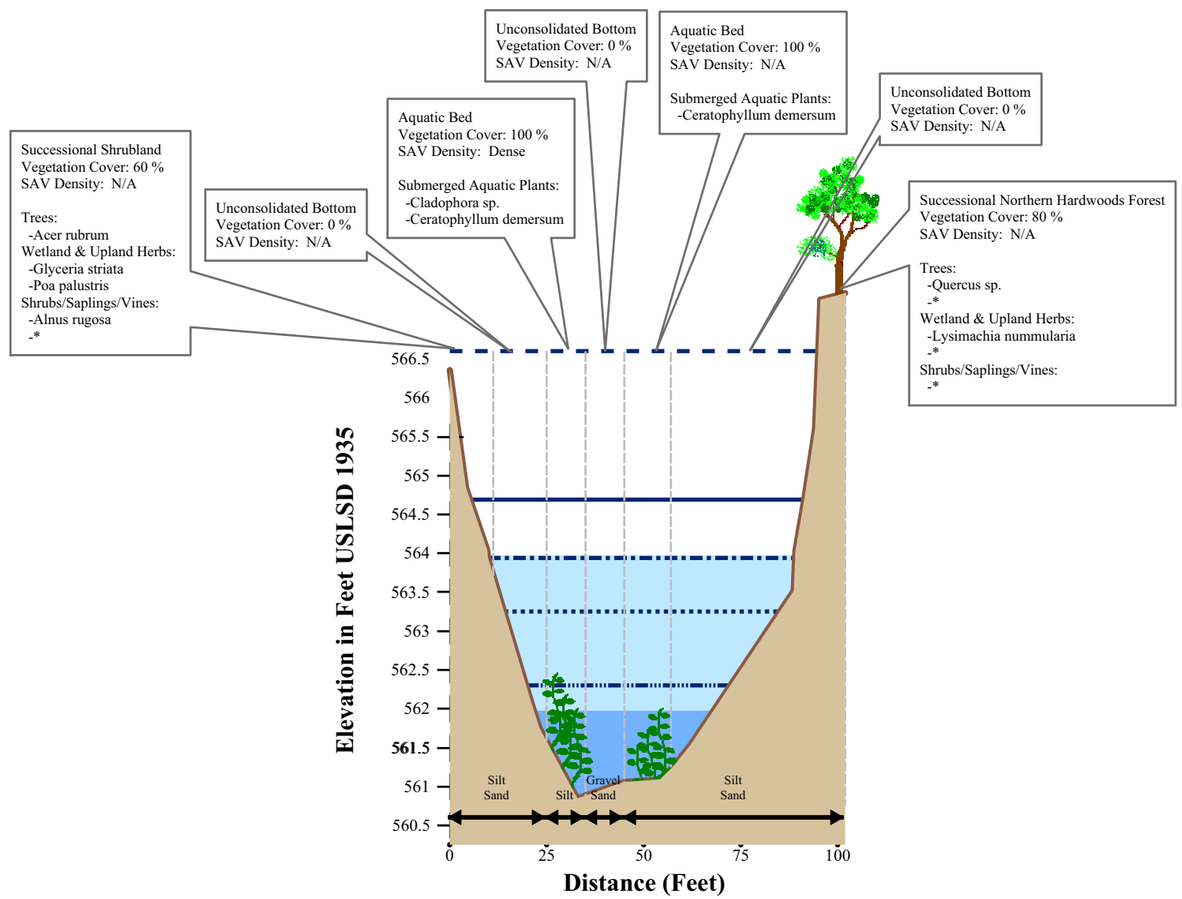

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF CAYUGA CREEK TRANSECT 2

LEGEND

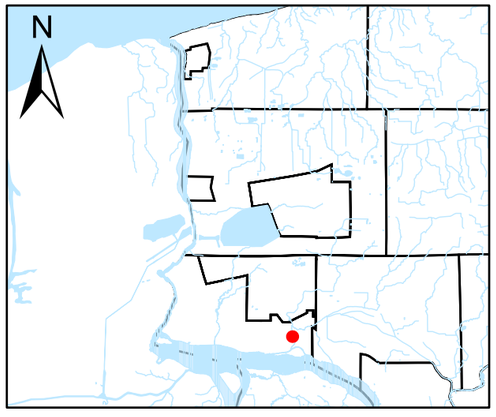
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/18/02 14:30)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



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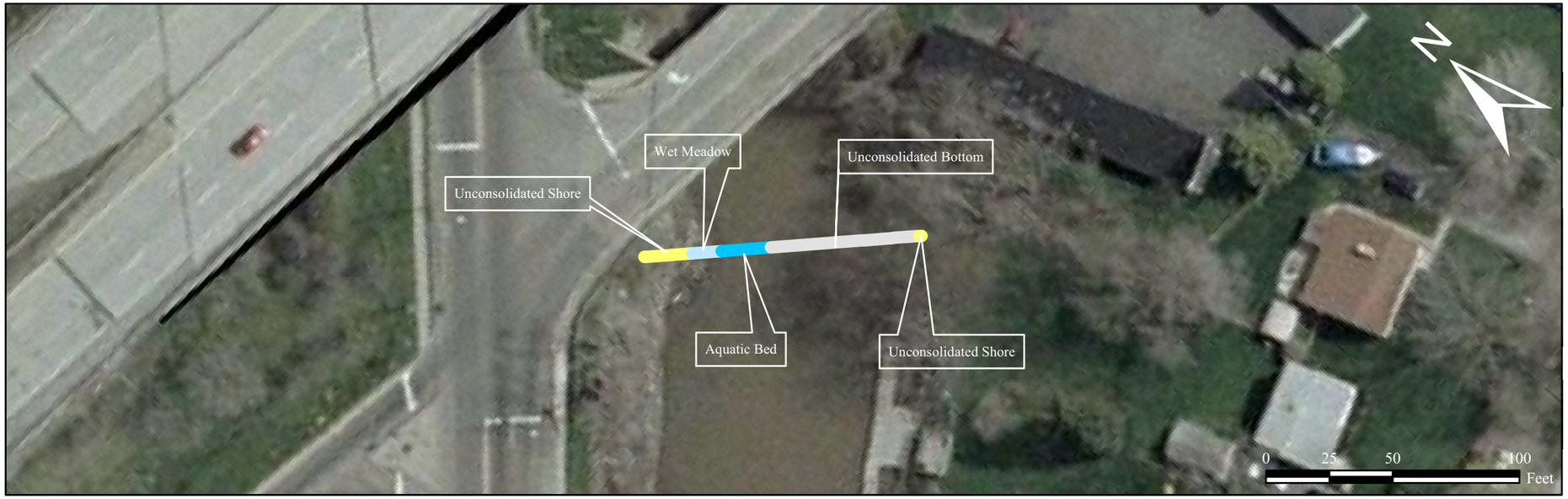

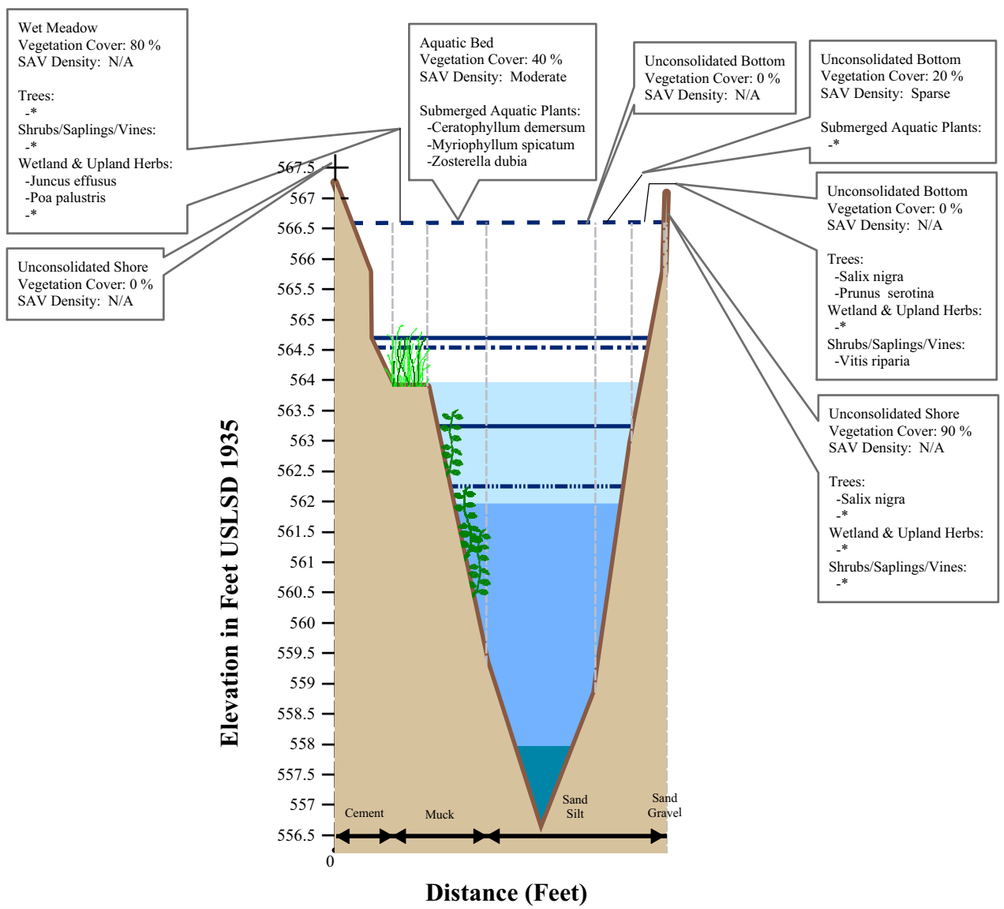

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF CAYUGA CREEK TRANSECT 3

LEGEND

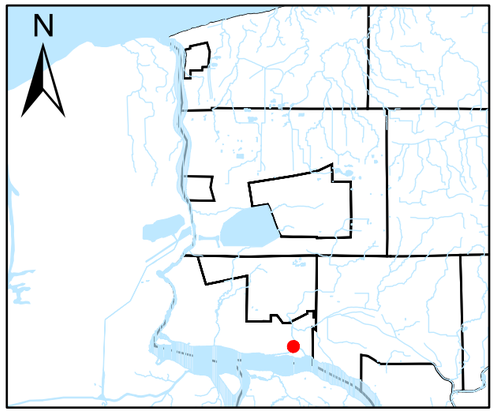
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/18/02 15:30)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:20

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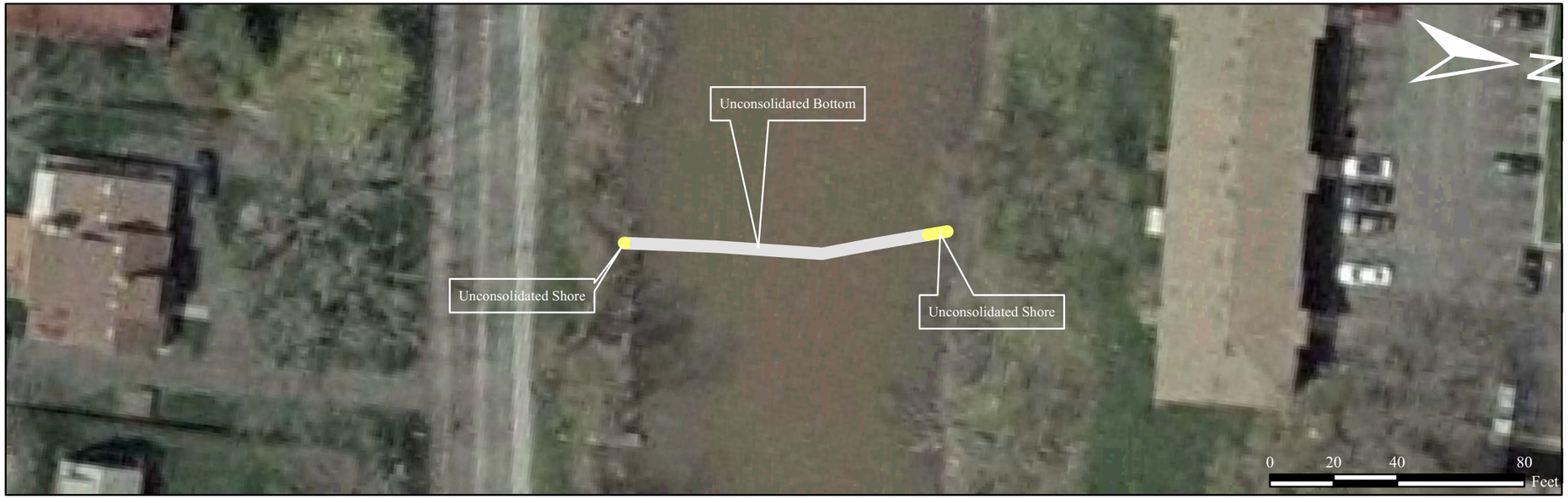

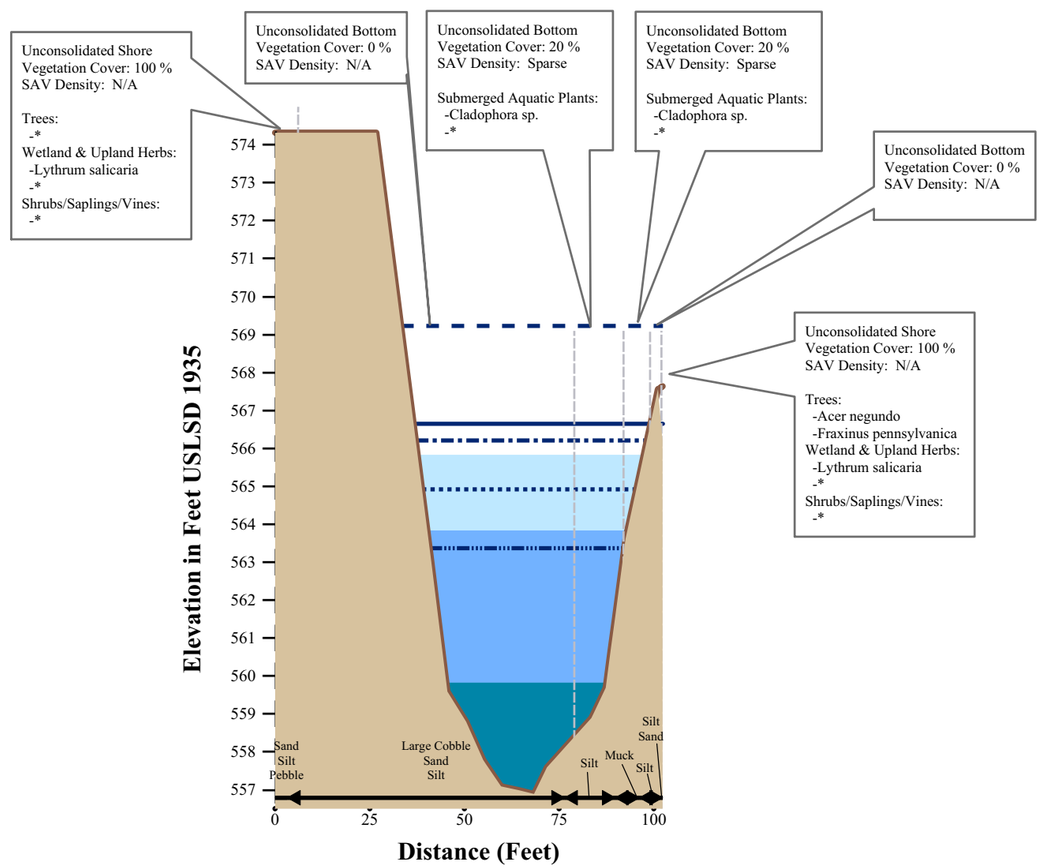

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF ELLICOTT CREEK TRANSECT 1

LEGEND

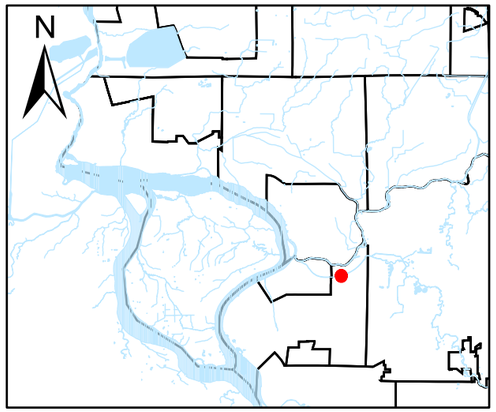
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/20/02 09:57)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:10

Appendix A-EC1

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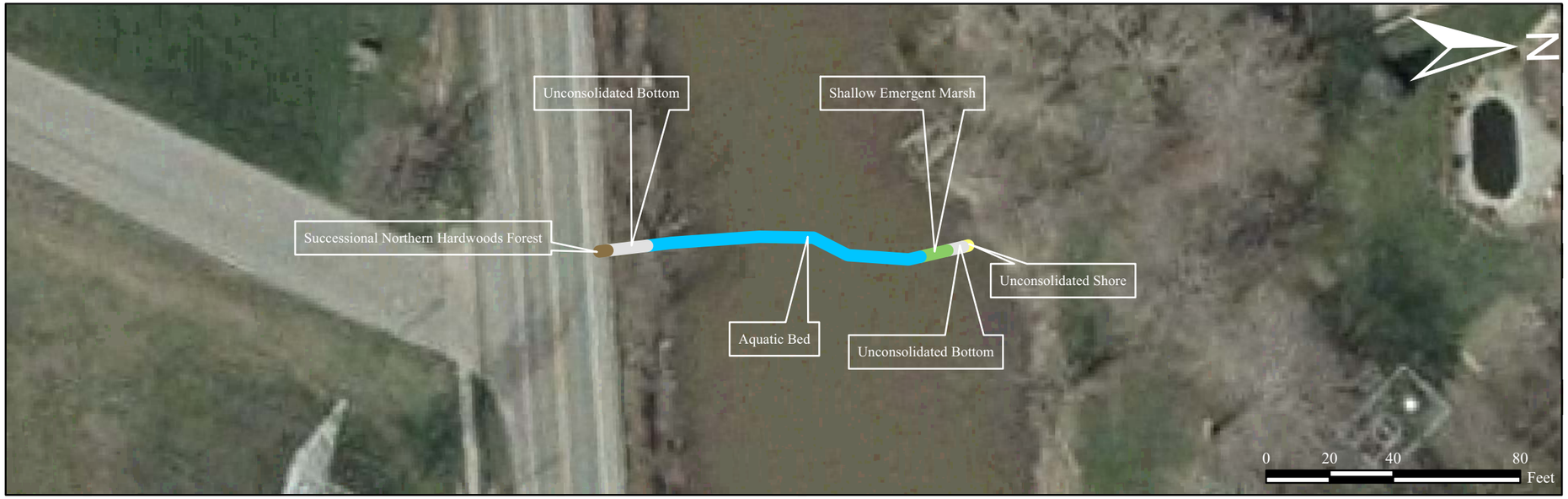

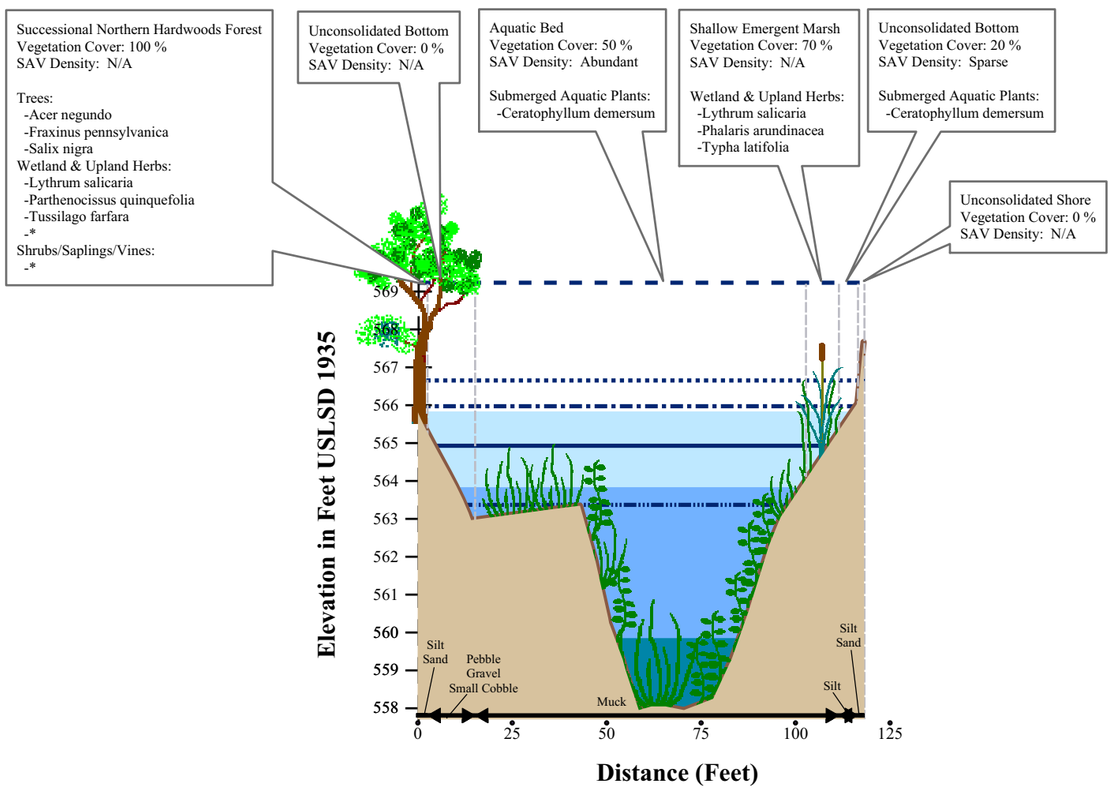

0 20 40 80
Feet

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

PLAN AND CROSS-SECTIONAL VIEWS OF ELLICOTT CREEK TRANSECT 2

LEGEND

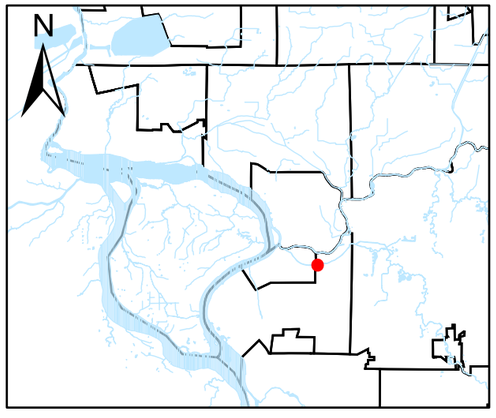
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/20/02 10:36)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



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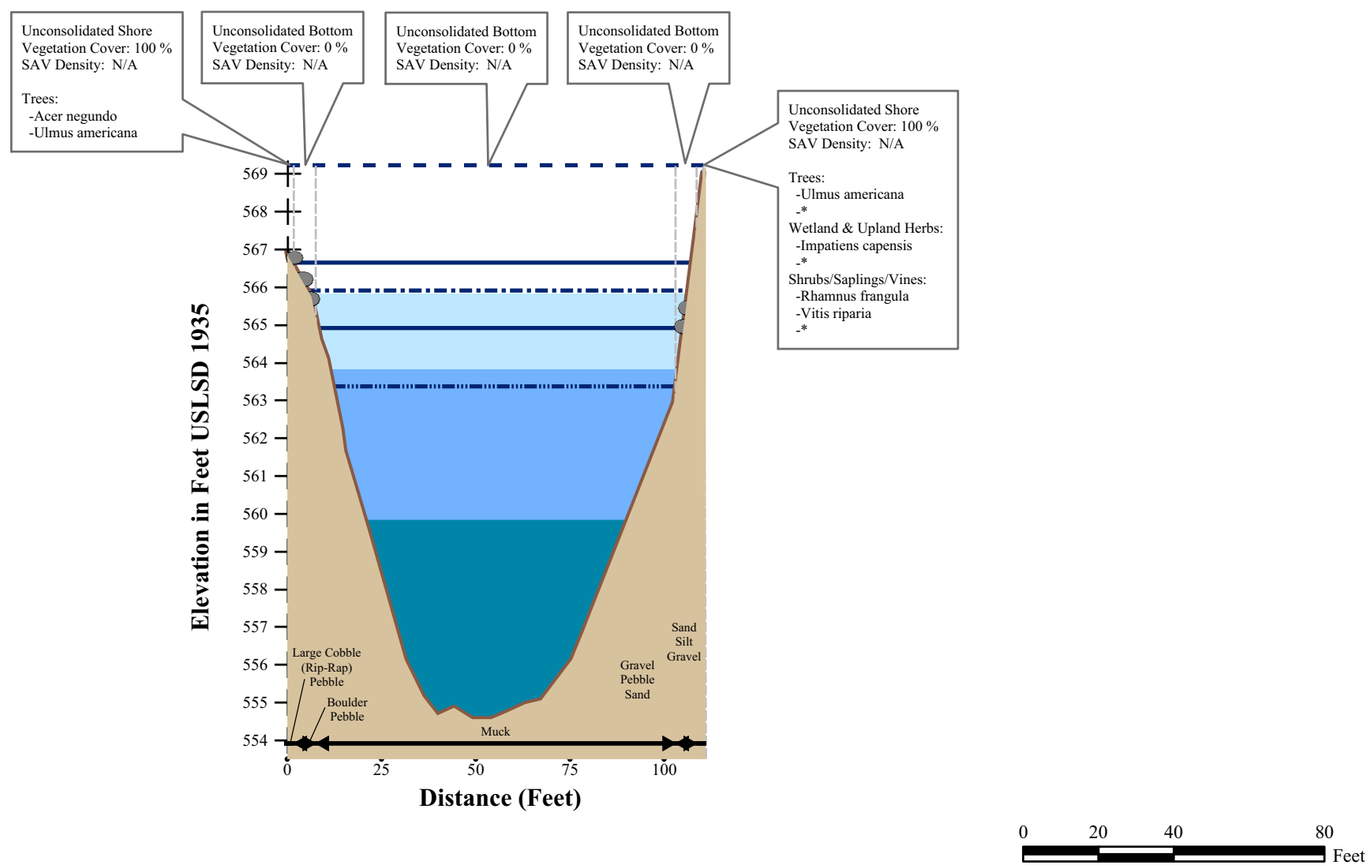

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF ELLICOTT CREEK TRANSECT 3

LEGEND

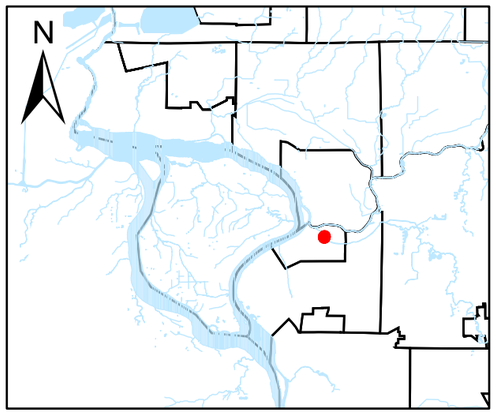
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/20/02 11:21)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



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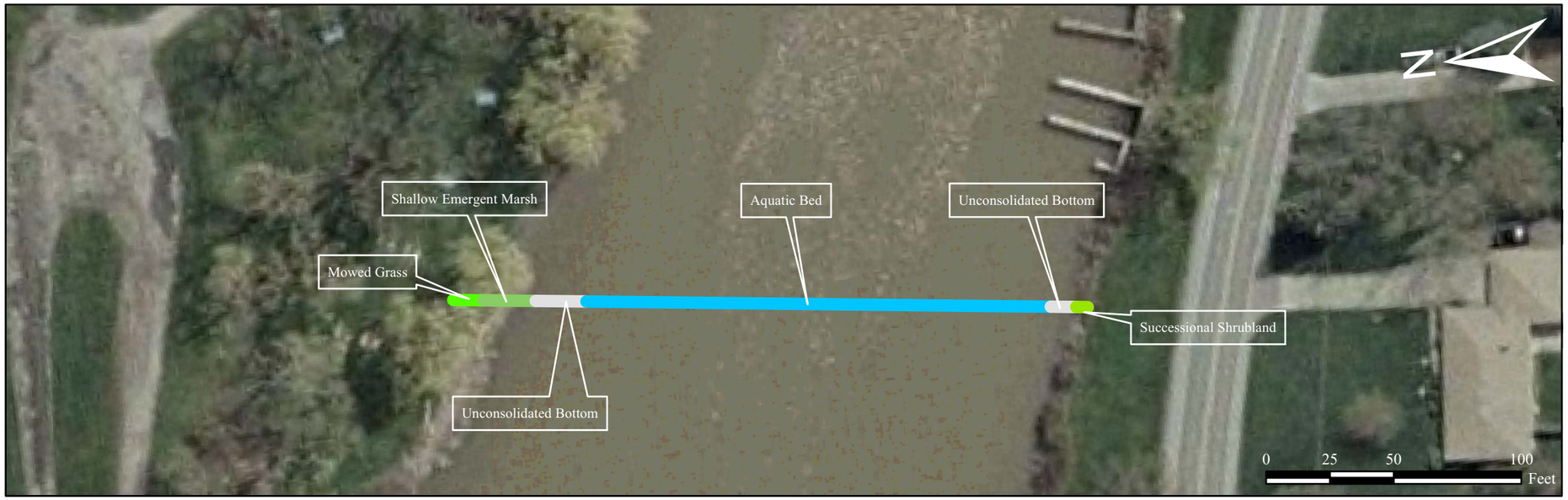

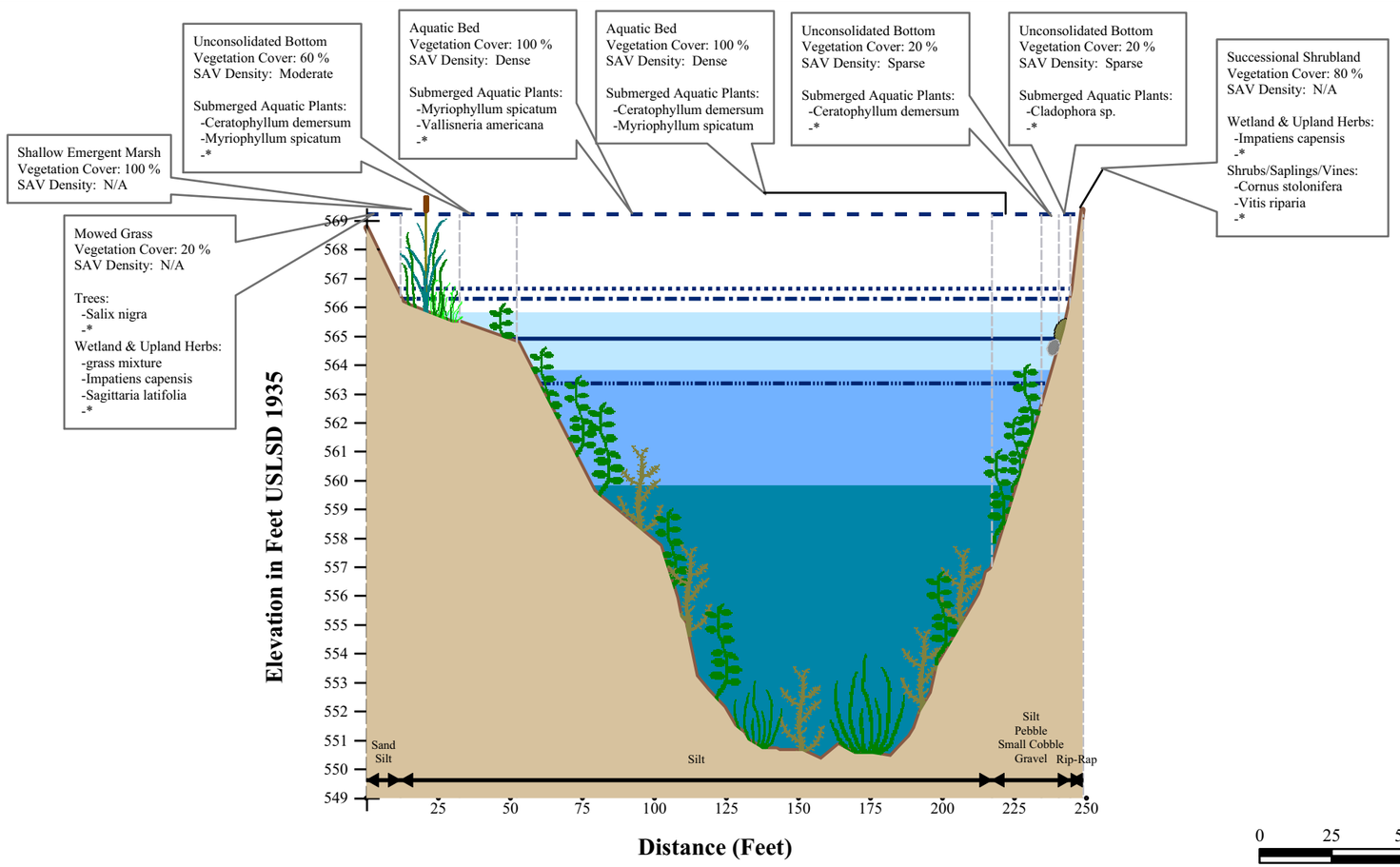

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NIAGARA POWER PROJECT (FERC NO. 2216)
EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TONAWANDA CREEK TRANSECT 1

LEGEND

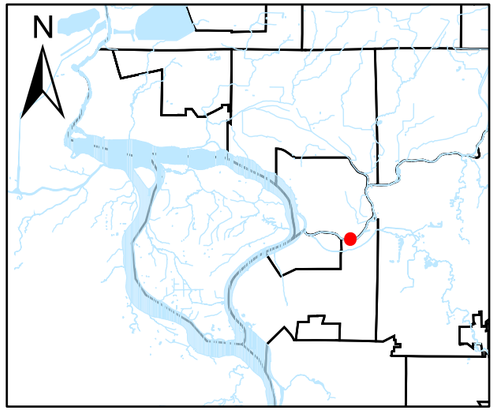
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/19/02 10:55)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:10

Appendix A-TC1

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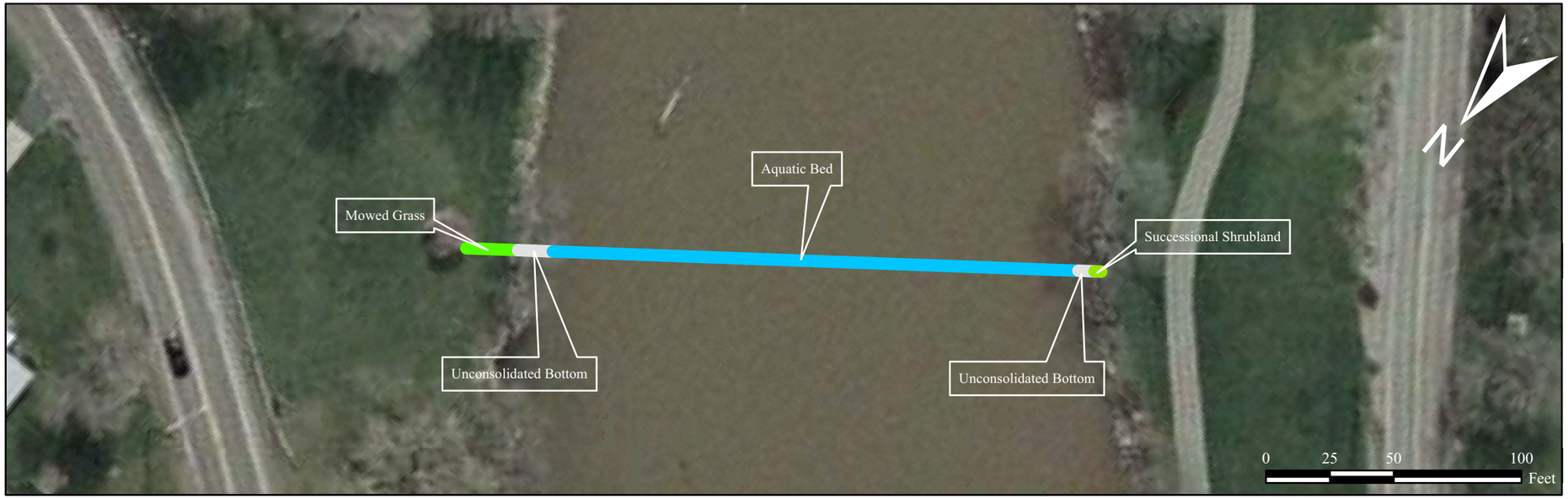

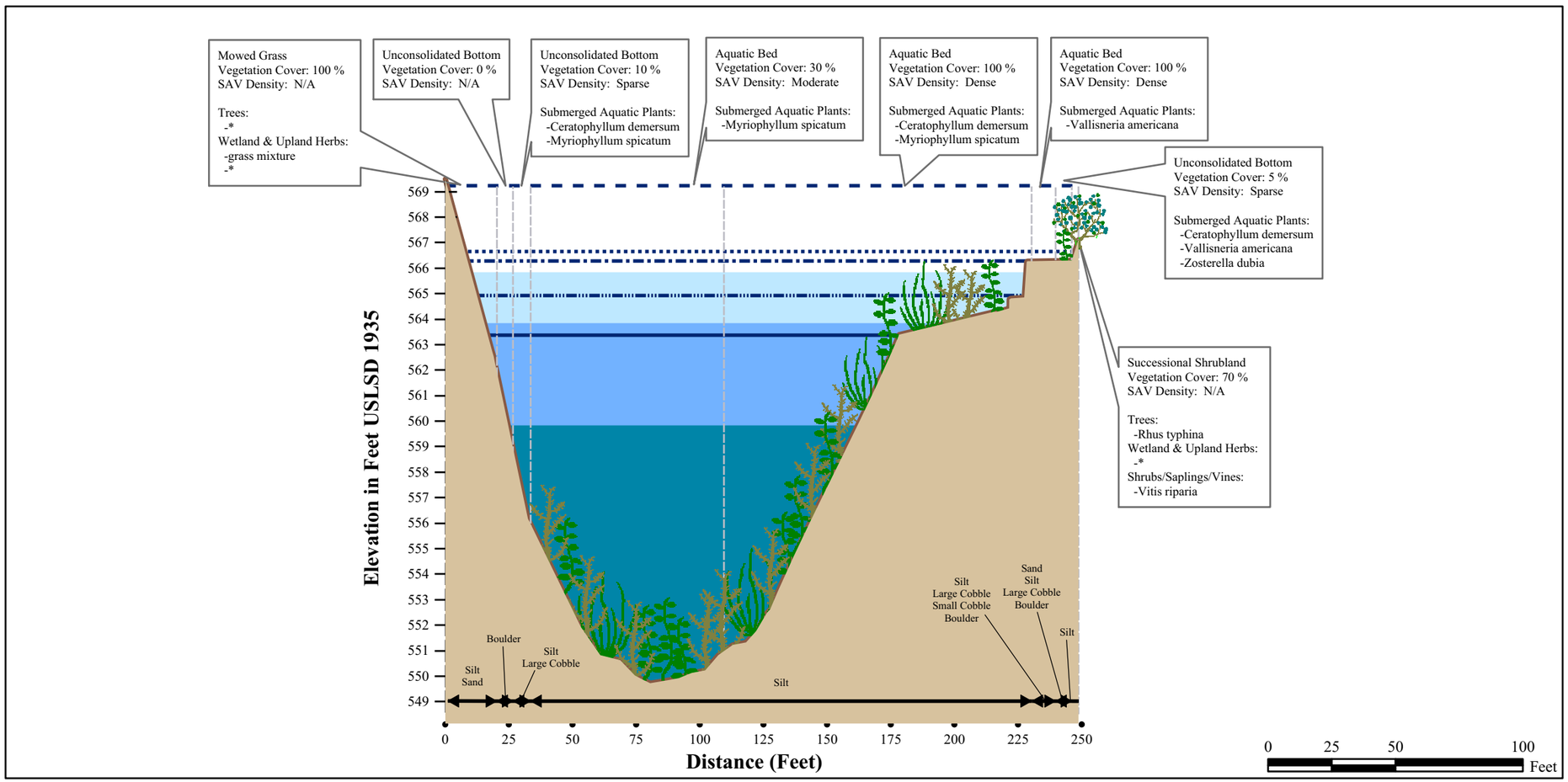

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TONAWANDA CREEK TRANSECT 2

LEGEND

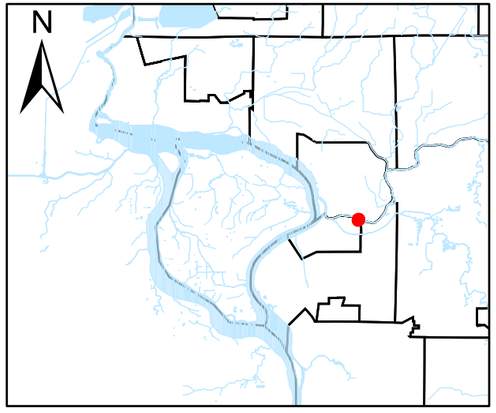
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/19/02 11:55)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:10

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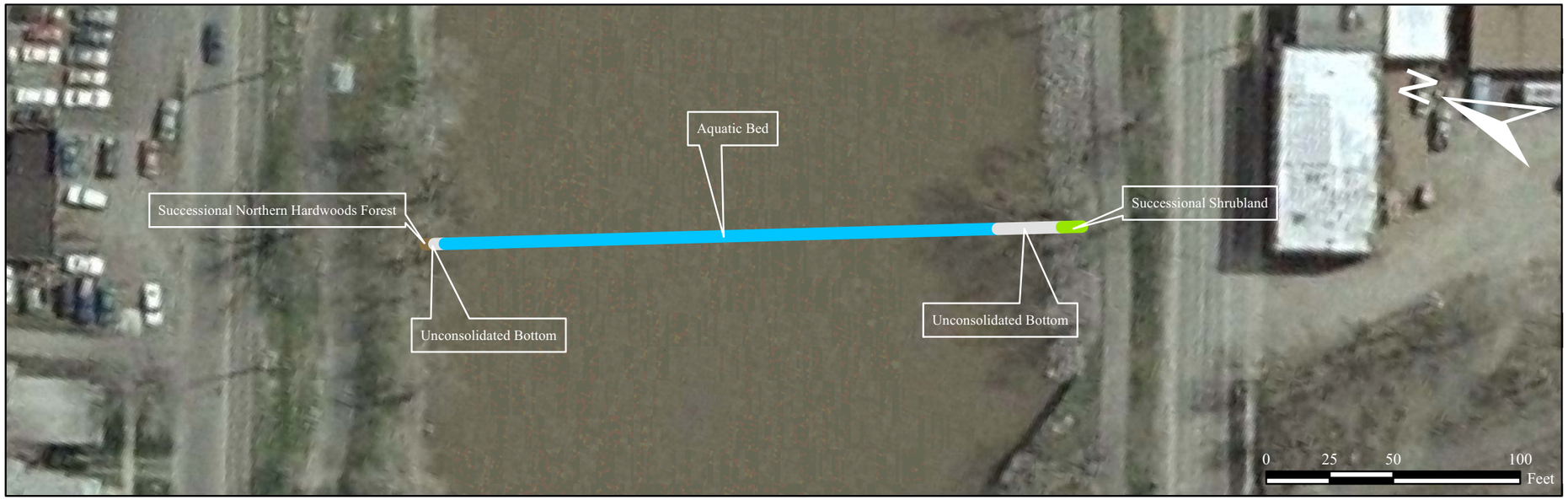

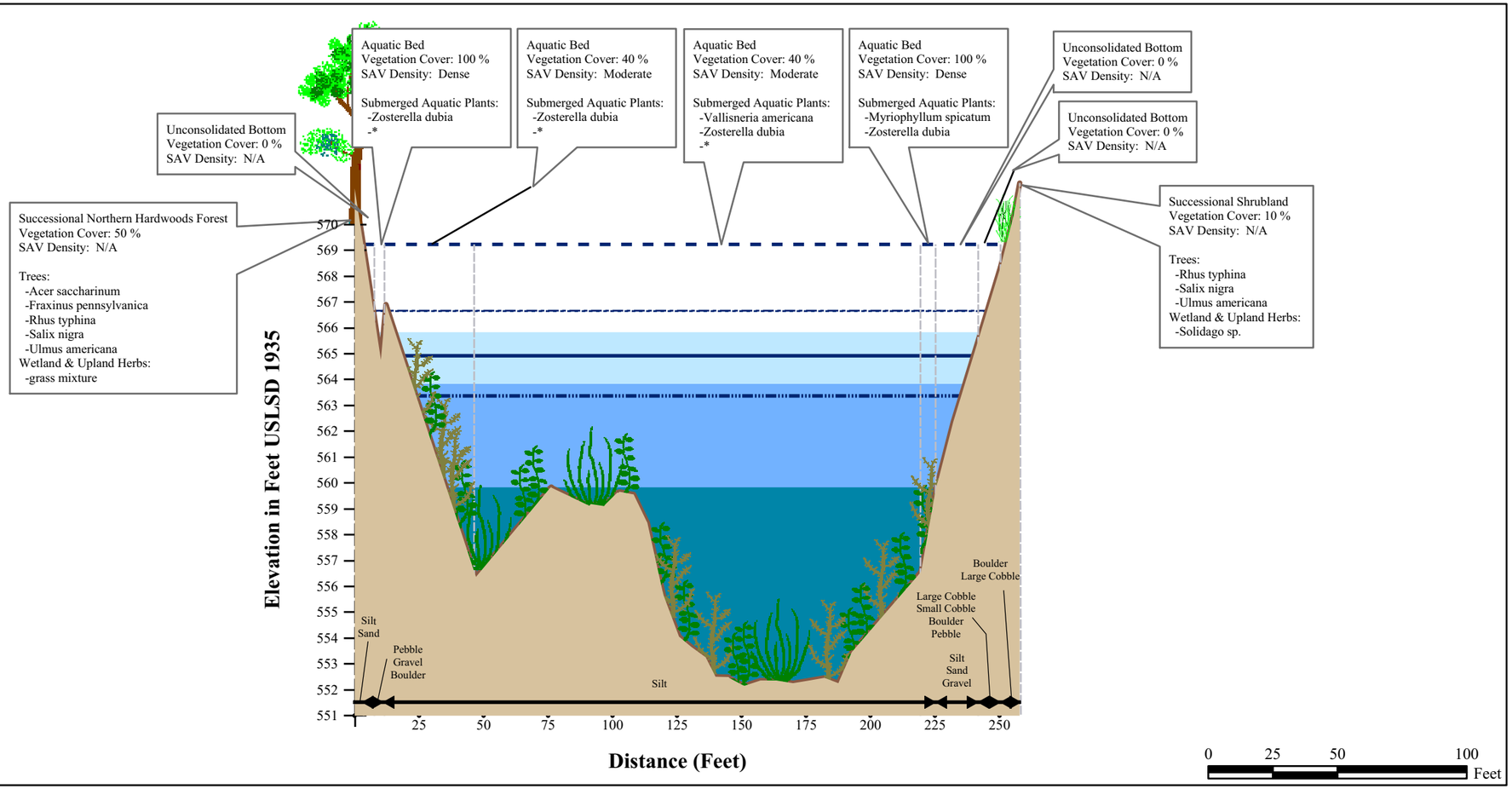

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EFFECT OF WATER LEVEL AND FLOW FLUCTUATIONS ON AQUATIC AND TERRESTRIAL HABITAT

PLAN AND CROSS-SECTIONAL VIEWS OF TONAWANDA CREEK TRANSECT 3

LEGEND

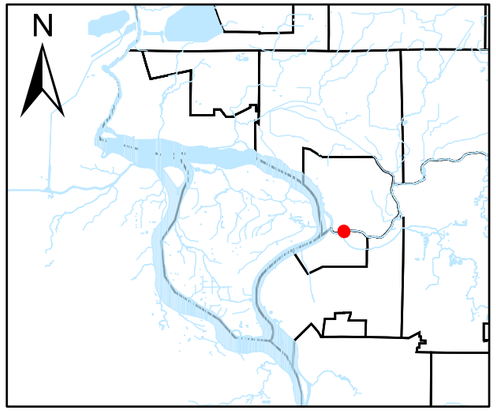
Water Depth at 50% Exceedance
- 0 to 2 feet
- 2 to 6 feet
- >6 feet

Water Levels
- Maximum
- 5 %
- 50 %
- 95 %
- Minimum
- Time of Survey (09/19/02 13:15)

SAV Density
- Sparse (< 25%)
- Moderately Abundant (25 - 50%)
- Abundant (50 - 75%)
- Dense (> 75%)

* Species occurring at 10 % or less coverage are not represented

Notes:
Water Elevations are percent exceedance levels from a duration analysis of annual water elevation data
Graphics composition of SAV and EAV represent species very generally, with no intention to show all species and density exactly



Ratio Vertical to Horizontal Scale 1:10

Appendix A-TC3

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APPENDIX A-13A
TRANSECT 13 - BUCKHORN MARSH/WOODS CREEK

Segment	Trees	Shrubs/Saplings/Vines	Wetland & Upland Herbs	Submerged Aquatic Plants
A	*Fraxinus pennsylvanica*	*Lindera benzoin* *Parthenocissus quinquefolia* *Vitis riparia*	*Polygonum virginianum* *Toxicodendron radicans*	
B	*Fraxinus pennsylvanica*	*Lindera benzoin*	*Boehmeria cylindrica* *Symplocarpus foetidus*	
C			*Impatiens capensis*	
D			*Nymphaea odorata* *Peltandra virginica* *Sagittaria latifolia*	*Ceratophyllum demersum* *Cladophora sp.*
E			*Impatiens capensis*	
F			*Solidago altissima*	
G			*Calamagrostis canadensis* *Carex stricta* *Impatiens capensis*	
H				*Ceratophyllum demersum* *Potamogeton zosteriformis* *Vallisneria americana*
I			*Pontederia cordata*	*Ceratophyllum demersum*
J			*Calamagrostis canadensis* *Carex stricta* *Impatiens capensis*	
K			*Nuphar luteum*	*Ceratophyllum demersum* *Potamogeton zosteriformis* *Vallisneria americana*
L			*Calamagrostis canadensis* *Carex stricta* *Impatiens capensis*	
M		*Cornus foemina*	*Carex comosa*	
N				
O	*Fraxinus pennsylvanica*		*Geum laciniatum* *Polygonum virginianum*	
P	*Quercus rubra* *Tilia americana*		*Geum laciniatum* *Polygonum virginianum*	

Note: This is a supplement to the plan and cross-sectional view of Transect 13, presented above. Species occurring at 10 % or less coverage are not listed.

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APPENDIX B - COMMON AND SCIENTIFIC NAMES OF PLANTS

Scientific Name	Common Name
Trees	
Acer negundo	box elder
Acer platanoides	norway maple
Acer rubrum	red maple
Acer saccharinum	silver maple
Acer sp.	maple
Ailanthus altissima	tree-of-heaven
Alnus rugosa	hazel alder
Alnus sp.	alder
Carya cordiformis	bitternut hickory
Carya ovata	shagbark hickory
Crataegus sp.	hawthorn
Fraxinus pennsylvanica	green ash
Fraxinus sp.	ash
Juglans cinerea	butternut
Juglans nigra	black walnut
Malus sp.	apple
Populus deltoides	eastern cottonwood
Prunus avium	sweet cherry
Prunus serotina	black cherry
Prunus sp.	cherry
Quercus bicolor	swamp white oak
Quercus palustris	pin oak
Quercus rubra	red oak
Quercus sp.	oak
Rhus typhina	staghorn sumac
Salix fragilis	crack willow
Salix nigra	black willow
Salix sp.	willows
Tilia americana	basswood
Ulmus americana	American elm
Ulmus sp.	elm
Zanthoxylum americanum	prickly ash

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Scientific Name	Common Name
Shrubs, Saplings, Vines	
Acer rubrum	red maple
Alnus rugosa	hazel alder
Cephalanthus occidentalis	buttonbush
Convolvulus sepium	hedge bindweed
Cornus amomum	silky dogwood
Cornus foemina	stiff dogwood
Cornus sp.	dogwood
Cornus stolonifera	red osier dogwood
Crataegus sp.	hawthorn
Cuscuta gronovii	dodder
Fraxinus pennsylvanica	green ash
Lindera benzoin	spicebush
Lonicera tatarica	Tartarian honeysuckle
Parthenocissus quinquefolia	Virginia creeper
Polygonum cuspidatum	Japanese knotweed
Prunus virginiana	choke cherry
Rhamnus cathartica	common buckthorn
Rhamnus frangula	glossy buckthorn
Rhus typhina	staghorn sumac
Rosa multiflora	multiflora rose
Rosa palustris	swamp rose
Rubus allegheniensis	northern blackberry
Rubus occidentalis	black raspberry
Salix fragilis	crack willow
Sambucus canadensis	black elderberry
Viburnum dentatum	arrowwood
Toxicodendron radicans	poison ivy
Vitis labrusca	fox grape
Vitis riparia	river bank grape
Zanthoxylum americanum	prickly ash

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Scientific Name	Common Name
Wetland and Upland Herbs	
Acorus calamus	sweetflag
Alisma plantago-aquatica	water plantain
Alliaria petiolata	garlic mustard
Angelica atropurpurea	purple-stem angelica
Apocynum cannabinum	Indian hemp
Arctium minus	common burdock
Arisaema triphyllum	jack-in-the-pulpit
Asclepias incarnata	swamp milkweed
Asclepias sp.	milkweed
Aster novae-angliae	New England aster
Aster sp.	aster
Aster vimineus	small white aster
Bidens connata	purple-stem beggar ticks
Boehmeria cylindrica	false-nettle
Butomus umbellatus	flowering rush
Calamagrostis canadensis	bluejoint grass
Carex comosa	handsome sedge
Carex scoparia	pointed broom sedge
Carex sp.	sedge
Carex stricta	uptight sedge
Cicuta bulbifera	water hemlock
Cinna arundinacea	stout woodreed
Circaea lutetiana	enchanter's nightshade
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Convolvulus arvensis	field bindweed
Convolvulus sepium	hedge bindweed
Cuscuta gronovii	dodder
Decodon verticillatus	water-willow
Dipsacus sylvestris	teasel
Echinochloa muricata	barnyard grass
Elymus canadensis	Canada wild rye
Epilobium coloratum	purple-leaved willow herb
Epilobium hirsutum	hairy willow herb

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Scientific Name	Common Name
Eupatoriadelphus maculatus	spotted joe-pye-weed
Eupatorium perfoliatum	common boneset
Eupatorium rugosum	white snakeroot
Euthamia graminifolia	flat-top fragrant goldenrod
Geum laciniatum	rough avens
Glyceria striata	fowl manna grass
Hibiscus moscheutos	rose-mallow
Impatiens capensis	spotted touch-me-not
Iris pseudacorus	yellow iris
Iris sp.	iris
Iris versicolor	blue flag
Juncus effusus	soft rush
Juncus sp.	rush
Leersia oryzoides	rice cutgrass
Lindera benzoin	spicebush
Ludwigia palustris	water purslane
Lycopus americanus	water horehound
Lycopus uniflorus	northern bugleweed
Lysimachia nummularia	moneywort
Lysimachia thrysiflora	tufted loosestrife
Lythrum salicaria	purple loosestrife
Mentha arvensis	field mint
Mimulus ringens	monkey flower
Nuphar luteum	yellow pond lily
Nymphaea odorata	white water lily
Onoclea sensibilis	sensitive fern
Panicum sp.	panic grass
Parthenocissus quinquefolia	Virginia creeper
Peltandra virginica	arrow arum
Phalaris arundinacea	reed canary grass
Phragmites australis	common reed
Physostegia virginiana	false dragonhead
Pilea pumila	clearweed
Poa palustris	fowl bluegrass
Poa pratensis	Kentucky bluegrass

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Scientific Name	Common Name
Polygala senega	Seneca snakeroot
Polygonum amphibium	water smartweed
Polygonum coccineum	swamp smartweed
Polygonum hydropiperoides	mild water pepper
Polygonum persicaria	lady's thumb
Polygonum punctatum	dotted water smartweed
Polygonum sagittatum	arrow-leaved tearthumb
Polygonum setaceum	swamp smartweed
Polygonum sp.	smartweed
Polygonum virginianum	jumpseed
Pontederia cordata	pickerel weed
Rhus typhina	staghorn sumac
Rubus allegheniensis	northern blackberry
Rumex verticillatus	swamp dock
Sagittaria latifolia	common arrowhead
Saponaria officinalis	bouncing bet
Saururus cernuus	lizard's tail
Scirpus americanus	three-square
Scirpus cyperinus	woolgrass
Scirpus fluviatilis	river bulrush
Scirpus validus	soft-stem bulrush
Solidago altissima	tall goldenrod
Solidago sp.	goldenrod
Sparganium americanum	lesser bur reed
Sparganium eurycarpum	great bur reed
Spartina pectinata	freshwater cordgrass
Symplocarpus foetidus	skunk cabbage
Thelypteris thelypteroides	marsh fern
Toxicodendron radicans	poison ivy
Triadenum virginicum	marsh St. Johnswort
Tussilago farfara	coltsfoot
Typha angustifolia	narrow-leaf cattail
Typha latifolia	broad-leaf cattail
Urtica dioica	stinging nettle
Urtica procera	tall nettle

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Scientific Name	Common Name
Urtica sp.	nettle
Veratrum viride	false hellebore
Verbena hastata	blue vervain
Vicia cracca	vetch
Viola sp.	violet
Xanthium strumarium	common cocklebur
Submerged Aquatic Plants	
Ceratophyllum demersum	coontail
Chara sp.	muskgrass
Cladophora sp.	filamentous algae
Elodea canadensis	common waterweed
Lemna minor	duckweed
Lemna sp.	duckweeds
Lemna trisulca	star duckweed
Myriophyllum spicatum	Eurasian water milfoil
Najas flexilis	slender naiad
Nitella sp.	nitella
Potamogeton amplifolius	large-leaf pondweed
Potamogeton crispus	curly-leaf pondweed
Potamogeton nodosus	long-leaf pondweed
Potamogeton pectinatus	sago pondweed
Potamogeton richardsonii	clasping-leaf pondweed
Potamogeton sp.	pondweed
Potamogeton zosteriformis	flat-stem pondweed
Scirpus subterminalis	clubrush
Utricularia vulgaris	common bladderwort
Vallisneria americana	wild celery
Zosterella dubia	water star-grass

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APPENDIX C - HABITAT REQUIREMENTS OF AQUATIC FOCUS SPECIES

To infer the outcomes of potential habitat effects due to water level fluctuations on fish, 13 species were chosen to represent the fish community of the upper Niagara River and its tributaries, 14 species of fish were chosen to represent the lower Niagara River, and four species of fish were chosen to represent the Lewiston Reservoir. (See Section 3.0 for list). The outcomes on benthic invertebrates were inferred from mussels, crayfish, and aquatic insects. The life history and habitat requirements for the fish and benthic invertebrate species are summarized in the following sections and in Table 5.2.1-1.

American Eel

American eels are a catadromous species living most of their lives in freshwater and migrating back to the ocean to spawn (Facey and Van Den Ayle 1987, Scott and Crossman 1979). Spawning is believed to occur in the Sargasso Sea east of the Bahamas and south of Bermuda. Larval American eels, or leptocephali, are transported by ocean currents to freshwater tributaries along the coast where they transform to juvenile (glass eels, and elvers) (Facey and Van Den Ayle 1987, Scott and Crossman 1979). Juvenile eels migrate upstream to where they spend the majority of their lives as yellow eels in rivers, streams, or lakes. Mature eels, or silver eels, migrate downstream and back to the Sargasso Sea where they spawn and eventually die (Facey and Van Den Ayle 1987, Scott and Crossman 1979). Maturation occurs in eight to 24 years with northern populations maturing later (ASMFC 2000).

American eels in the Niagara River are yellow eels that have migrated up the St. Lawrence River and across Lake Ontario. These eels are three to eight years old as they pass over the Moses-Saunders Dam at Massena, New York (Reid 2001). No other life stage of eel is found in the Niagara River other than perhaps the silver downstream migratory life stage. American eels in the Niagara River historically are restricted to the lower river although there may be access to the upper river through the Welland Canal and the New York State Barge Canal System. American eels are reported in Lake Erie, although rarely (Smith 1985; Scott and Crossman 1979).

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Yellow eels are bottom oriented, feeding primarily on demersal fishes and invertebrates, crayfish, snails, and worms (ASMFC 2000). They are primarily nocturnal, spending daylight hours buried in soft sediments or under larger rocks (Smith 1985; Scott and Crossman 1979).

Bluntnose Minnow

Bluntnose minnows are a nest building spawner depositing their eggs under the surface of flat stones, boards, logs, or other objects that provide a suitable surface (Scott and Crossman 1979). The male hollows out a nest underneath a suitable object creating a shallow depression. The adhesive eggs are deposited on the underside of the overhanging object. Nests are constructed in 0.5 to three foot deep water. Spawning occurs in late May to June when water temperatures reach 60˚ to 64˚ F and may continue until August (Scott and Crossman 1979; Smith 1985). Males guard and provide water flow through the nest. The eggs hatch in approximately 7-14 days depending on water temperature (Scott and Crossman 1979; Smith 1985).

Bluntnose minnow adults prefer sand to gravel substrate in shallow clear lakes and ponds but are also found in slow moving rocky or gravely streams (Scott and Crossman 1979). They appear to avoid heavy macrophyte beds. They are a bottom oriented, feeding on algae, bottom detritus, insect larvae, and zooplankton (Scott and Crossman 1979; Smith 1985).

Brown Bullhead

Brown bullhead spawn in the late spring and summer as water temperatures approach 69.8˚ F (Scott and Crossman 1979). Smith (1985) reported that spawning occurs from late May through June. Spawning occurs in nests cleared by the adults, in relatively shallow areas (less than 4.0 feet), with little or no velocity, and on preferred substrates of mud, sand, or gravel (Scott and Crossman 1979; Auer 1982). Brown bullhead will nest under and in cover such as boards, hollow stumps, and tires, or in burrows (Scott and Crossman 1979). Spawning occurs during daylight hours usually around the

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shoreline, in coves, bays, or in creek mouths. The eggs are demersal and adhesive. Either parent or both may guard the nest. Eggs typically hatch in six to nine days at temperatures between 69.1˚ and 73.9˚ F (Scott and Crossman 1979).

Brown bullhead yolk-sac fry emerge and remain immobile in the nest for approximately seven days, after which they begin to swim and actively feed (Scott and Crossman 1979). Either or both parents guard the fry for approximately two weeks, during which time they reach approximately 2 inches in length (Scott and Crossman 1979; Smith 1985). Brown bullhead fry prefer shallow areas (less than one foot deep), little to no velocity, primarily fine substrates, and are sometimes associated with vegetation (Adams and Hankinson 1928).

Initially, juvenile brown bullhead use similar habitat as fry, and gradually shift to habitats preferred by adults as they grow. They generally prefer shallow areas with little or no velocity, soft substrates, and abundant vegetation or other covertypes (Raney et al. 1940; Becker 1983).

Adult brown bullhead are bottom oriented (i.e., demersal) and occur primarily in shallow, warm water areas of lakes and rivers with abundant vegetation and sand to mud substrates (Scott and Crossman 1979). Adults are found in both lentic and lotic environments and, while preferring shallow waters, have been reported at depths up to 40 feet. Brown bullheads are tolerant of warm temperatures, low dissolved oxygen levels, and pollutants that may limit other species (Scott and Crossman 1979).

Chinook Salmon

Chinook salmon are anadromous salmonids indigenous to the west coast of North America. They were first introduced into Lake Erie from 1873-1878 by Michigan and Ohio and into Lake Ontario from 1874-1881 by Ontario (Scott and Crossman 1979). New York State began stocking Chinook salmon into Lake Ontario in 1969. Currently the Lake Ontario population is maintained through annual stockings by New York and Ontario.

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Chinook salmon are, for the most part, a fall spawning species in the Great Lakes (Smith 1985). In their native range they exhibit at least three spawning strategies with spring, summer, and fall spawning runs depending on river size and distance covered during migration (Beauchamp et al. 1983). Spawning in New York Waters begins in late August, but usually occurs from September through October (Smith 1985). Spawning can occur between 40˚ and 57˚ F (Beauchamp et al. 1983; Raleigh et al. 1986). Chinook salmon build nests (redds) in clear, well-oxygenated streams (Beauchamp et al. 1983; Raleigh et al. 1986; Scott and Crossman 1979). They prefer small to large cobble (1-10 inches) substrates at depths greater than one foot, and water velocities between 1.5 and 2.4 fps (Raleigh et al. 1986). They will spawn in gravel to large cobble substrates (less than 1 to >6 inches). Spawning depth is less important than water velocity in selecting spawning sites, and spawning depth can vary considerably (about 1 foot to >20 feet). The eggs are demersal and are typically deposited at the center of the nest where they fall within the interstitial spaces in the gravel substrate (Scott and Crossman 1979).

Incubation and hatching are temperature-dependent. Eggs require an average of 882 to 991 temperature units for hatching (1 temperature unit = 1 degree Fahrenheit above freezing for a period of 24 hours) (Beauchamp et al. 1983). Successful hatching occurs at temperatures of 39˚ to 61˚ F (Allen and Hassler 1986). Scott and Crossman (1979) reported that the eggs hatch in the spring and the fry remain in the in the gravel for 2 to 3 weeks.

Fry and juveniles remain in their natal rivers from 1 to 18 months (Beauchamp et al. 1983; Allen and Hassler 1986). Fry prefer velocities of less than 1.6 fps, depths greater than 0.5 feet, and gravel substrates (Raleigh et al. 1986). Juveniles tend to prefer deeper, faster water with larger substrates (Raleigh et al. 1986).

Adult Chinook salmon in the Great Lakes are pelagic, mid-lake inhabitants and therefore do not show a preference for substrate type, depth, or water velocity. Depth distribution is related to temperature, dissolved oxygen, and prey abundance. Adult Chinook salmon are known to remain in the marine environment from one to six years with the average being three and four years (Beauchamp et al. 1983).

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Emerald Shiner

Limited information exists on emerald shiner spawning. Evidence suggests they have a prolonged spawning season in late spring to early summer with some spawning reported as late as mid-August (Scott and Crossman 1979; Smith 1985). Water temperatures during spawning are around 75˚ F (Smith 1985). Emerald shiners appear to be broadcast spawners, most likely in mid-water areas.

Hatching occurs quickly, within 24 to 32 hours after fertilization, followed by rapid growth. Emerald shiners can reach 8.9 mm (0.35 inches) in approximately 11 days and young of the year can average 50 mm (1.96 inches) by mid-November (Scott and Crossman 1979).

Emerald shiner juveniles and adults are primarily pelagic, inhabiting large lakes and rivers. They are an offshore schooling species that stays near the surface during the summer months, moving into shallow inshore waters in autumn and spring (Scott and Crossman 1979; Smith 1985).

Greater Redhorse

Greater redhorse spawn from May to July in high gradient runs and riffles when water temperatures are between 55˚ and 66˚ F (Healy 2002; Scott and Crossman 1979). They prefer shallow depths (0.3-3 feet), moderate velocities (0.1-3.8 fps), and gravel or cobble substrates (Healy 2002). After spawning the adults are known to move downstream to lower velocity runs (Bunt and Cooke 2000).

Larval and juvenile greater redhorse in Minnesota rivers prefer lower velocity pools (Healy 2002). Age-0 fish prefer depths of 0.7 feet and velocities of 0.69 fps (Healy 2002). Juvenile greater redhorse (greater than age-0) prefer slightly deeper pools (2-5 feet deep) and slightly higher velocities (1.2 fps) (Healy 2002).

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Adult greater redhorse prefer large clear streams and rivers with coarse substrates such as gravel, cobble, and boulders (Healy 2002, Trautman 1981). Bunt and Cooke (2002) in the Grand River, Ontario, Canada reported the adult's summer range was in low velocity runs (depths of 1.5 ft and velocities of less than 0.6 fps). Like other redhorse species, they are bottom oriented feeding on insects, invertebrates, worms, and mollusks (Scott and Crossman 1979).

Lake Sturgeon

Lake sturgeon spawn from early-May to late-June in swift water, rapids, the tailraces of hydroelectric projects, or the bases of small falls in water two to 39 feet deep (Hayes 2000; Knights et al. 2002, Manny and Kennedy 2002). Preferred water velocities are between 0.32 fps and 2.29 fps (Threader et al. 1998). Spawning depends on temperature, with peak spawning occurring at temperatures between 50˚ and 57.2˚ F (Kempinger 1988). Clean rock, gravel, and stone bottom substrates are used for spawning by mature adults (Houston 1987; Bouton 1994; Auer 1996; Hay-Chmielewski and Whelan 1997; Borkholder et al. 2002; Knights et al. 2002; Hughes 2002). Where suitable spawning streams are unavailable, lake sturgeon may spawn in wave action over ledges or around rocky islands (Scott and Crossman 1979). The eggs are demersal and adhesive and adhere to stones and vegetation. In general, females spawn every three to seven years and males may spawn every other year (Hay-Chmielewski and Whelan 1997).

Lake sturgeon eggs hatch in 8-14 days at temperatures between 60.1˚ and 64.0˚ F (Kempinger 1988); MacNeill and Busch 1994). The time to hatching depends on water temperature (Kempinger 1988). The yolk sac is absorbed in 9-18 days, and within two-weeks the fry resemble the adult lake sturgeon (Scott and Crossman 1979). At emergence, and from the fry and through the juvenile life stage, lake sturgeon are nocturnal drifters that move downstream in riverine systems (Kempinger 1988, MacNeill and Busch 1994).

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In the Niagara River, juvenile and adult lake sturgeon were studied by Mr. Chris Lowie and Mr. Thomas Hughes as part of a Great Lakes native fish restoration project (USFWS 1999; USFWS 2002). To determine movement patterns and habitat preferences in the Niagara River, sturgeon were captured and fitted with ultrasonic tags (Hughes 2002; USFWS 2002). Tagged sturgeon showed some preference for a back eddy area known as Peggy's Eddy below Joseph Davis State Park and the Queenston Long Drift near Lewiston. Sturgeon preferred areas with bottom velocities between 0.62 and 1.2 fps and depths between 30 and 35 feet. Juvenile lake sturgeon seemed to prefer nearshore, slow-water currents (mean bottom velocity 0.62 fps) in Peggy's Eddy and the Queenston Long Drift. Subadults preferred areas with currents of approximately 0.88 fps, and adults seemed to prefer the faster currents (mean bottom velocity 1.2 fps) of the river and the area of the River's confluence with the lake. Juveniles, subadults, and adults all occupied similar depths between 30 and 35 feet (USFWS 2002). Threader et al. (1998) reported that juvenile lake sturgeon preferred foraging on substrates of silt, sand, gravel, and cobble, foraging depths of between 6.6 feet and 23.0 feet, and foraging velocities between 0.16 fps and 1.3 fps.

Sturgeon are known to use activity centers (Borkholder et al. 2002) or core areas (Knights et al. 2002). Borkholder et al. (2002) found that 80% of daytime observations were concentrated in four activity centers, and all tagged fish showed some affinity for specific pools. Like Peggy's Eddy and the Queenston Long Drift, the preferred habitat for sturgeon were areas along transition zones from high current to low current where deposition may occur, such as back eddies. All studies found sturgeon to preferentially use areas over soft substrates such as silt or sand (Borkholder et al. 2002, Knights et al. 2002, Hughes 2002). Sturgeon activity centers generally have low current velocities (Seyler 1997, Borkholder et al. 2002, Hughes 2002). Current velocities under 1.3 fps were preferred by sturgeon in a Minnesota study (Borkholder et al. 2002). Seyler (1997) found that adult lake sturgeon did not prefer habitats with current velocities exceeding 2.0 to 2.3 fps, and Hughes (2002) suggested that juvenile sturgeon prefer areas where current velocities are even lower. The preferred habitats of sturgeon in the lower Niagara River were characterized by sand and gravel, and relatively few zebra mussels. Adults appeared to prefer the lake or main river whereas juveniles preferred back eddy environments (Hughes 2002). In the upper river, young-of-the-year sturgeon appear to concentrate in the waters around Buckhorn Island State Park, where currents are lower than in the main river channel (USFWS 1999).

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Historically, lake sturgeon were believed to spawn in the fast flowing water upstream of the Peace Bridge at the head of the upper Niagara River near the southern end of the Black Rock canal (Goodyear et al. 1982).

Lake Trout

Lake trout spawn in the Great Lakes from September though November at temperatures ranging from 48˚ to 57˚ F (Scott and Crossman 1979; Marcus et al. 1984; Sly and Schneider 1984). Spawning occurs over rubble and boulders (substrate >2.5 inches in diameter with interstitial spaces generally > 8 inches deep), typically on bars or reefs at depths of one to 40 feet, with reports of fish spawning at 100 to 200 feet in Seneca and Cayuga Lakes (Scott and Crossman 1979; Smith 1985). In the Great Lakes, spawning typically occurs in water of ~9 to ~60 feet deep, although it is believed that spawning may occur at depths of up to 260 feet (Marsden et al. 1995). It is possible that lake trout in the Great Lakes do not spawn in water shallower than ~ 9 feet. Lake trout spawn primarily in lakes and rarely in rivers (Scott and Crossman 1979; Marcus et al. 1984). Sly and Schneider (1984) reported lake trout spawning over a cobble-gravel beach in eastern Lake Ontario. River-spawning populations of lake trout in eastern Lake Superior spawn over large boulders intermixed with coarse gravel (Loftus 1958); however, the only known native river-spawning stocks of lake trout in the Great Lakes were in Lake Superior. The eggs are demersal, falling into the interstitial areas of the substrate.

Hatching time varies; it can range from 15-21 weeks at temperatures between 32.5˚ and 33.8˚ F (Scott and Crossman 1979). Fry typically seek out deeper water within a month after hatching.

Adult lake trout are typically found near the bottom of cool, well oxygenated lakes at depths ranging from 40 to 175 feet (Scott and Crossman 1979). Their preferred temperatures range between 50 and 63˚ F (Scott and Crossman 1979; Smith 1985).

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Largemouth Bass

Largemouth bass typically spawn late spring to early summer, with peak spawning early to mid-June as water temperatures reach 61-72˚ F (Stuber et al. 1982; Smith 1985; Scott and Crossman 1979). Optimum weekly mean temperatures for spawning are between 68˚ and 72˚ F (Stuber et al. 1982). Optimum water velocities are between 0 and 0.09 fps (Stuber et al. 1982). Largemouth bass spawn on nests constructed by the male in 0.5-26 feet of water, with an average of 1.6-2.9 feet (Stuber et al. 1982). Gravel is the preferred substrate, although largemouth bass will construct nests on other substrates, including vegetation, roots, sand, mud, and cobble (Stuber et al. 1982; Scott and Crossman 1979). Where largemouth and smallmouth bass coexist, largemouth bass will spawn sooner, since they nest in shallower, protected waters that warm sooner (Scott and Crossman 1979). The eggs are demersal and adhesive and are typically laid over the entire nest bottom (Scott and Crossman 1979). Males guard the nest during incubation.

At the preferred spawning temperatures, eggs hatch in three to five days (Scott and Crossman 1979; Smith 1985). Fry remain in the nest until the yolk sac is absorbed (6-7 days) then emerge and begin feeding. Optimal water velocities for largemouth bass fry are 0-0.02 fps, with a maximum tolerance of 0.88 fps (Stuber et al. 1982). Fry require 40-80% cover with greater than 3.3 feet water depth for optimal survival (Stuber et al. 1982). Optimal temperatures for fry growth are between 80.1˚ and 86˚ F (Stuber et al. 1982).

Specific habitat requirements for juvenile and adult largemouth bass are the same. Adult largemouth bass inhabit the upper levels of warm water in lakes and rivers and are rarely found in depths greater than 20 feet (Scott and Crossman 1979). Largemouth bass adults and juveniles are usually found associated with extensive growths of EAV and SAV, particularly water lilies, cattails, and various species of pondweed (Scott and Crossman 1979; Stuber et al. 1982; Smith 1985). Optimum cover is between 40% and 60% coverage of the littoral area. Adults are more prevalent in slower waters, with optimum velocities of less than or equal to 0.2 fps (Stuber et al. 1982). Soft to fine substrates are preferred over rocky substrates.

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Muskellunge

Muskellunge typically spawn in shallow (less than 6.0 feet deep) lentic waters during the spring at water temperatures between 48.9˚ and 59.0˚ F (Scott and Crossman 1979; Cook and Solomon 1987). Optimum spawning temperature is 55˚ F (Cook and Solomon 1987). These conditions typically occur between May and mid-June. Harrison (1978) reported that spawning in the Niagara River took place in heavily vegetated lotic areas at depths of 3-7 feet and at higher than the reported optimal temperatures (61˚-64˚ F). Harrison concluded that the limited amount of shallow, low velocity waters on the Niagara River may have required muskellunge to spawn in the faster and deeper waters than those they normally preferred. Muskellunge prefer abundant vegetation and fines or organic substrates, however no type of vegetation, depth, or cover is critical to reproduction (Cook and Solomon 1987). Muskellunge eggs are semi-demersal, non-adhesive, and are randomly broadcast over submerged vegetation (Scott and Crossman 1979). Eggs are intolerant of sedimentation, of low dissolved oxygen levels, and of high hydrogen sulfide levels (Cook and Solomon 1987). Spawning typically continues for one week.

Hatching occurs 8-14 days after spawning at water temperatures between 54˚ and 62˚ F (Cook and Solomon 1987). Yolk-sac fry are inactive, remaining within the spawning vegetation until the yolk sac is absorbed, in approximately 10 days. Muskellunge fry typically remain in or near the spawning area where the submerged vegetation provides cover (Cook and Solomon 1987). Preferred vegetation is a mix of dense and sparse SAV and EAV. These areas are typically 3.3 feet deep, have little to no velocity, and have substrates consisting of sand, muck, silt, and detritus (Cook and Solomon 1987).

In sampling for juvenile muskellunge in the upper Niagara River, NYSDEC (1994 and 1995) found that juveniles were most prevalent at water depths of 2-6 feet, in substrates dominated by consolidated silt-clay or sand, and in moderate to dense vegetation. Another observation was that almost every site where juvenile muskellunge were observed, wild-celery was a dominant or significant component of the SAV. No water velocity preferences were discussed. The area with the highest catch rate, however, was an embayment upstream of the Niagara Parks Marina. It is assumed to have relatively slow water velocities (NYSDEC 1994; NYSDEC 1995). The lower river has also been sampled for

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juvenile muskellunge (NYSDEC 1996). Young of the year were collected from locations that had the same depths and SAV characteristics as those locations in the upper river where young-of-the-year muskellunge were collected.

Adult muskellunge utilize a variety of water depths and cover types associated with their foraging patterns (Cook and Solomon 1987). They are regularly found associated with dense growths of several species of pondweed (*Potamogeton* spp.) and typically inhabit areas less than 15 feet deep (Scott and Crossman 1979). Larger muskellunge are often found in less vegetated water at depths up to 50 feet, particularly during the summer and winter months (Scott and Crossman 1979). Low-velocity waters are preferred, along with sand, gravel, fines, or organic substrate. Optimum water temperature for adults is 78˚ F (Scott and Crossman 1979), with a reported summer range of between 75˚ and 81˚ F (Smith 1985).

Northern Pike

Spawning typically occurs in shallow (less than 20 in.) lentic waters over submerged vegetation soon after ice-out (Casselman and Lewis 1996; Inskip 1982; Clark 1950; Scott and Crossman 1979), but spawning has been documented to occur in water up to 16 feet deep (Farrell 2001); deeper water being used as the spawning season progresses. Harrison and Hadley (1978) found that 97% of the northern pike collected during spawning season in the upper Niagara River waters were collected in its tributaries despite extensive mainstem river sampling. Movement into the spawning areas (i.e., tributaries, flooded marshes, and wetlands) occurs shortly after ice-out as water temperature rise to 46˚-54˚ F (Casselman and Lewis 1996; Inskip 1982; Clark 1950). Spawning typically occurs from late-March to late-April, depending on water temperatures (Clark 1950; Scott and Crossman 1979; Franklin and Smith 1963). Optimal spawning substrates are shallow-flooded with moderately dense vegetation such as grasses and sedges, although type or species of vegetation does not appear to be a limiting factor with the exception of cattails, which appear to not be suitable spawning substrate for northern pike (Casselman and Lewis 1996; Inskip 1982). Northern pike eggs are demersal and very adhesive. They are broadcast randomly across the vegetation where they quickly sink and attach to the vegetation (Scott and Crossman 1979).

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Maximum hatching success occurs at temperatures between 48˚ and 59˚ F (Inskip 1982). Eggs hatch within 12-14 days at 64˚-68˚ F (Scott and Crossman 1979). Northern pike yolk-sac fry have small papillae on the front of their heads that allow them to attach to the vegetation. This keeps them suspended above the bottom and potential areas with low oxygen or high hydrogen sulfide levels (Inskip 1982). Yolk-sac fry may stay attached for 6-10 days. Fry average 0.28-0.35 inches in length at hatching, growing to 0.59-0.79 inches within 10-24 days (Inskip 1982; Franklin and Smith 1963). Fry habitat requirements are the same as those for spawning.

Emigration of fry from the spawning area take place from one to six weeks after hatching, and possibly depends on temperature, light intensity, food supply, or water levels (Inskip 1982; Franklin and Smith 1963). Juvenile northern pike move to deeper water, preferably adjacent to the spawning area (Casselman and Lewis 1996). Preferred habitat is dense submergent and emergent vegetation, with 40-90% coverage or other cover such as snags or submerged brush (Casselman and Lewis 1996). A positive correlation exists between depth and juvenile size for the first growing year (Casselman and Lewis 1996). Casselman and Lewis (1996) reported that for the first year, water is approximately 0.32 feet deep for every 0.46 inches of body length up to 5.9 inches in length. Depth preferences during the first year would then range between 0.32 and 4.0 feet. Growth is rapid, with juveniles reaching approximately 1.6 inches by the first month and approximately 5.9 inches by the end of the first growing season. Optimum temperature for juvenile growth is 66˚-73˚ F (Casselman and Lewis 1996; Inskip 1982). Preferred substrates are mostly gravels, sands, fines, or organic muck, as these substrates are most typically associated with SAV/EAV beds (Inskip 1982).

Adult northern pike generally prefer shallow vegetated areas (usually less than 13 feet), but sometimes are found as deep as 39 feet (Casselman and Lewis 1996). Larger adults will utilize open water or the open water macrophyte interface more than smaller adults or juveniles. Chapman and Mackay (1984) found that larger northern pike were found in deep, unvegetated waters more frequently than smaller individuals. Northern pike in the St. Lawrence River have been caught with downriggers in water as deep as 60 feet. Very dense vegetation appears to be suboptimal for larger fish whereas the macrophyte-open water interface zone may provide important foraging habitat for larger adults

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(Casselman and Lewis 1996). Macrophyte growth and density may affect northern pike density and size distributions. Lakes with dense macrophytes tend to have larger populations of smaller northern pike than lakes with more open water-macrophyte interface areas (Casselman and Lewis 1996). Optimum water temperature for adult growth is reported to be between 66˚ and 70˚ F (Inskip 1982, Casselman and Lewis 1996).

Rainbow Smelt

Rainbow smelt are typically anadromous and run up streams and rivers from the sea or large lakes (in the case of landlocked forms) in the spring to spawn (Scott and Crossman 1979). They are indigenous to the Atlantic coastal drainage from New Jersey to Labrador. They have been successfully introduced into many inland waters, including the Great Lakes (Buckley 1989). Rainbow smelt begin their spawning migrations in March though April soon after ice-out and spawn at water temperatures between 48˚ and 64˚ F (Buckley 1989; Scott and Crossman 1979; Jilek et al. 1979). In the Great Lakes, they typically spawn in streams and along offshore gravel shoals from late-April to early-May (Scott and Crossman 1979; Jilek et al. 1979). Spawning can occur over three weeks, but one week is more typical. Spawning takes place in water with velocities ranging from 1.97-2.62 fps and depths ranging from 0.3 to 4.3 feet, with higher egg deposition in areas with the highest velocities (Buckley 1989). Rainbow smelt prefer sand and gravel substrates for spawning, with eggs deposited over gravel having a higher survival rate (Scott and Crossman 1979; Banner and Hayes 1996; Buckley 1989). The eggs are demersal and adhesive and quickly become attached to the substrate, which allows the egg to sway (balloon-like) in the current (Scott and Crossman 1979; Buckley 1989).

Hatching may occur anywhere from 2 to 3 weeks after fertilization (Scott and Crossman 1979). On hatching, the yolk-sac larvae drift downstream with the current and concentrate near the surface (Buckley 1989; Scott and Crossman 1979). As the fry grow, they tend to concentrate near the bottom during the day in inshore areas along sand and gravel beaches, and move near the surface at night, apparently to feed (Scott and Crossman 1979; Buckley 1989).

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Juvenile and adult smelt are pelagic, schooling fish that inhabit the midwater areas of lakes and rivers, with their depth in the water column depending on light and temperature. They have been found near the bottom of Lake Erie in 80 feet of water during daylight hours (Scott and Crossman 1979). Banner and Hayes (1996) report the optimal temperature preference range for adults and juvenile is between 39˚ and 68˚ F. Being pelagic, adult and juvenile rainbow smelt have no distinct substrate preference. Coastal populations of juveniles have, however, been reported in and have a high preference for wild-celery (*Zostera marina*) (Buckley 1989; Banner and Hayes 1996).

Rainbow Trout

Rainbow trout are anadromous salmonids indigenous to the west coast of North America. They were introduced in New York in 1874 or earlier (Scott and Crossman 1979). They are, for the most part, a spring spawner with two distinct migrations, an early run in the fall with the adults overwintering in the spawning river and a typically larger spring run just prior to spawning. Spawning can occur from March to August, but usually occurs from mid-April to late-June at temperatures between 50˚ and 60˚ F (Scott and Crossman 1979; Raleigh et al. 1984). Rainbow trout build nests (redds) in clear, well-oxygenated streams (Barnhart 1986). Spawning rainbow trout prefer gravel substrates, depths between 1 and 8 feet, and water velocities between 1.6 and 3.0 fps (Raleigh et al. 1984; Barnhart 1986). The eggs are demersal and are typically deposited at the center of the nest where they fall within the interstitial spaces in the gravel substrate (Scott and Crossman 1979).

Hatching is temperature-dependent and incubation can take from approximately 19 days at 59˚ F to 80 days at 41˚ F (Barnhart 1986). The optimal temperature for embryo incubation is 14-54˚ F (Raleigh et al. 1984). When spawning occurs in April or May, fry remain in the gravel for 2 to 3 weeks after hatching, then emerge from the nest in mid-June to mid-August (Scott and Crossman 1979; Barnhart 1986). Rainbow trout fry remain in the riffle areas of their natal streams, usually in the shallow waters along the streambank. They prefer water depths from 0.8 to 1.6 feet, velocities from zero to 0.5 fps, and cover in the form of rock crevices, vegetation, and debris piles (Raleigh et al. 1984). As the fry grow,

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they tend to move downstream to deeper and faster water. Stream-resident fry overwinter in shallow, low-velocity areas with substrate components from 4 to 16 inches in diameter (Raleigh et al. 1984).

Juvenile rainbow trout prefer velocities of zero to 0.98 fps, depths greater than 2.0 feet, and substrates of cobble and boulder (Raleigh et al. 1984). Preferred temperatures are between 50˚ and 72˚ F. Juveniles in Lake Ontario and Lake Erie tributaries tend to migrate out to the lakes to avoid rising stream temperatures during the summer months. In other populations, however, juveniles may reside in the natal streams for one to four years (Barnhart 1986).

Adult rainbow trout in the Great Lakes are pelagic, mid-lake inhabitants and therefore do not show a preference for substrate type. Depth distribution is related to temperature, dissolved oxygen, and prey abundance. Lake-resident rainbow trout adults prefer water temperatures between 45˚ and 64˚ F and prefer dissolved oxygen levels between 7 and 9 mg/l (Raleigh et al. 1984).

Rock Bass

Rock bass spawn from late spring to early summer (mid-May to mid-June) at temperatures between 60˚ and 70˚ F (Scott and Crossman 1979; Smith 1985). Spawning occurs in shallow nests built by the males in diverse areas ranging from swamps to gravel shoals (Scott and Crossman 1979). Preferred depths are between 2 and 4 feet (Bovee et al. 1994). Bovee et al. (1994) reported that rock bass in the Huron River, Michigan, showed a definite preference for spawning areas with little or no velocity, and were most commonly found in areas with no velocity. Rock bass prefer gravel substrate and instream cover such as velocity shelters (logs, boulders, root wads) and emergent vegetation (Bovee et al. 1994, Smith 1985). The eggs are demersal and adhesive (Scott and Crossman 1979).

Hatching occurs within three to four days at temperatures between 68.9˚ and 69.8˚ F (Scott and Crossman 1979). The male guards the nest and fry for up to 14 days (Smith 1985). Fry habitat requirements are the same as spawning habitat requirements.

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Juvenile rock bass prefer depths of between 1.1 and 2.5 feet for summer, and between 2.5 and 3.5 feet for winter (Bovee et al. 1994). They prefer waters with velocities from zero to 0.82 fps, and are often associated with instream cover such as logs, boulders, root wads, and emergent vegetation (Bovee et al. 1994). Smith (1985) reports that the young are frequently abundant in aquatic vegetation.

Rock bass adults generally inhabit rocky areas in shallow waters (Scott and Crossman 1979). Optimal depths for adults reported by Bovee et al. (1994) ranged from 1.3 to 2.8 feet in summer and 2.5 to 3.5 feet in winter. Optimal velocities ranged from 0.16 to 0.92 fps in summer and zero to 0.66 fps in winter (Bovee et al. 1994).

Smallmouth Bass

Smallmouth bass spawn in the spring to early summer (mid-April to July) at water temperatures between 55˚ and 77˚ F, with egg deposition occurring mostly between 61˚ and 65˚ F (Edwards et al. 1983; Scott and Crossman 1979). Smallmouth bass build nests in areas with little or no velocity, generally at depths of 2 to 6 feet (range from 2-20 feet), and on coarse substrates (preferably gravel) (Edwards et al. 1983, Scott and Crossman 1979). Spawning nests are usually associated with instream cover such as logs, stumps, or boulders (used as velocity shelters in riverine environments). The eggs are demersal and adhesive and are usually attached to clean substrate in the center of the nest (Scott and Crossman 1979). The male guards the nest and newly hatched fry.

Hatching occurs in 4 to 10 days at temperatures typically found during the spawning period (Scott and Crossman 1979). The yolk sac is absorbed within 12 days and the fry typically remain on the nest another 5-7 days, still guarded by the male. Larval smallmouth bass remain on the nest for 5-7 days (Scott and Crossman, 1979). They prefer velocities of less than 0.5 fps and will use cover as velocity shelters (Edwards et al. 1983). Fry will utilize a variety of substrate types, with a preference for gravel or a gravel/cobble mix (Edwards et al. 1983). Optimal water temperature for fry growth is between 68˚ and

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86˚ F and their preferred depths are less than 2.4 feet (Edwards et al. 1983). Smallmouth bass fry may be found anywhere from late spring through summer.

Juvenile smallmouth bass prefer somewhat shallower waters than do the adults, with a preferred depth of 2.4 feet or greater. Adults prefer depths of 4.0 feet or greater (Edwards et al. 1983). Juvenile and adult smallmouth bass both prefer low current velocities, but are both found in lotic waters with adequate velocity shelters (Edwards et al. 1983). Optimal water velocities for juveniles and adults are between zero and 0.5 fps (Edwards et al. 1983). They both prefer coarse substrates (primarily cobbles and boulders) and are often associated with instream cover. Adult smallmouth bass will move to deeper water to avoid temperature extremes and become relatively inactive at less than 50˚ F (Scott and Crossman 1979).

Walleye

Walleye spawn in the spring shortly after ice-out at water temperatures between 43˚ and 52˚ F (McMahon et al. 1984; Scott and Crossman 1979). Spawning occurs at preferred depths of 2.5 to 5.0 feet (McMahon et al. 1984; Beak 1992), with the reported range of less than 1.0 to 20 feet (Pitlo 1992). Water velocity preferences range from 2.0 to 3.6 fps, with optimal velocities between 2.5 and 3.0 fps (McMahon et al. 1984). Walleye will spawn on substrates sized from sand through cobble, however a gravel-cobble mix is the preferred substrate (McMahon et al. 1984). Beak (1992) found walleye spawning over gravel/cobble, cobble/rock, and cobble/boulder substrates on the Trent River, Ontario. Eggs are demersal and non-adhesive after hardening. They are broadcast and fall into the crevices of the substrate (Scott and Crossman 1979).

Eggs hatch within 12 to 18 days at temperatures reported for spawning (Scott and Crossman 1979). The yolk sac is quickly absorbed and within 10 to 15 days after hatching, the fry emerge from the substrate and are dispersed by drifting with the currents (Scott and Crossman 1979). Fry are typically found at water depths between 1 and 12 feet, over substrates ranging from silt to gravel, and in waters

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with velocities less than 0.25 fps (McMahon et al. 1984). They show no strong preference for cover and become primarily demersal after the brief pelagic stage (Nobel 1972; Scott and Crossman 1979). Walleye fry typically inhabit nearshore areas and move to deeper waters as juveniles (Scott and Crossman 1979). The optimum water temperature for growth is near 72˚ F (McMahon et al. 1984).

Juvenile walleyes prefer depths of 4.0 to 6.0 feet, little or no velocity, substrates of silt through gravel, and sparse vegetation (McMahon et al. 1984). Depth preferences increase with size and lateness of the season, with larger juveniles inhabiting waters as deep as 20 feet by the fall months (Festa et al. 1987).

Adult walleyes have similar habitat preferences as larger juveniles. They prefer calm water, but are found in water with velocities up to 3 fps (McMahon et al. 1984). Adults prefer water depths greater than 4.0 feet with depth preferences increasing with increased water clarity (McMahon et al. 1984). Walleyes are sensitive to light and use deeper waters and objects as cover from light. Preferred substrates include silt through cobble/boulders, sometimes associated with vegetation-open water interface zones, although there is no strong requirement for vegetation (McMahon et al. 1984; Beak 1992).

White Sucker

Whites suckers begin upstream migrations to their preferred spawning areas usually from mid-April to early June when water temperatures reach 50˚ F (Scott and Crossman 1979; Smith 1985; Twomey et al. 1984). Spawning occurs on gravel substrates in shallow, flowing waters. Optimum spawning depths are between 0.2 and 1.0 feet and optimum velocities are between 1 and 2 fps (Twomey et al. 1984). Eggs are broadcast and adhere to the gravel or drift downstream where they adhere to substrates in areas with slower water (Scott and Crossman 1979; Twomey et al. 1984).

The eggs hatch in approximately two weeks at temperatures of 50˚–59˚ F (Scott and Crossman 1979). Fry emerge from the gravel approximately 9 to 11 days after hatching and drift downstream at

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night to (Twomey et al. 1984). White sucker fry prefer waters deeper than 1 foot and with velocities less than 0.3 fps (Twomey et al. 1984).

Adult white suckers are habitat generalists and can tolerate a wide range of environmental conditions (Twomey et al. 1984). In New York they are commonly found in nearly every habitat type from small streams to large lakes and rivers (Smith 1985). They are bottom oriented and feed primarily on invertebrates (Scott and Crossman 1979; Smith 1985). White suckers are typically found in warm, shallow waters in lakes, streams, and rivers usually within the top 20-30 feet. Adults show a preference for waters with velocities between 0.16 and 0.66 fps and depths between 2.3 and 9.8 feet (Twomey et al. 1984).

Yellow Perch

Yellow perch spawning takes place in the spring from mid-April to early-May at temperatures between 45° and 55° F (Kreiger et al. 1983; Scott and Crossman 1979). Hokanson (1977) reported that the most frequently found water temperatures during spawning are between 43° and 48° F. Spawning habitat has water depths of 1.2 to 9 feet, velocities less than 0.25 fps, substrates of mud or silt, and aquatic vegetation or submerged brush (Scott and Crossman 1979; Becker 1983; Kreiger et al. 1983). Eggs are extruded as an adhesive gelatinous accordion-folded string or mass that is semi-buoyant. This egg mass is easily transported by wave action until it adheres to the submerged vegetation or sometimes the bottom (Scott and Crossman 1979).

The eggs hatch approximately 8-10 days after spawning, but have been reported to take as long as 27 days at 46.9° F (Scott and Crossman 1979). The yolk sac fry are inactive for approximately five days until absorption of the yolk, when they become pelagic and drift with the current. Yellow perch fry are generally found in the upper 5.0 feet of the water column but have been found at depths to 20 feet (Nobel 1968). Because of their pelagic nature, fry may be found offshore as well as nearshore. When occurring in the nearshore area they are typically associated with vegetation, little to no water velocity, and silt or

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silty-sand substrates (Kreiger et al. 1983). As the fry grow, they become less pelagic and move into littoral areas where they become demersal (Carlander 1997). Yellow perch fry may be found from spring through mid-summer.

Young juvenile yellow perch prefer shallower waters compared to older juveniles and adults. The preferred depth range for young juveniles is between 1.6 and 2.0 feet and from 5.0 to 20.0 feet for older juveniles and adults. Beak (2000) found numerous yellow perch adults in Lake Michigan at depths of up to 95 feet (deepest water sampled) and had reliable reports of numerous adults captured in commercial bottom-set gill nets as deep as 200 feet. Juveniles and adults prefer little to no velocity, silt, gravel and cobble substrates, and moderate amounts of vegetation (Kreiger et al. 1983; Robillard and Marsden 2001).

Giant Floater

The giant floater is a native freshwater mussel of the Unionidae family found throughout the United States, including the upper Niagara River (Riveredge 2005). Freshwater mussels of the Unionidae have separate sexes. Fertilization occurs within the female as she inhales sperm released into the water by the male. The fertilized eggs develop in the female brood pouch or gills. The intermediate larval stage, called the glochidium, is parasitic and uses a variety of fish species as host (Pennak 1978). The glochidia attach themselves to the gills of the host fish and can be released any time from late spring to late fall or early winter. Referenced information on giant floaters has conflicting glochidia release dates, ranging from October through May (Watters and O'Dee 1998). Watters and O'Dee (1998) classify giant floaters as winter releasers, with the suggestion that they may have a complicated reproductive strategy that may vary from population to population.

The parasitic stage lasts typically from 10 to 30 days, with some records of as long as 190 days (Pennak 1978). There are few reports of harm to the host species. At the end of the parasitic stage, the mussel breaks out of a cyst formed on the fish and falls to the bottom, where it begins the juvenile stage.

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Small juvenile mussels burrow into the sediments where they develop to adults. The juvenile stage lasts from one to as many as eight years (Pennak 1978).

Giant floater adults are typically found in ponds, lakes, and rivers over mud and other soft bottoms with little or no current. Rocky substrates and softer substrates prone to shifting with resultant high turbidities are unsuitable habitat (Pennak 1978). Most unionids are found in shallow waters, typically less than 3.6 feet deep. In larger rivers, they have been reported as deep as 23 feet (Pennak 1978).

Giant floaters, which are relatively mobile, have been reported to follow the water during drawdowns of a wetland adjacent to Lake Erie (Nichols and Wilcox 1998). Mussels can move by means of contractions of the foot muscle fibers, resulting in a series of short "hunching" movements (Pennak 1978).

Burrowing Mayflies

Mayflies are small to medium size insects found only near freshwater, in which their immature larval stages are spent (Pennak 1978). The burrowing mayfly (*Hexagenia* spp.) larva burrows in mud, muddy sand, or other soft sediments in permanent freshwater habitats. Two species of burrowing mayflies, *Hexagenia limbata* and *H. rigida* are key species in western Lake Erie, providing an important food source for forage fish (Kreiger 2000). Large swarms of millions of individual subadults and adults were reported to be nuisances in the 1940s and early 1950s (Kreiger 2000). Densities of *Hexagenia* larvae in sediments of western Lake Erie averaged from 300 to 500 per m^2 (10.76 square feet) (Kreiger 2000). During the 1960s through the mid-1990s the numbers of burrowing mayflies in Lake Erie were drastically reduced, reportedly by low oxygen due to eutrophication. Their numbers have rebounded in recent years.

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Mating occurs during flight over water where the fertilized eggs are deposited (Pennak 1978). The mating stage may last from as little as a few minutes to more typically 24-48 hours (Merritt and Cummins 1996). Kreiger (1999) reported the peak emergence of mating *Hexagenia* adults occurred in late-June with emergence reported as late as mid-October. The eggs become attached to the debris on the substrate and hatch in a few days to a few months. Eggs typically develop and hatch within a few weeks but can remain dormant for over 11 months (Merritt and Cummins 1996).

Little is known of species-specific aquatic life histories of burrowing mayfly nymphs. There are numerous stages of larval mayflies, with more than 40 nymphal ecdyses known for one species. Many species are active in winter and grow at temperatures as low as 34˚ to 39˚ F (Pennak 1978). Length of larval life varies with temperature, but is typically three to six months (Merritt and Cummins 1996). *Hexagenia limbata* development has been reported to take as long as one to two years in Lake Winnipeg in northern Canada and as short as 17 weeks in warmwater canals in Utah (Merritt and Cummins 1996).

Crayfish

Crayfish of the genus *Cambarus* mate in the spring, summer, and fall months, with mating in the spring less likely in the more northern areas of the United States (Pennak 1978). The female lays the fertilized eggs on the ventral side of her abdomen anywhere from several weeks to several months after mating (Pennak 1978). Incubation takes from two to 20 weeks, depending on temperature. The first instar typically lasts two to seven days and the second 4 to 12 days (Pennak 1978). By the third instar, the young crayfish leave the female, at first intermittently and then permanently. Crayfish hatched in the spring may have 6 to 10 molts by autumn. Adult crayfish utilize burrows, stones, or debris to remain hidden during the day. Feeding occurs from dusk until dawn. *Cambarus* spp. inhabits both lentic and lotic waters.

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APPENDIX D - HABITAT REQUIREMENTS OF WILDLIFE FOCUS SPECIES

Common Mudpuppy

The common mudpuppy, an aquatic salamander, inhabits a variety of permanent water bodies, including rivers, reservoirs, inland lakes, and Great Lakes bays and shallows. It tends to move into shallower waters in spring and fall but seeks deeper water in winter and summer (Harding 1997). Hatchlings prefer microhabitats with relatively low current, frequently in deeper waters (Bishop 1994). Throughout its range, the mudpuppy remains active during the winter (Petranka 1998).

In clear waters, the common mudpuppy tends to be nocturnal, remaining hidden beneath rocks, logs, and other objects during the day. It can be active both night and day in shallow inlets and coves with thick aquatic vegetation (Harding 1997). Individuals normally walk or crawl slowly over the bottom in search of food. The mudpuppy is a generalist predator that will consume a wide variety of prey ranging in size from *Daphnia* ephippia (egg sacs) to fish, and including carrion. A food habits study in New York determined that the most important prey by bulk were crustaceans, insects, fish, annelids, mollusks, and amphibians (Harding 1997; Petranka 1998).

The mudpuppy breeds in shallow water, primarily during late September through November, in western New York and the Great Lakes Region (Bishop 1994; Harding 1997). Fertilization is delayed, with eggs deposited in late May or early June. Females construct nests by excavating depressions beneath rocks, logs, boards, and other objects. Nests are typically constructed in water ranging from 0.33 to 9.8 feet deep. Eggs are attached singly to the undersides of the overlying object. Females guard the eggs against predators through hatching. Hatching in northern populations occurs from July to August (Petranka 1998). The newly hatched larvae average about one inch in length. Forelegs are fairly well developed (Bishop 1994).

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Northern Spring Peeper

Outside the breeding season, the northern spring peeper inhabits woodlands, old fields, and shrubby areas (Harding 1997). Adults feed on small arthropods such as spiders, mites, ticks, pill bugs, and a variety of insects. Tadpoles feed largely on algae and other soft or decaying plant material (Harding 1997).

The northern spring peeper uses temporary and permanent ponds and marshes for breeding (Harding 1997). Based on 1990s Marsh Monitoring Program data from Buckhorn Marsh, the vast majority of spring peeper breeding occurs in woodland vernal pools located well above the zone influenced by Niagara River water levels (Rosenburg unpublished data). Although choruses of mating calls are often heard between late March and late May in the southern and central Great Lakes basin, most breeding seems to occur in April (Harding 1997). Eggs are laid singly or in small clusters, attached to twigs or aquatic vegetation near the bottom (Wright and Wright 1995; Harding 1997). The eggs hatch in 4-15 days and transform into froglets in 45-90 days (Harding 1997). Based on this information, most metamorphosis occurs in June and July in the southern and central Great Lakes basin. Wright and Wright (1995) reported a 90-100 day transformation period, with froglets emerging between July 1 and August 1.

The spring peeper overwinters primarily in upland woodlands, beneath logs, bark, and fallen leaves. This frog can survive subfreezing temperatures by producing a glucose-based “antifreeze” that causes ice to form in the extracellular spaces rather than in the body cells (Harding 1997).

Green Frog

The green frog is a shoreline species that inhabits the edges of ponds, lakes, swamps, impoundments, slow streams, and rivers. This species seems to be more tolerant of open, sparsely vegetated sites than the bullfrog (*Rana catesbeiana*). Shallow, temporary waters are generally avoided (Harding 1997). Adults of this species are largely a “sit and wait” predator, taking any prey of

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appropriate size that comes within reach. They consume a variety of aquatic and terrestrial insects and other invertebrates. Tadpoles feed largely on algae, other planktonic organisms, and decaying animal and plant debris (Harding 1997).

Male green frogs begin calling in early to mid-May and continue to call throughout the prolonged breeding season, sometimes into August (Harding 1997). A thin, floating egg mass is usually attached to emergent or surface vegetation (Wright and Wright 1995; Harding 1997). Hatching occurs in 3-5 days. Tadpoles that hatch early in the season may transform into froglets late in their first summer, but those hatching later will overwinter as larvae and transform during the following summer (Harding 1997).

The green frog overwinters in the water, buried shallowly beneath bottom mud or debris. Dormancy typically lasts from early November to early April (Harding 1997). Tadpoles seek winter cover in crevices between rocks, fallen logs, and branches (Monds 1995).

Northern Leopard Frog

The northern leopard frog is typically found in open habitats, including marshes, lake and stream edges, sedge meadows, and upland fields. In summer, it often moves well away from water into meadows and other grassy places (Wright and Wright 1995; Harding 1997). Adults are carnivorous, feeding on terrestrial invertebrates such as insects and insect larvae, spiders, slugs, snails, and earthworms. Larger adults may also eat small vertebrates (Monds 1995; Harding 1997). Larvae eat algae, phytoplankton, periphyton, and detritus (Monds 1995).

In the early spring, the leopard frog seeks shallower waters for breeding (e.g., temporary ponds, marsh pools, stream backwaters), sometimes migrating over a kilometer (0.6 mi) from hibernation areas in permanent water bodies (Harding 1997). The peak of breeding is usually in April, although the season may extend into May in the northern parts of the Great Lakes region. One or more egg masses are deposited, usually attached to submerged twigs or stems, but may just rest on the bottom (Wright and

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Wright 1995; Harding 1997). Many of the egg masses are laid in very shallow water and it takes little evaporation to leave them exposed (Wright and Wright 1995). Hatching occurs in 1-3 weeks and tadpoles transform in 2-3 months (Harding 1997). Based on this information, most metamorphosis occurs between late June and mid-August in the southern and central Great Lakes basin. Wright and Wright (1995) reported a 60- to 80-day transformation period, with tadpoles transforming in July.

The leopard frog usually overwinters in permanent waters (i.e., larger ponds, lakes, and streams), where it may sit on the bottom or under the edges of rocks or logs, or conceal itself beneath a light layer of silt (Harding 1997). Hibernacula include deep or running water that will not freeze or become anoxic (Monds 1995).

Common Snapping Turtle

The common snapping turtle is one of the more aquatic species of turtles. It has been found in almost every kind of freshwater habitat within its range. It prefers slow-moving water with a soft mud or sand bottom and abundant aquatic vegetation. Most of the water bodies in which it lives are shallow. However, it may occur along the edges of deep lakes and rivers, including weedy inlets and bays of the Great Lakes (Harding 1997). Close proximity to permanent bodies of water appears to be an important feature (Graves and Anderson 1987; Ernst et al. 1994).

The snapping turtle is active both day and night, with a tendency to be most active near dawn and dusk. It eats a broad variety of invertebrates, fish, frogs, salamanders, small turtles, snakes, birds, small mammals, plants, and carrion. Young snapping turtles actively forage for food, but older individuals often lie in ambush to seize prey (Ernst et al. 1994).

Egg laying usually occurs from mid-May to mid-June. An open, well-drained site with loose sand, loam, or organic matter is usually selected. Females will make considerable migrations to find

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suitable nesting areas. Emergence from the nest occurs from mid-August to early October (Ernst et al. 1994; Harding 1997).

The snapping turtle spends a lot of time buried in mud during the fall as water temperatures fall below 59˚ F. It enters hibernation by late October when water temperatures drop to about 41˚ F. It may simply sit on the bottom, burrow into the mud on the bottom, settle beneath logs or plant debris, crawl up under overhanging banks, or retreat into muskrat burrows (Graves and Anderson 1987; Ernst et al. 1994; Harding 1997). Preferred hibernacula seem to have a combination of:

- Water shallow enough to let the turtle reach the surface to breathe without having to swim upward, but deep enough to prevent its freezing to the bottom;
- A location that is likely to be the last to freeze over and/or the first to thaw;
- Mud deep enough for the turtle to bury itself; and
- Some additional cover, such as vegetation, brush, muskrat den, or overhanging bank (Meeks and Ultsch 1990).

In northern latitudes, the snapping turtle does not emerge from hibernation before April, when water temperatures rise above 41˚ F. Feeding usually does not begin until water temperatures reach 59˚ F. Not all snapping turtles become totally dormant in winter, even in the north; individuals have been seen moving under the ice in midwinter (Ernst et al. 1994; Harding 1997). If waterways dry during the summer, some snapping turtles aestivate in the mud while others migrate to nearby areas (Graves and Anderson 1987; Ernst et al. 1994).

Midland Painted Turtle

The midland painted turtle prefers slow-moving, shallow water such as ponds, marshes, lakes, and creeks. The presence of a soft bottom, basking sites, and aquatic vegetation is preferred. This turtle

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frequently moves overland between water bodies. Deeper or spring-fed water are favored during the fall and winter. Spring movements are often noted as turtles move to smaller, more productive ponds (Ernst et al. 1994).

The painted turtle is a diurnal feeder. It typically forages along the bottom and among clumps of aquatic plants. It is an omnivorous generalist in the broadest sense, eating a very broad variety of plants and animals, living or dead (Ernst et al. 1994).

Courtship and mating normally occur from March to mid-June, with peak egg-laying in June and early July. A female may lay two or more clutches of eggs. Open upland areas with loamy or sandy soil are selected. Nests are usually dug within 200 m of water, but may be as far away as 600 m (Ernst et al. 1994). The incubation period generally ranges from 50 to 80 days. Many hatchlings overwinter in the nest, postponing emergence until spring. The baby turtles are quite resistant to freezing, but prolonged cold temperatures with little insulating snow cover may result in high rates of hatchling mortality (Harding 1997).

The midland painted turtle has a high tolerance for cold and can withstand a body temperature of 28˚ F. It is not uncommon to see this species swimming under the ice (Ernst et al. 1994; Harding 1997). It tends to move into deeper waters from September through October. Most painted turtles do not feed at water temperatures below 50˚ F. Winter dormancy begins as water temperatures fall below 68˚ F. Winter dormancy may be spent in the soft bottom of a water body, within muskrat lodges or bank burrows, underneath overhanging dirt banks, or on land (e.g., floodplain areas). The water of the hibernation site may be as much as two meters deep, but is usually less, and turtles bury themselves as deep as 37 inches into the soft bottom (Ernst et al. 1994).

The painted turtle emerges shortly after ice cover has completely disappeared, when water and bottom temperatures are steadily rising. In some of the more northern populations, individuals may bask

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in February or early March during warm spells if ice has melted. Turtles typically begin to emigrate from hibernating ponds to outlying bodies of water as early as mid-March (Ernst et al. 1994).

Drought conditions may force the painted turtle either to seek a more permanent water body or aestivate in the soft substrate. Pond drying during the winter may result in an increased rate of mortality due to extended exposure of hibernating turtles to freezing temperatures (Ernst et al. 1994).

Great Blue Heron

The great blue heron occurs in a variety of habitats, including lakes, rivers, and wetlands. It feeds by wading in water, usually containing emergent or submergent vegetation, in search of fish and other prey. This feeding behavior is successful only in shallow (up to 1.6 feet deep), clear water with a firm substrate (Short and Cooper 1985). While it feeds primarily on fish, the great blue heron is opportunistic and will also take crayfish and other aquatic invertebrates, frogs, salamanders, snakes, and small mammals. It feeds both night and day, with peaks of activity near dawn and dusk (Ehrlich et al. 1988; Butler 1992). Its usual hunting method is to stand motionless in shallow water and wait until prey comes within striking distance. This species is very wary but is highly adaptable, fishing in suburban ponds, around fishing docks and even in back yards.

The great blue heron nests in trees or, less commonly, shrubs in upland or wetland environments near water. Its large stick nest is commonly placed 16-66 feet above the ground (Short and Cooper 1985, Ehrlich et al. 1988; Butler 1992). The nesting period is typically March through May.

A few great blue herons can usually be found along ice-free shorelines of the Niagara River during the winter. Most, however, migrate south for the winter.

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Mallard

The mallard occurs in a broad variety of wetland, riverine, and lacustrine habitats where it feeds by dabbling on the surface in shallow waters. It is highly adaptable in its use of foods, eating a broad variety of native and domestic sources. Seeds of smartweeds (*Polygonum* spp.), soft-stem bulrush (*Scirpus validus*), three-square (*Scirpus americanus*), and burreeds (*Sparganium* spp.) are the predominant foods consumed in freshwater marshes (Bellrose 1976). Other foods include grain, acorns, insects, and other aquatic invertebrates (Ehrlich et al. 1988; Drilling et al. 2002).

The mallard is indiscriminate in its selection of nest sites. It prefers upland to marsh, but may nest in wet meadow or shallow emergent marsh habitats. Nests are usually located within 300 feet of water in dense vegetation about 24 inches tall. The nest consists of a bowl or scrape in plant litter or the moist earth. Nesting is usually initiated between April 10 and April 30. The incubation period is 28 days, on average. Hens frequently renest if the first effort fails due to flooding, predation, or other disturbance. Young are precocial and, within 12 hours of hatching, the hen leads them to water (Bellrose 1976; Drilling et al. 2002). A mallard hen may lead her brood across extensive areas when water levels fall (Bellrose 1976).

The mallard frequents Niagara River marshes from early spring, when ice first melts, until the marshes freeze again in late fall or early winter. Many spend the winter in open water areas of the Niagara River and its larger tributaries.

Canvasback

The canvasback breeds primarily in northwestern and central Canada. It winters in large rafts on the Niagara River and other ice-free areas of the Great Lakes, especially in areas with extensive SAV. The canvasback usually feeds by diving in water 6.6 to 29.5 feet deep, but it will occasionally dabble in shallow water areas. The canvasback uses its long, sloping bill to forage in bottom sediments for plant

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and animal foods. Rootstalks, tubers, and stems of SAV are most commonly eaten. The canvasback's diet includes about 80% aquatic plants such as wild-celery (*Vallisneria americana*) and pondweeds (*Potamogeton* spp.). Animal material includes mollusks, crustaceans, insects, and various fish (Bellrose 1976; Ehrlich et al. 1988; Mowbray 2002).

Greater Scaup

Large rafts of greater scaup use the Niagara River and Lewiston Reservoir in winter months and during spring and fall migration. Its breeding range in North America is primarily western Alaska. This diving duck forages for benthic organisms in 3.3 to 32.8 feet of water. The greater scaup is an opportunistic feeder, eating a wide variety of bivalves, gastropods, crustaceans, vascular plants, and algae. In freshwater habitats, plants often dominate the diet (Bellrose 1976; Ehrlich et al. 1988; Kessel et al. 2002).

Virginia Rail

The Virginia rail can be found in freshwater marshes with abundant emergent vegetation, especially cattails (*Typha* spp.) and sedges (*Carex* spp.). It is described as a habitat generalist and vagrant that is capable of exploiting a highly ephemeral niche (Conway 1995). It probes mudflats and shallow water with its long, slightly decurved bill to search for invertebrates, small fish, and an occasional seed. The Virginia rail is well adapted for life in flooded wetlands, as it can dive and swim, using its wings to propel itself under water (Conway 1995).

The Virginia rail usually selects drier areas in the marsh in which to nest. Water depths in the vicinity of nests have been reported to range between 4.7 and 17 in. (Andrle and Carroll 1988). The nest is usually constructed a few inches above the water and secured to surrounding grasses or reeds. Frequently there is a runway of grasses along the last meter to the nest (Eckert and Karalus 1981). Some nests are built on raised tussocks by the water's edge (Harrison 1978). Eggs are typically laid in May

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(Andrle and Carroll 1988). Incubation takes 18-20 days. Precocial young may leave the nest immediately after hatching, and it is reported that young are able to swim on their first day (Ehrlich et al. 1988; Conway 1995). Two broods may be reared per year (Ehrlich et al. 1988).

This rail occurs as a summer resident, as well as a spring and fall migrant, in western New York State. Few winter occurrences have been recorded.

American Coot

The American coot nests in freshwater marshes, along lakes, ponds, streams, and rivers (Andrle and Carroll 1988). It is highly dependent on semi-permanent and permanent wetlands that provide a stable source of standing water and emergent vegetation. Wetlands that contain a high degree of interspersion between emergent vegetation and open water result in higher nest densities and greater breeding success (Allen 1985).

This rail feeds by gleaning plant and animal matter from water, substrate, and plant surfaces (Ehrlich et al. 1988). Plants are the primary food sources. Pondweeds (*Potamogeton* spp.), water milfoil (*Myriophyllum* spp.), and filamentous algae are most commonly eaten, but a variety of other plants may also be consumed. Animal foods make up a larger percentage of the diet prior to and during the egg-laying period, and hatchlings are typically fed a variety of invertebrates (Allen 1985).

The American coot nests over water in emergent vegetation. The nest is typically a floating platform anchored to emergent vegetation (Ehrlich et al. 1988; Allen 1985). Persistent emergent vegetation such as cattails and bulrushes provides the best cover and the most suitable nest construction material (Allen 1985). The average water depths at American coot nests have ranged between 1.6 and 2.3 feet (Allen 1985). Stable water levels during the breeding season are required for optimal breeding conditions. Poor cover and shallow water may contribute to high rates of nest failure due to greater

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visibility and accessibility of nests to predators (Allen 1985). Renesting attempts are made if the first attempt fails. Incubation takes 21-25 days and young are precocial (Ehrlich et al. 1988).

American coot populations fluctuate according to water and marsh conditions. For example, during drought conditions of the early and middle 1960s, breeding ground surveys showed a severe drop in the numbers of this species (Andrle and Carroll 1988).

Most American coots migrate out of the investigation area for the winter, although a small number usually stay year-round on the Niagara River and other ice-free water bodies.

Spotted Sandpiper

The spotted sandpiper may be found in a wide variety of habitats, including the shorelines of streams, rivers, lakes, ponds, and temporary pools. It also feeds in marshes, meadows, fields, and cultivated land. Its primary habitat requirement is open terrain near temporary or permanent sources of water. It searches for food by probing along beaches and muddy shores, often wading into the water, and may catch flying insects out of the air. It feeds primarily on aquatic and terrestrial insects, but also catches young fish, crustaceans, and mollusks in shallow water (Ehrlich et al. 1988; Oring et al. 1997).

Nests of the spotted sandpiper are usually located near water. They are typically placed on an elevated site among thick grasses or sedges, brush, logs, rocks, or driftwood. This shorebird commonly has two or three clutches per year. Incubation takes 20-24 days. Precocial young leave the nest shortly after hatching and are capable of flight after 17-21 days (Ehrlich et al. 1988).

The spotted sandpiper occurs in western New York as a summer resident and a spring and fall migrant.

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Bonaparte's Gull

The Niagara River is an important wintering and migration stopover area for the Bonaparte's gull. It occurs in very large concentrations, especially at Niagara Falls and the power plant tailraces. On its wintering grounds, the Bonaparte's gull feeds primarily on fish. Crustaceans such as crayfish may also be taken on occasion. It feeds mostly by dipping into the water's surface from the air, but it may also drop from the air and dive beneath the surface in search of prey (Ehrlich et al. 1988; Burger and Gochfeld 2002).

Muskrat

The muskrat is a semi-aquatic rodent that is seldom seen far from water. It is most frequently associated with emergent marsh habitats, but may also be found in slow-moving streams, lakes, ponds and ditches. Water depths of 1.5-4.0 feet are most suitable for the muskrat (Allen and Hoffman 1984). In such areas, water seldom freezes to the bottom in winter but is shallow enough to support rooted plants (Kurta 1995). 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.

The muskrat is active year-round, following crepuscular and nocturnal activity patterns. It feeds primarily on the roots and basal portions of aquatic plants, with cattail (*Typha* spp.) and bulrush (*Scirpus* spp.) being the most important plants (Wilson and Ruff 1999). In addition, it eats small amounts of meat (e.g., crayfish, mussels, small fish, turtles, frogs) (Kurta 1995; Wilson and Ruff 1999).

In marsh environments, the muskrat constructs houses (lodges) from mud and emergent plants. The 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

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(Kurta 1995; Wilson and Ruff 1999). High water levels may negatively affect muskrats by forcing them out of their lodges and burrows (Allen and Hoffman 1984).

Young are born mostly between March and October (Kurta 1995). They are blind and helpless at birth but grow rapidly. They are able to leave the nest and swim by 2 weeks of age and are weaned at 3-4 weeks.

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