Management of Submerged Aquatic Vegetation in Lake Banook

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Atlantic Remediation Conference

Fredericton, NB

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Agenda

1 Scope and key Findings of Our Study

2 Discussion of likely Causes

3 Consideration of Management Options

4 Summary

5 Questions

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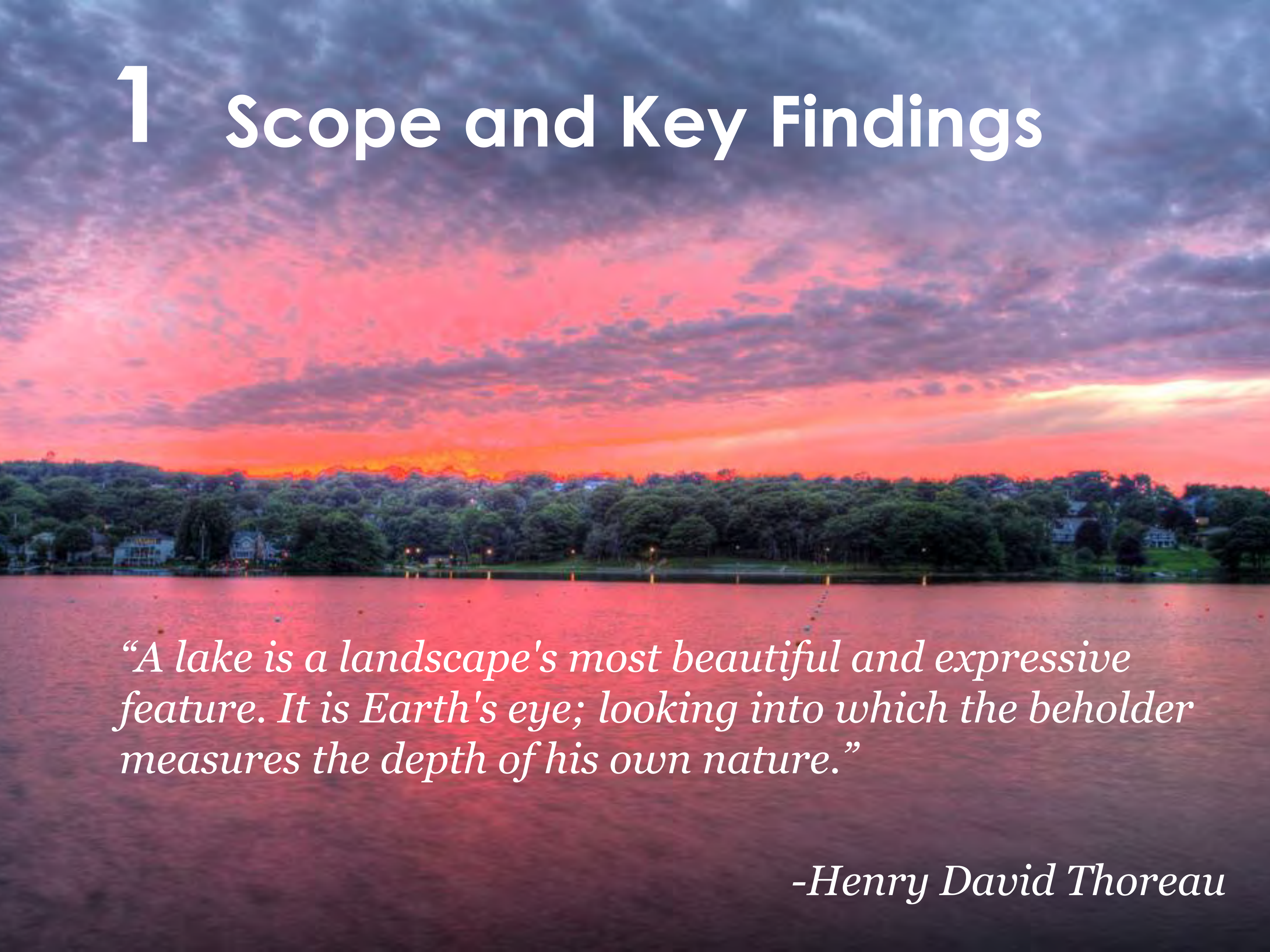
1 Scope and Key Findings



"A lake is a landscape's most beautiful and expressive feature. It is Earth's eye; looking into which the beholder measures the depth of his own nature."

-Henry David Thoreau

Understanding causes

Water Quality

- November 2013
- Historic

Watershed development

- Types
- Maturity
- Recent changes

Vegetation Mapping

- Where is the density?
- What species?

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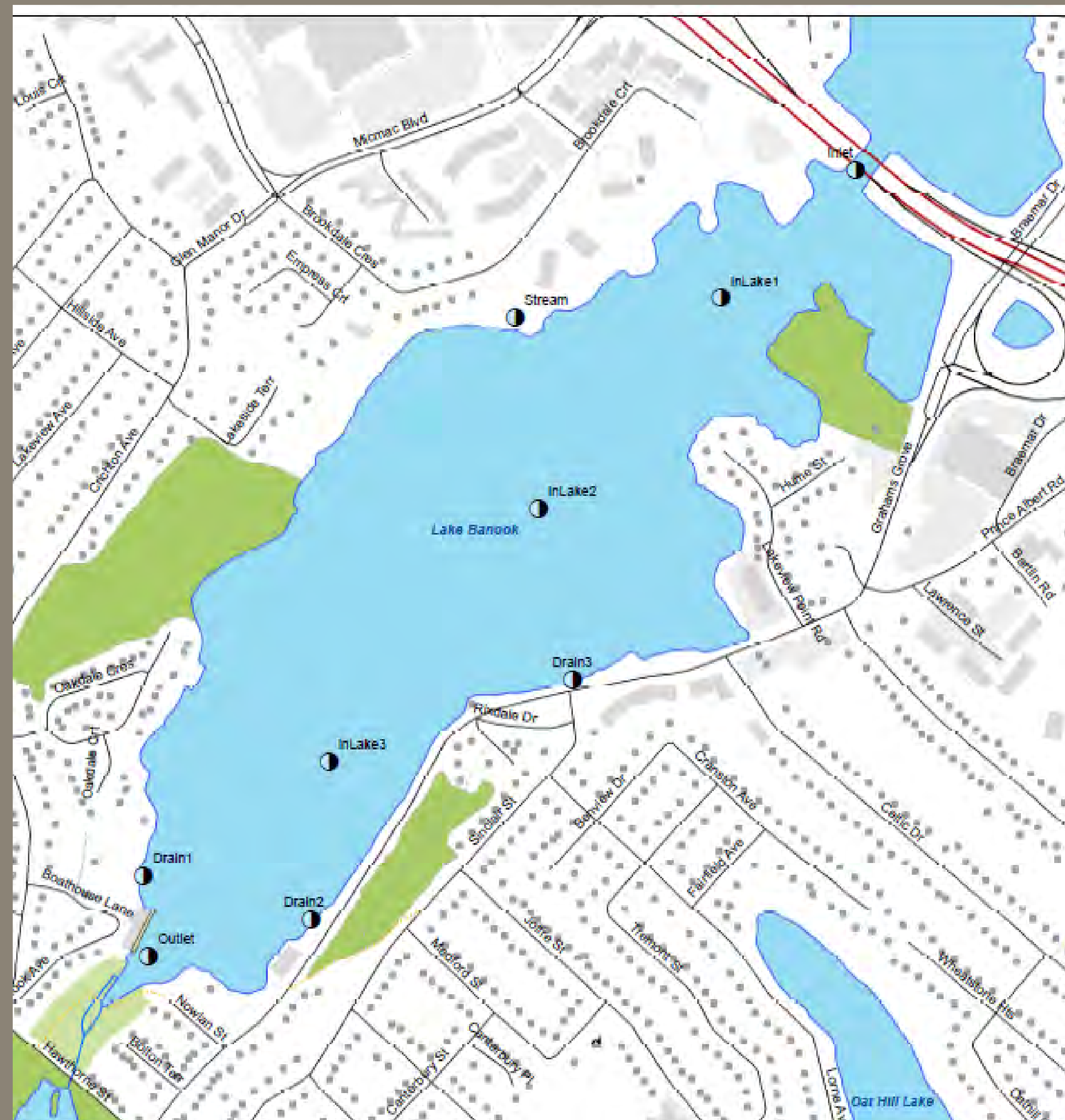
Water Quality
November 2013

In situ
- temperature
- oxygen
- specific conductivity

Laboratory
- nitrogen
- phosphorus
- total suspended solids



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Water Quality – November 2013

- InLake Stations
  - Low nutrients
  - No total suspended solids detected
  - High specific conductance
- Lake input stations before rainfall
  - Higher nutrients than InLake (specifically stream)
  - High TSS from Drain 1
- Lake input stations immediately after rainfall
  - Slightly higher nutrients than before rain
  - TSS similar to before rain

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Historic Water Quality Data

Duration

- Dating back to 1980

Frequency

- Annually since 2006
- Spring and fall

Where

- Lake center

What

- In situ parameters
- Lab parameters

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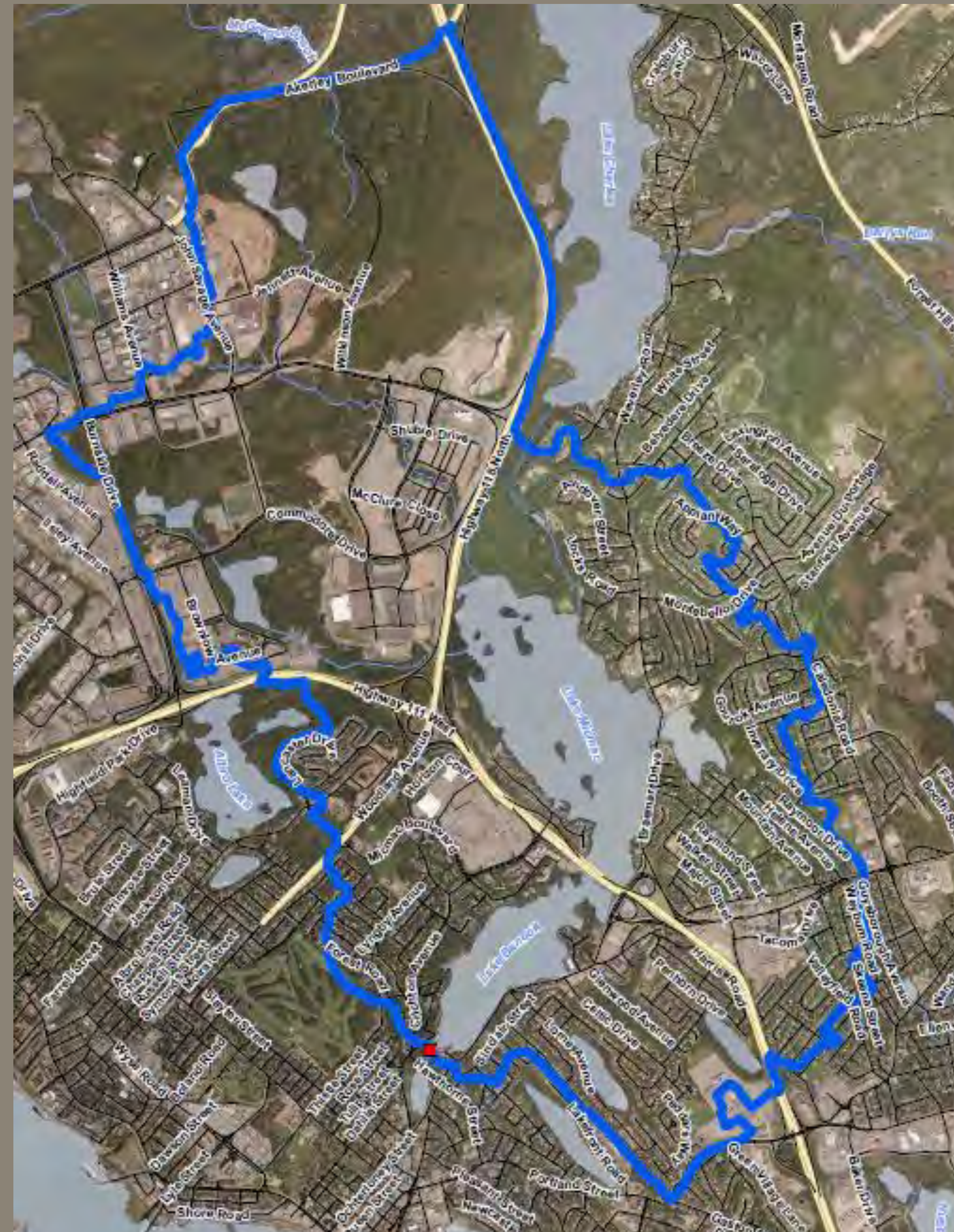
Historic Water Quality Data

Key Findings

- High total dissolved solids
- High chloride
- Low levels of nutrients in the water column
- Very low total suspended solids

Watershed Development

General Industrial	• *Developing*
Residential	• *Various densities* • *Mature*
Commercial	• *Mature*
Park	• Various



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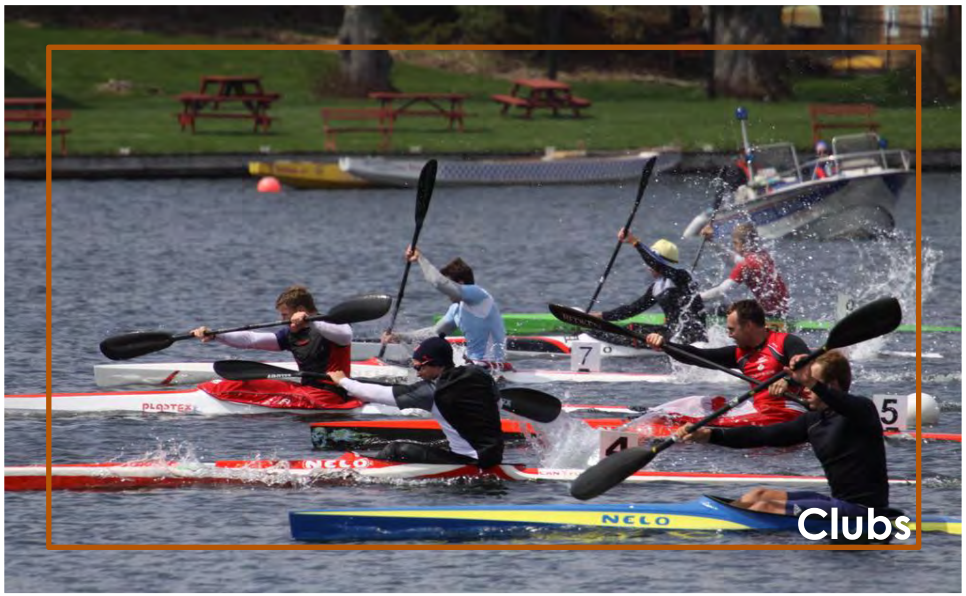

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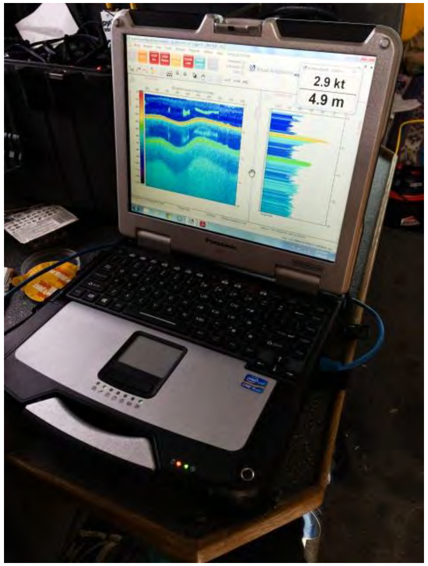
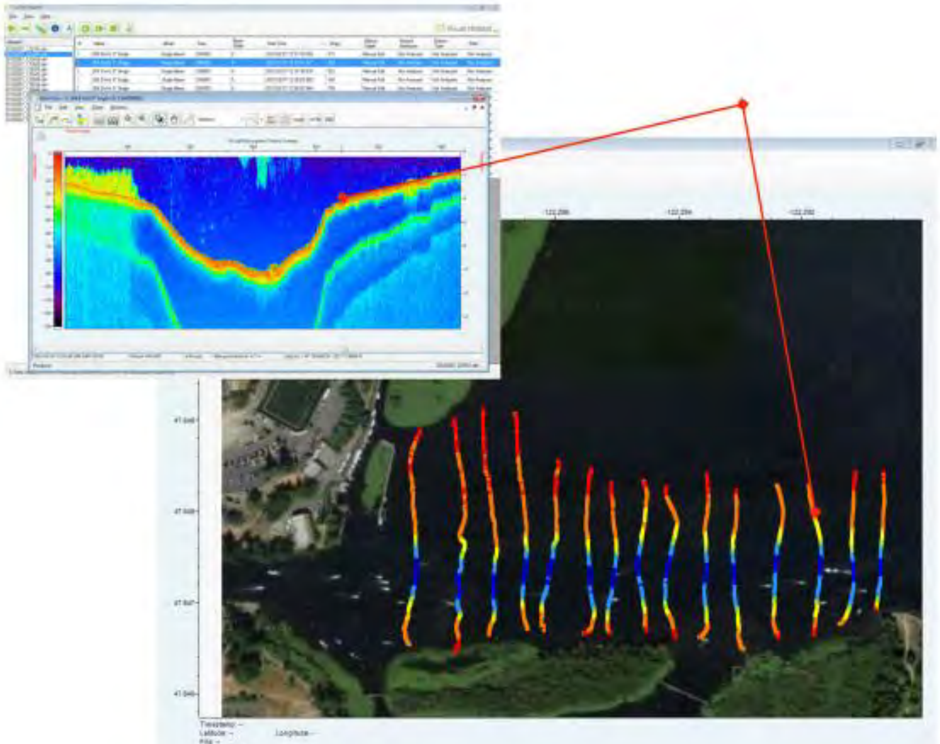
Vegetation Mapping

Stantec single beam acoustics (BioSonics) plus underwater video

- Bathymetry
- Percent cover
- Canopy height
- Sediment classifications





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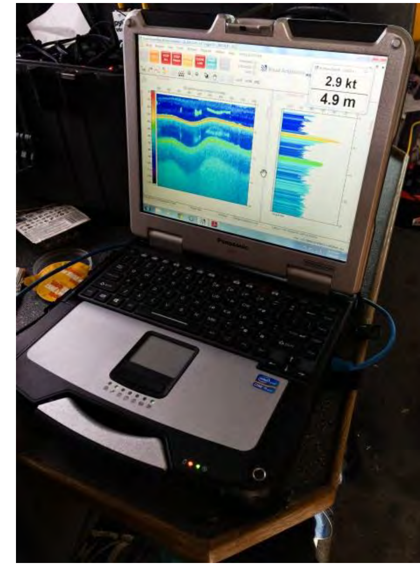
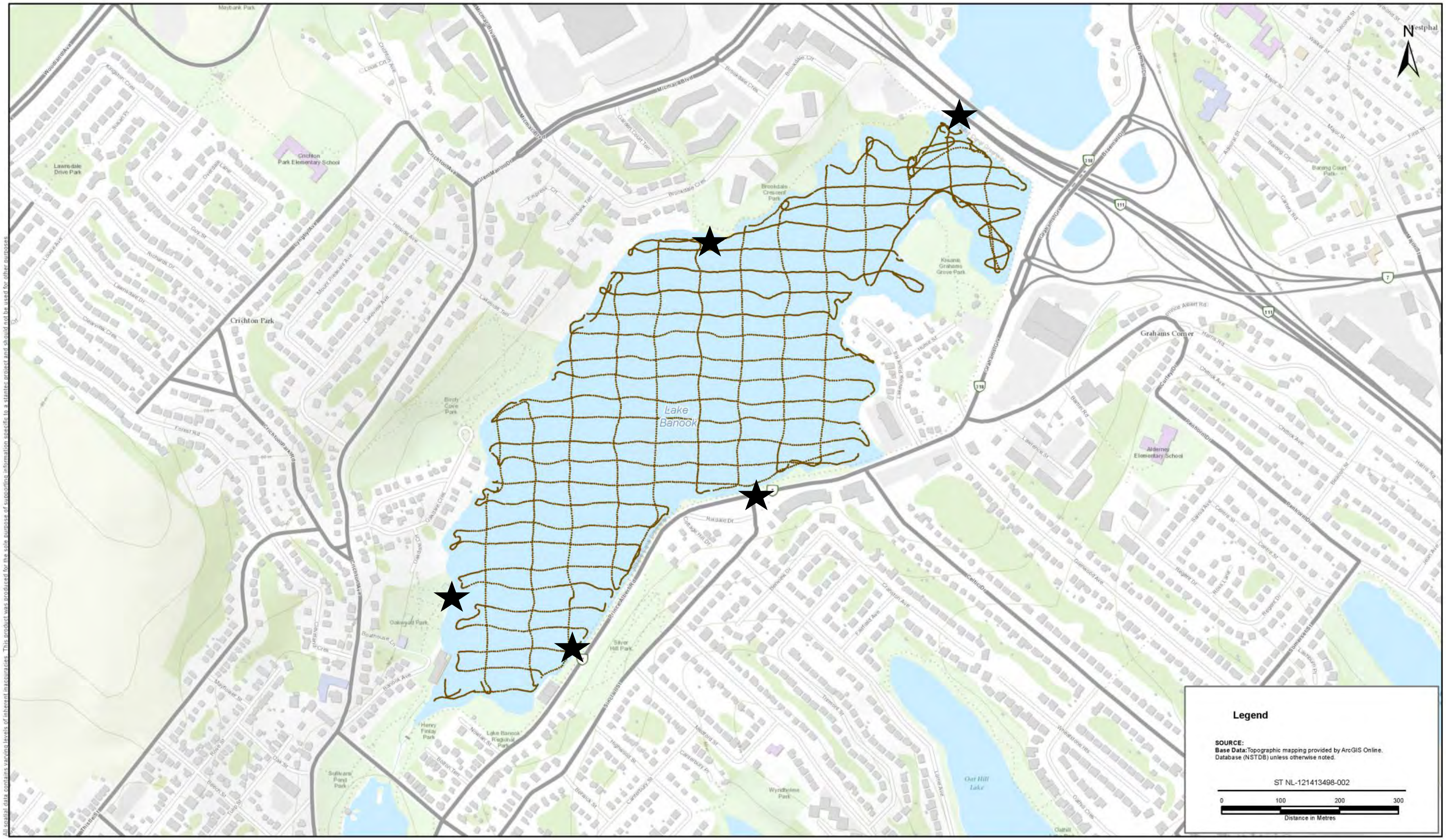
Vegetation Mapping

- **Sampled in Oct 2013 as part of Stantec R&D remote sensing project**
- **~70,000 acoustic data points, 50 m grid spacing**
- **Biosonics accuracy**
  - **Range: 1.7 cm ± 0.2% of depth**
  - **Positional: <3 m, 95% typical**
- **Dominant species**
  - **Clasping Leaf Pondweed (*Potamogeton perfoliatus*)**
  - **Slender Leaf Pondweed (*Potamogeton filiformis*)**



Sampling Grid



PREPARED BY: H Ward

REVIEWED BY: C Shupe

CLIENT: Halifax Regional Municipality

Banook Lake Weed Study

Lake Banook Sample Point Locations

FIGURE NO. 1

DATE: May 19, 2015

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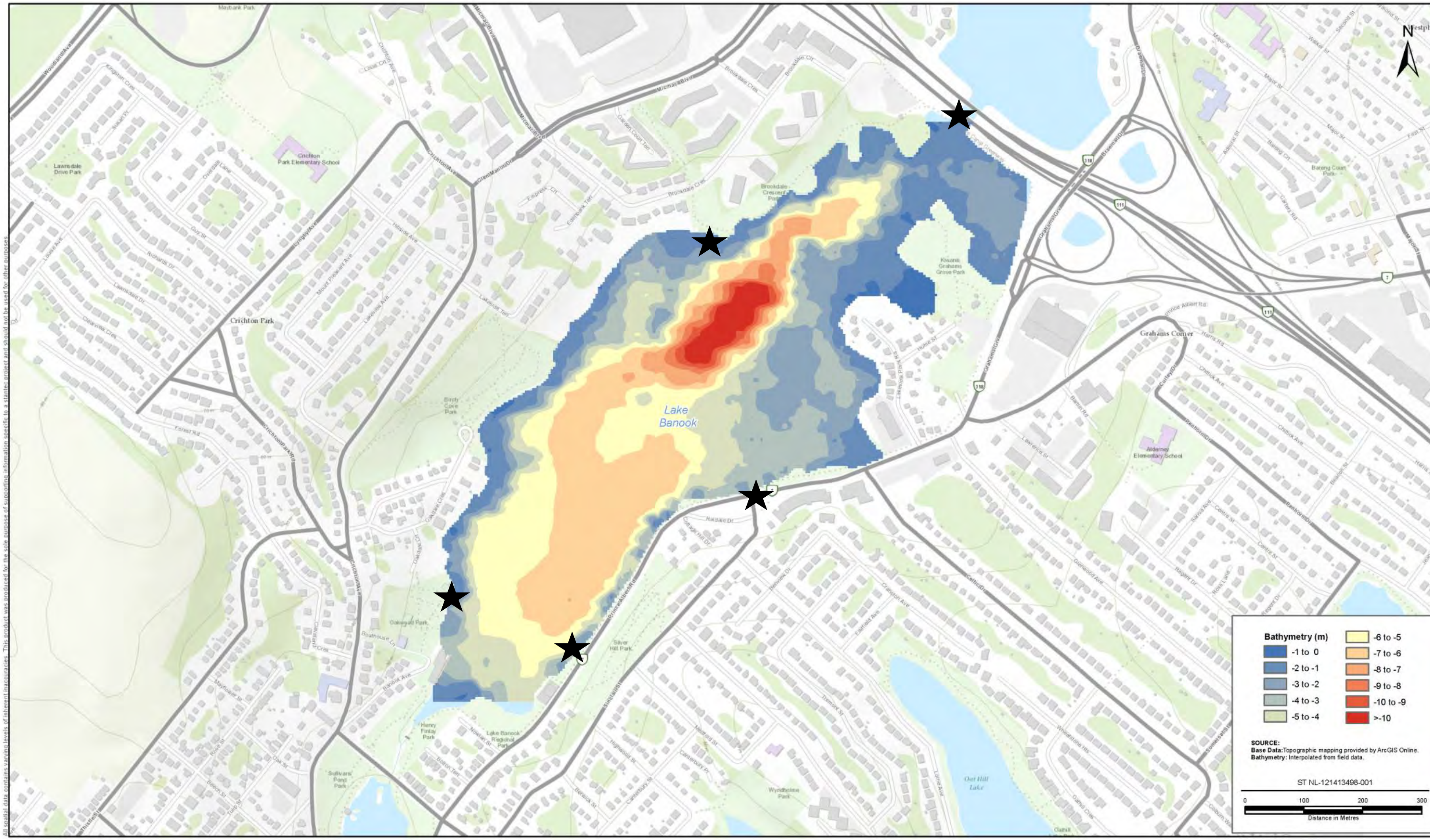
Bathymetry



PREPARED BY H Ward	Banook Lake Weed Study	FIGURE NO. 4
REVIEWED BY C Shupe		DATE May 19, 2015
CLIENT Halifax Regional Municipality	**Bathymetry of Lake Banook - Interpolated**	Stantec

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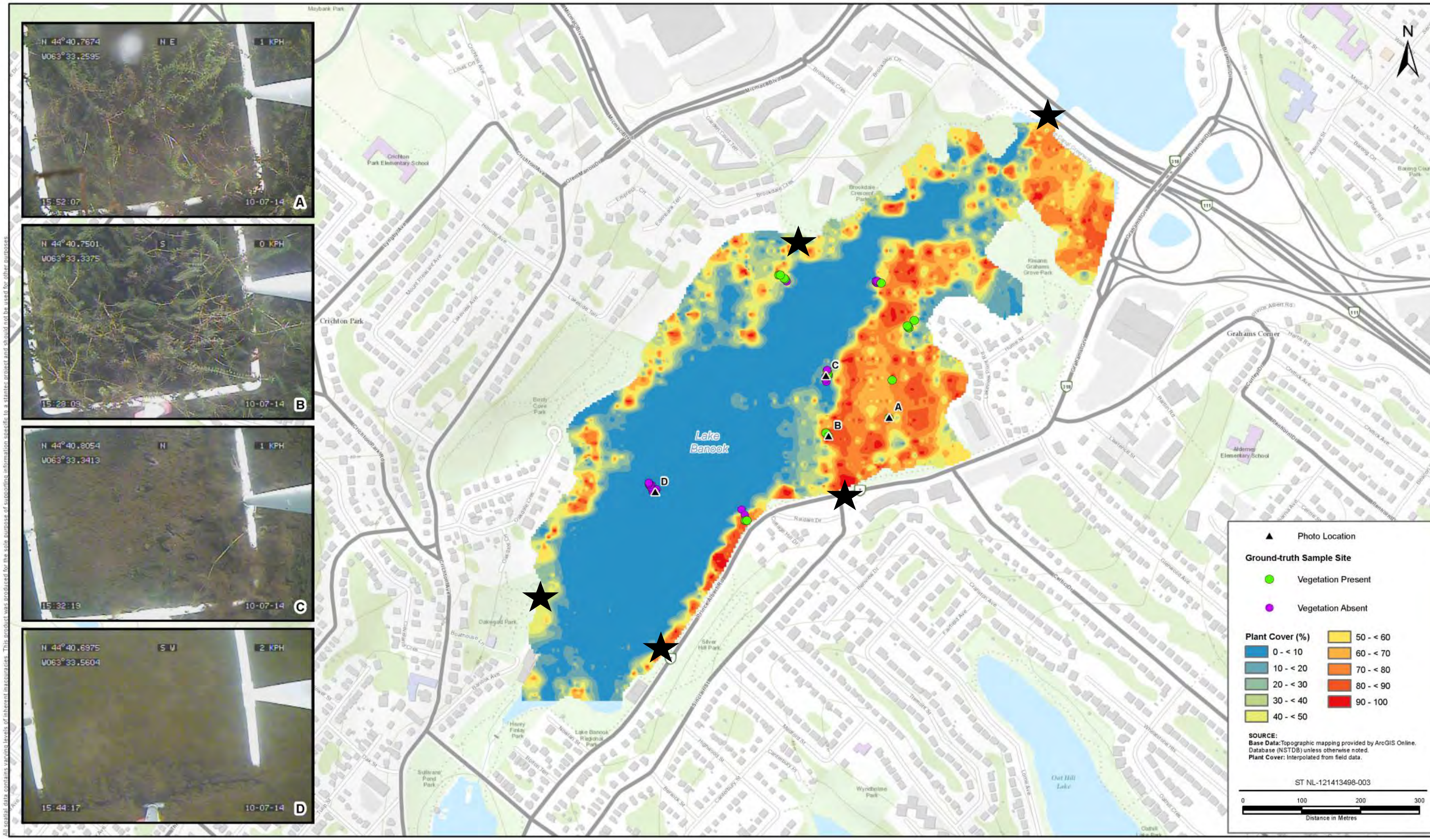
Percent Cover



PREPARED BY H Ward	Banook Lake Weed Study	FIGURE NO. 6
REVIEWED BY C Shupe	**Lake Banook Percent Plant Cover & Ground-truth Sample Sites**	DATE May 19, 2015
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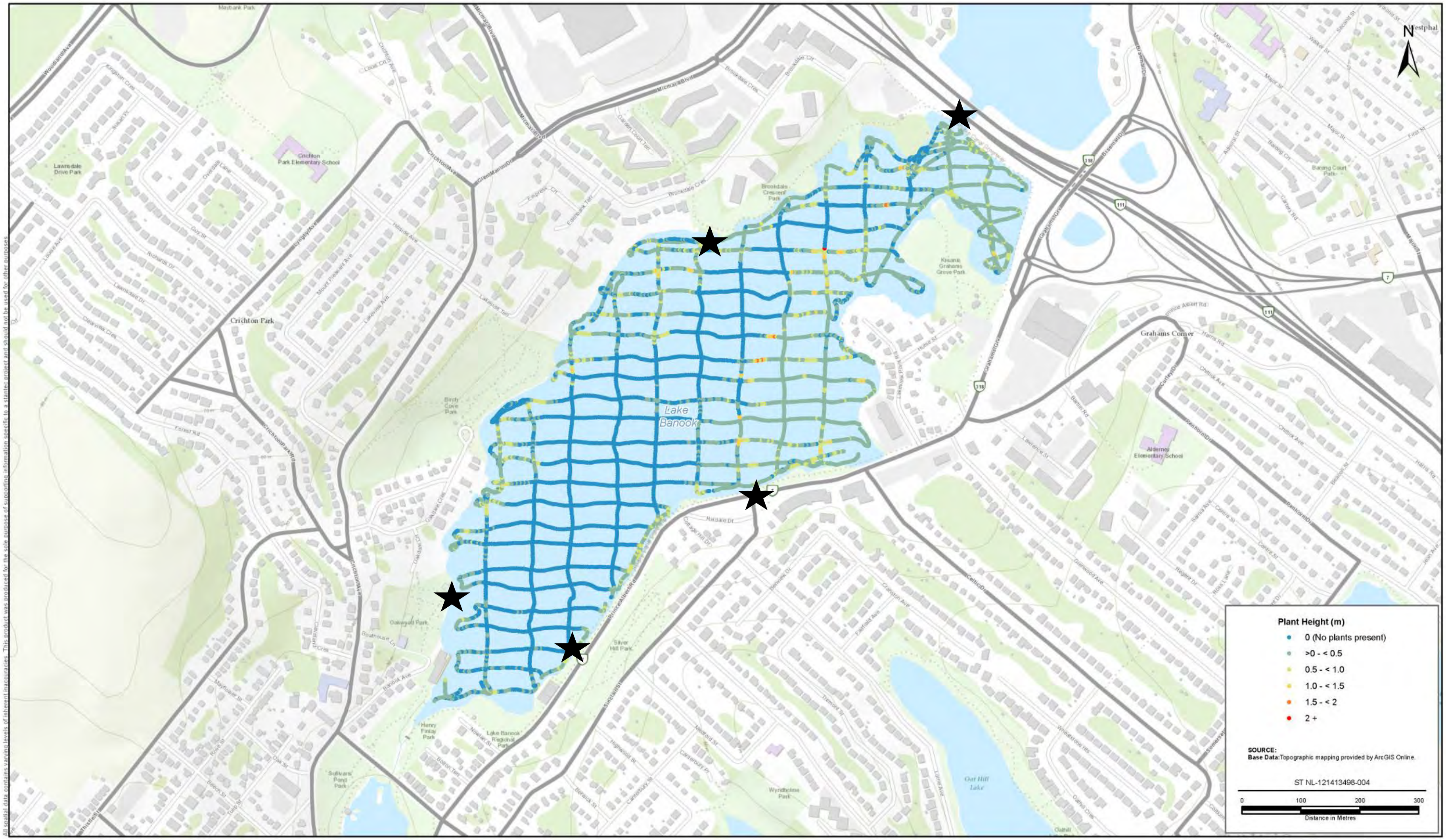
Canopy Height



PREPARED BY H Ward	Banook Lake Weed Study	FIGURE NO. 7
REVIEWED BY C Shupe		DATE May 19, 2015
CLIENT Halifax Regional Municipality	**Submerged Aquatic Vegetation Canopy Height – Field Points**	Stantec

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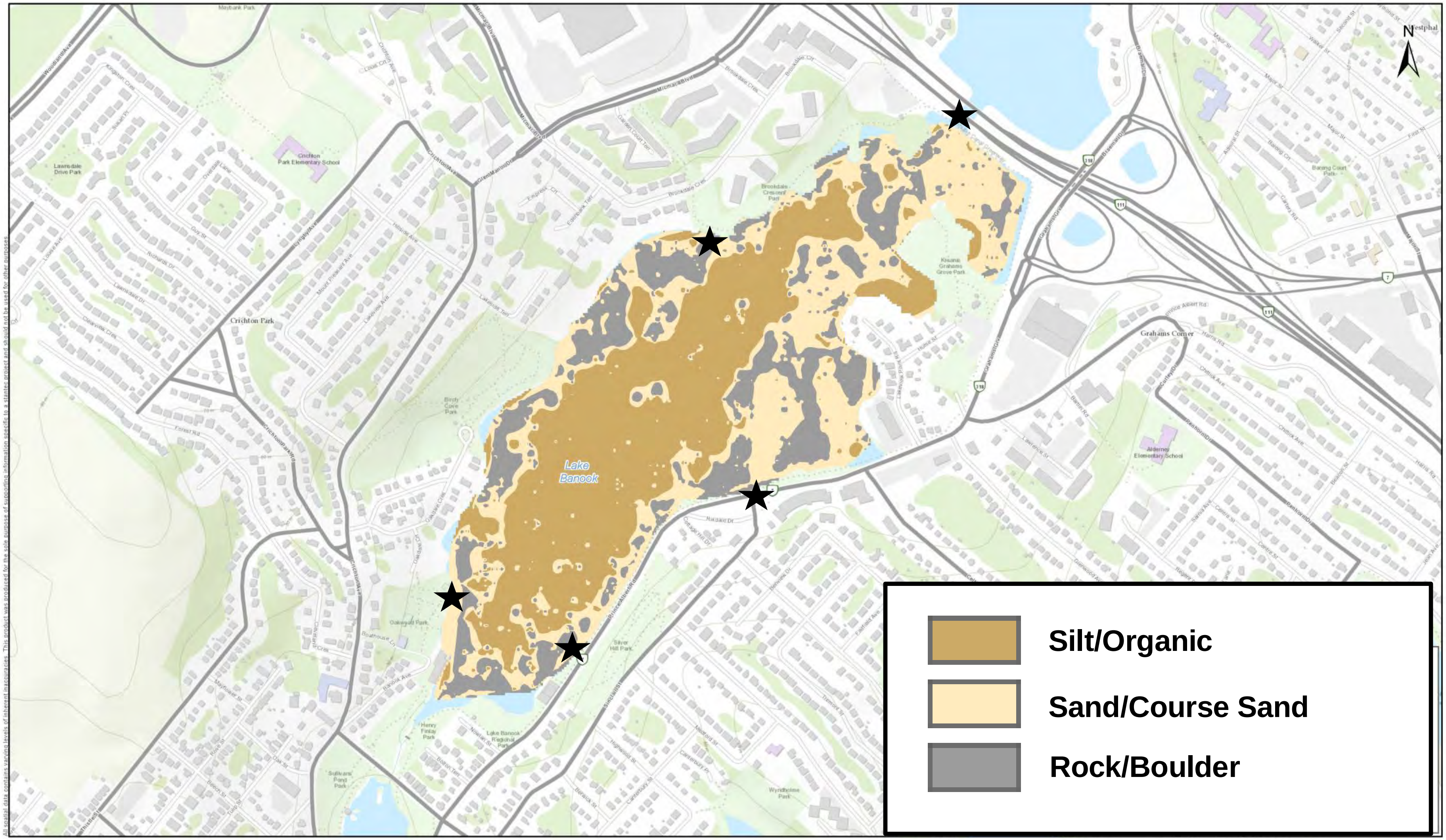
Substrate Type



PREPARED BY H Ward	Banook Lake Weed Study	FIGURE NO. 9
REVIEWED BY C Shupe	**Lake Banook Sediment Type – Interpolated**	DATE May 19, 2015
CLIENT Halifax Regional Municipality		Stantec

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2 Discussion of Likely Causes

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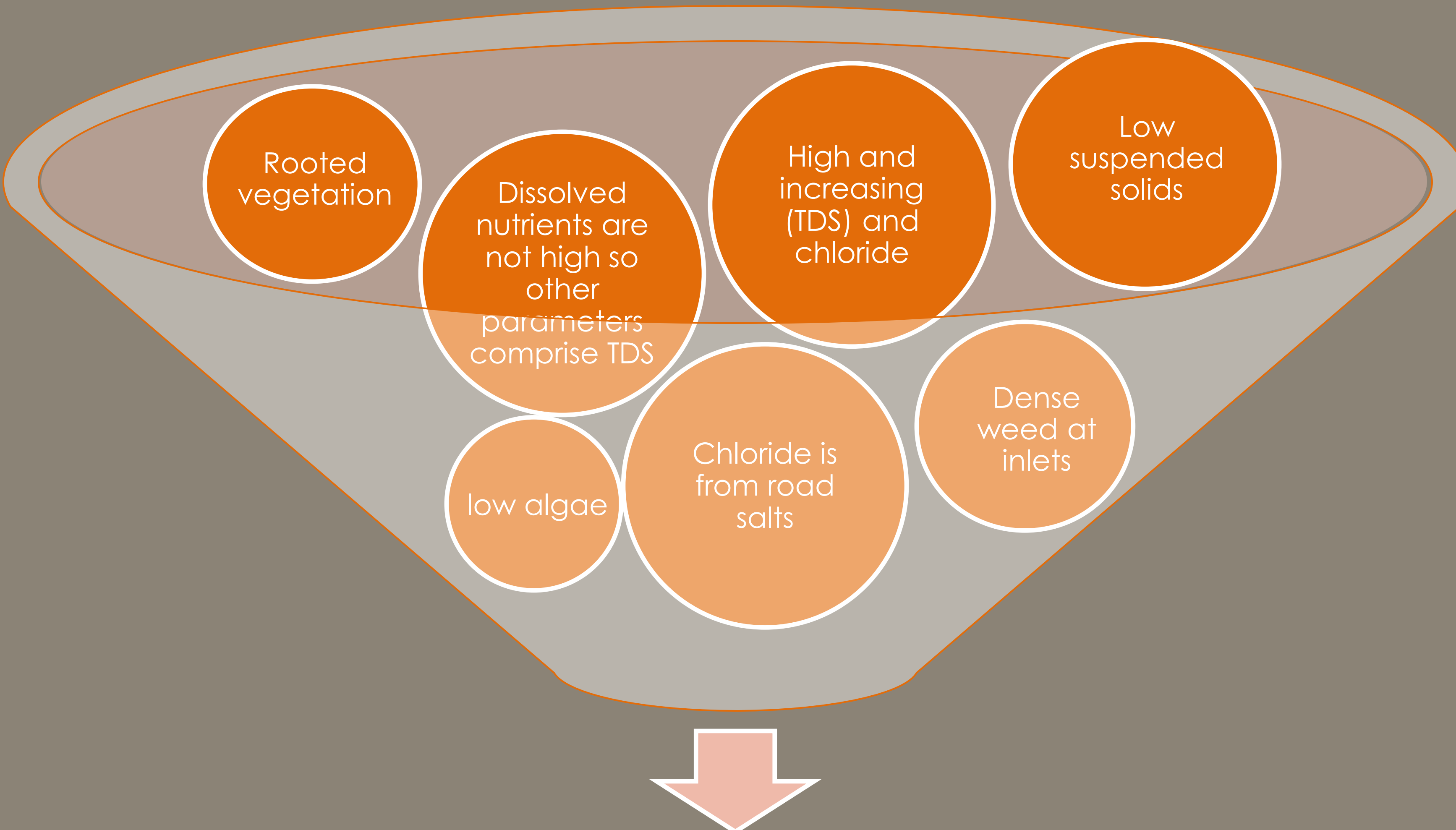
Lets put it together…



Suggests that there are urban non-point source contaminants getting to the lake but they are settling out, enriching sediments

Lets put it together…

…sudden bloom in 2009 following winter/spring lake drawdown

- Disturbance ecology – hearty plants given the chance to out-compete existing plants
- Light/oxygen/wind exposure to sediments alters biogeochemistry
- New niches for colonization by hearty and adaptable vegetation


3 Options for Management
Advice from the Lake…
Take time for calm reflection
Be clear
Be full of life!
Make waves!

Long Term Solutions

Addressing the causes:

Reduction of sediment loading to the lake

Source control

- Erosion Prevention

Conveyance control

- Infrastructure maintenance
- Green infrastructure solutions

Capture before delivery to the lake

- Engineered or natural containment
- Green infrastructure solutions

Detailed Evaluation

Available options

1. **Herbicides**
2. **Mechanical Harvesting**
3. **Sediment Dredging**

- General Description
- Specific Requirements
- Risks
- Approvals Required
- Costs

Herbicides

Goal is to affect plant before turions are produced to prevent reproduction

Many options available

- Contact herbicides act immediately and kill plant tissue on contact
- Systemic require uptake and take several weeks to act

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Herbicides

Further evaluation of specific options required to balance risk, timing, expected effectiveness in Lake Banook

- Early spring, before turion growth but after water has reached 18°C
- Low wind/mixing conditions
- Low suspended solids
- Granular or liquid form

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Herbicides

Considerations

- Not directly toxic to fish, but BOD demand of decay may suffocate them
- May kill beneficial vegetation, including shore-stabilizing plants
- Releases nutrients during decay, which further enriches sediment
- May take 5 years of application to achieve balance

Mechanical Harvesting

Vessel based mowing and collection

Transfer to truck

Disposal at appropriate facility

Mechanical Harvesting

Considerations

- Can be completed any time and multiple times a year
- May not be required after several years
- Vegetation should be removed to remove BOD demand, propagules and nutrients from the system
- Incidental kill of fish and invertebrates
- Difficult near docks and in shallow water
- Desirable vegetation removed as well

Mechanical Harvesting

- **Water Approval from NS Environment**
- **Consultation with Department of Fisheries and Oceans; authorization required**
- **Approval from disposal facility**

Sediment Dredging

Physical removal of enriched sediment and problem biomass

Dewatering of sediment

Disposal

Sediment Dredging

Considerations

- Benthic habitat destruction
- Removal without suspension
- Large area required for containment for dewatering
- No on-site disposal options, so transport required for disposal
- Interruption of activities
- Sediment may continue to accumulate

Sediment Dredging

- Water Approval from NS Environment
  - Dewatering
  - Alteration of water body
- Department of Fisheries and Oceans will review for serious harm to fish, and aquatic Species at Risk
- *Navigation Protection Act* authorization
- Approval from disposal facility
- Testing for land disposal/dewatering
- Transport requirements

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Costs

Herbicides $36k to $119k per year

* Multiple years required

Mechanical Harvester

*May not require multiple years

* Contracted for $182,000 per year

* Operation $19k to $24k per year

Dredging $645k to $1M

*not including dewatering

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4 Summary

Sudden growth of vegetation in the lake was likely the result of following sequence:

non-point source urban sediment input;

→

sediments enrichment; and

→

lake level draw-down caused disturbance ecology

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4 Summary

Long Term Solutions

- Source Control
- Infrastructure maintenance
- Green Infrastructure

Short Term Solutions

- Herbicides
- Mechanical harvesting*
- Sediment dredging

***Commenced with monitoring August 2015**

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5 Reflection

Category	Method/ Technology	Description	Specific Requirements or Limitations	Expected Effectiveness in the Short Term	Expected Effectiveness in the Long Term	Risks
Chemical	Aquatic herbicide: Endothall	A contact, rapid acting herbicide that is applied in early spring (Helfrich et al, 2009). Can reduce shoot biomass and the production of turions (Poovey et al, 2002). More suited to whole lake or large block treatments in lakes with little wind and wave action (Johnson et al, 2012).	Water temperature range is an important consideration in the effectiveness of this herbicide on shoot biomass and turion formation (Poovey et al, 2002,Netherland et al, 2000). Treatment requires the use of a boat (Government of Nova Scotia).	Excellent (Helfrich et al, 2009). Large reduction in biomass in each year of treatment (Johnson et al, 2012).	Will need yearly treatments. Turion numbers should decrease with each year of treatment. Ongoing management necessary (Johnson et al, 2012).	Can be toxic to fish and other aquatic life. Important to note that dead plants remaining in the water will release nutrients into the lake-this can promote growth of weeds. Fish kills may also result due to reduced oxygen content caused by rotting vegetation. Lake should be treated in sections and/or combined with aeration to maintain sufficient oxygen levels for fish (NSE). Algae blooms are possible due to nutrients released when macrophytes are killed (NSE). Herbicide may also kill beneficial vegetation (Helfrich et al, 2009). Soil along the shoreline may be influenced by the lack of vegetation, erosion may result (NSE). May require more than five consecutive years of treatment to get rid of all turions (Johnson et al, 2012).
	Aquatic herbicide: Fluridone	Persistant and slow-acting herbicide that is applied in early spring. Residue can persist for 2-12 months. Expensive and will not kill algae (Helfrich et al, 2009).	No restrictions for fishing, swimming or human consumption. Cannot use water for crop irrigation for 30 days following application (Helfrich et al, 2009). Treatment requires the use of a boat (Government of Nova Scotia).	Excellent but slower acting than other two; expect to see results in 30-90 days (Helfrich et al, 2009). Large reduction in biomass in each year of treatment (Johnson et al, 2012).	Will need yearly treatments. Turion numbers should decrease with each year of treatment. Ongoing management necessary (Johnson et al, 2012)	
	Aquatic herbicide: Diquat	Wide-spectrum contact herbicide, applied in early spring, used to control submersed weeds. Rarely found in the water after 10 days (Helfrich et al, 2009). Can reduce shoot biomass as well as the production of turions (Poovey et al, 2002). Good for use in areas with wind and wave action as this herbicide will still reduce shoot biomass despite short exposure time (Johnson et al, 2012). Rapid acting and kills top growth only (NSE).	Following application, must wait fourteen days before water can be used for livestock, irrigation or drinking. One day waiting period required before swimming (Helfrich et al, 2009). Water temperature range is an important consideration in the effectiveness of this herbicide on shoot biomass and turion formation (Poovey et al, 2002; Netherland et al, 2000). Treatment requires the use of a boat that does NOT stir up the bottom (herbicide is ineffective following contact with soil) (NSE).	Good (Helfrich et al, 2009). As with other herbicides, can expect to see a large decrease in biomass in the first year of treatment.	Will need yearly treatments. Ongoing management necessary (Johnson et al, 2012)	
	Dye (shade)	Dyes reduce the light available to underwater plants, inhibiting photosynthesis (Roegge & Evans, 2003; NSE). Plants will still grow but as a result of diminished light intensity will have far fewer stems per turion and stems will be weak (Tobiessen et al, 1992).	This method is not effective when there is significant outflow (Roegge & Evans, 2003). Roots must be in water that is about 0.5-1.0 m deep; dye is not effective in depths less than 1 metre (NSE). This should be done at the onset of the growing season and the dye must persist for several weeks (Helfrich et al, 2009).	Productivity of most all plants in the lake will be diminished.	Several yearly treatments required to significantly impact density and distribution of plant.	Low productivity of plants will result in a change in the productivity of the system. Fish and other aquatic species may be affected.
	Alum binding (nutrient limitation)	Internal phosporus (P) loading to a eutrophic lake from sediment can continue after the external source has been removed. Dosing lake sediments with aluminum sulfate can bind P that exists in the water column and render it neutral in the sediment and unable to further contribute to excessive weed growth (Kennedy & Cooke, 1983; James, 2011).	Most effective on suspended algae. Control of nutrient inputs mandatory. May need to combine with aeration (NSE).	In the first year, can expect P to be precipitated out of water column and held in the sediment on the bottom of the pond-unavailable for uptake by plants.	Higher volumetric doses may result in effective long-term control (James, 2011). Ongoing treatments may be necessary.	

Category	Method/Technology	Description	Specific Requirements or Limitations	Expected Effectiveness in the Short Term	Expected Effectiveness in the Long Term	Risks
Mechanical	Sand capping	Black plastic sheeting is used to line the bottom of the lake and a layer of sand or gravel is used to cover the plastic. Nutrient exchange is reduced and rooted weeds are unable to establishment themselves (Helfrich et al, 2009; NSE).	Plastic must be perforated in order to permit gases to escape. Waterfowl nesting sites and fish spawning areas should not be covered (Helfrich et al, 2009). Use is restricted to smaller areas (Tobiessen et al, 1992)	Cap will prevent plant growth in the first year.	Very effective long term. Plant growth will be prevented so long as the cap remains.	Reduction of aquatic macrophytes will impact the ecosystem severely.
	Mechanical Harvesting	Cutting, pulling or dredging is performed to remove plants from the problem area (Roegge & Evans, 2003). Mechanical harvesters or cutters can be used. Process must include collection of free-floating material.	Might only be temporary; elimination of the whole plant and entire root system is desirable (Roegge & Evans, 2003). Plant cuttings should be removed promptly from the lake in order to prevent propagation.	Most plant biomass can be removed in the year of harvest-results are seen immediately (Roegge & Evans, 2003).	Without multiple treatments, may not be effective over the long-term (Roegge & Evans, 2003). Unless roots are removed, success will remain short-term (NSE). Difficult to acheive long-term results.	Pondweed can propagate through cuttings; this method could intensify the problem (Roegge & Evans, 2003). Plants left in the water could contribute to further weed growth (Helfrich et al, 2009).
	Water level manipulation	Manipulating the water level of the lake during the fall and winter months will expose the aquatic vegetation to harsh conditions (Helfrich et al, 2009) Method 2: Drain lake to allow suspended solids and phosphorus to exit the system (Shantz et al, 2004)	Water level would need to be altered during the fall/winter. Mud on the bottom of the pond should freeze up to 10 cm and weeds should be physically removed (Helfrich et al, 2009)	Likely to see results in the year following the water level drawdown.	Unsure of long term success; recolonization may occur. Other management tools may be necessary. Repeat treatments may be required.	
	Sediment Dredging/Removal	The removal of the sediments on the bottom or along the shoreline of the lake. This method can also physically remove plants as well as nutrients required for plant growth. Dredging can be done following lake drainage or by using draglines (Helfrich et al, 2009).	Severe disruption of the habitat and human activities occuring on/near the lake. Depth at which plants typically grow as well as water clarity are determining factors of whether dredging will work to reduce pondweed. Space for a settling lagoon may be necessary (NSE; Tobiessen et al, 1992).	Physical removal of the plants will result in a decrease of biomass in the first year (Tobiessen et al, 1992).Dredging may also disrupt/remove turions buried in the soil, which would minimize pondweed growth in the following year.	Long term success may be possible. Plants may grow the year after dredging but at a much smaller density and biomass (Tobiessen et al, 1992).	Glacial boulders may be present in area from shore up to 5 m water depth (Huppertz et al, 2008).
	Shading	A dark colored geotextile material can be attached to floats. This device can be positioned near dense areas for spot treatment. The float creates shade and decreases the amount of light reaching the plants (Helfrich et al, 2009). Plants may still grow but as a result of diminished light intensity will have far fewer stems per turion and stems will be weak (Tobiessen et al, 1992).	Must be in place for at least a month to be effective (Helfrich et al, 2009), and floast must be well anchored (NSE). Timing would be key in order to limit the light available to plants during turion formation. Limited to smaller areas, and area being treated is unusable while floats are in place (NSE).	May reduce plant productivity and turion development in the first year.	More likely to see results in consecutive years and with continued treatments.	May not be effective in reducing pondweed populations. May influence other plant species.

Remedy Option	Evaluation Results	Expected effectiveness
Herbicide (e.g., Endothall, Fluridone, Diquat)	Herbicide has potential to stunt early season growth and prevent the plants from reaching the top of the water column and access to sunlight. After several years of application, established roots may perish and vegetation may be inhibited from reestablishing due to insufficient light penetration.	Expected to be effective in the short term. Single application will not result in long term effectiveness
Mechanical Harvesting	Mechanical harvesting will provide an immediate reduction in aquatic biomass. Repeated harvesting to prevent the plants from gaining access to sufficient sunlight in the upper portions of the water column may result in the death of the established roots, and vegetation may be inhibited from reestablishing due to insufficient light penetration if water levels are maintained.	Expected to be effective in the short and long term
Sediment dredging / removal	Removal of enriched sediment and established rooted vegetation would provide immediate and long-term reduction in rooted aquatic vegetation in problem areas.	Expected to be effective in the short and long term

4 Consideration of Options

Herbicides

Herbicide	Swimming	Fishing	Irrigation	Drinking
	Days of Restriction			
Endothall	0	3	7	-
Diquat	3	1	3	14
Fluridone	0	0	30	0

Recommendations for restrictions on activities following herbicide treatments using common types

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Herbicides

- Class II approval under Activities Designation Regulations of the Nova Scotia *Environment Act*
- Class V Aquatic Vegetation Certificate
- Department of Fisheries and Oceans consultation
- Advance public notification

Costs

Herbicides $36,000 to $119,000 per year

* Multiple years required

Herbicide	Cost per ha	Cost for 1/3 of lake (approx. 16 ha)	Cost for 1/2 of lake (approx. 24 ha)	Whole Lake Treatment (47 ha)
Endothall	$1,730 - $ 2,470	$ 28,000 - $ 40,000	$ 42,000 - $ 60,000	$ 81,500 - $ 116,000
Fluridone	$990 - $1,850	$ 16,000 - $ 30,000	$ 24,000 - $ 45,000	$ 46,500 - $ 87,000
Diquat	$740 -$990	$ 12,000 - $ 16,000	$ 18,000 - $ 24,000	$ 35,000 - $ 46,500
Summary	$740 - $2,470	$ 12,000 - $ 40,000	$ 18,000 - $ 60,000	$ 35,000 - $ 116,000

Costs

Mechanical Harvester

Contracted for $182,000 per year

Purchase from $ 96,000 to $ 295,000

Operate $19,000-$24,000 per year

Item:	Assumptions:	Estimated cost:
Harvester operator	$20/hour; 100 - 150 hours per year	$2000 - $3000
Maintenance/parts	Minor repairs/maintenance	$2000 - $5000
Fuel for harvester	50 liters/8 hours = 625 - 938 liters @ $1.50/l	$940 - $1400
Helper	$20/hour; 100 hours	$2000
Dump truck driver	$20/hour; 100 hours	$2000
Disposal	$75 per ton disposal costs, 135 ton/yr	$10,000
	Approximate Annual Operation Cost Total	$19,000-$24,000

Costs

Dredging $645,000 to $1,000,000

*not including dewatering

Item	Assumptions	Magnitude of Cost Estimate
Engineering Design	Method selection, sediment and erosion control design, dewatering design, etc.	$20,000 - $50,000*
Approvals	Consultants retained for this work	$10,000 - $20,000*
Dredging	9,000 m^3 of sediments for removal	$100,000 to 1,000,000*
Dewatering	9,000 m^3 of sediments of saturated sediments	Not likely feasible
Transport	16,650 ton to be transported in 22 ton tandem trucks at $40 for a round trip	$16,500
Disposal	16,650 ton disposed at $30 per ton	$499,000