

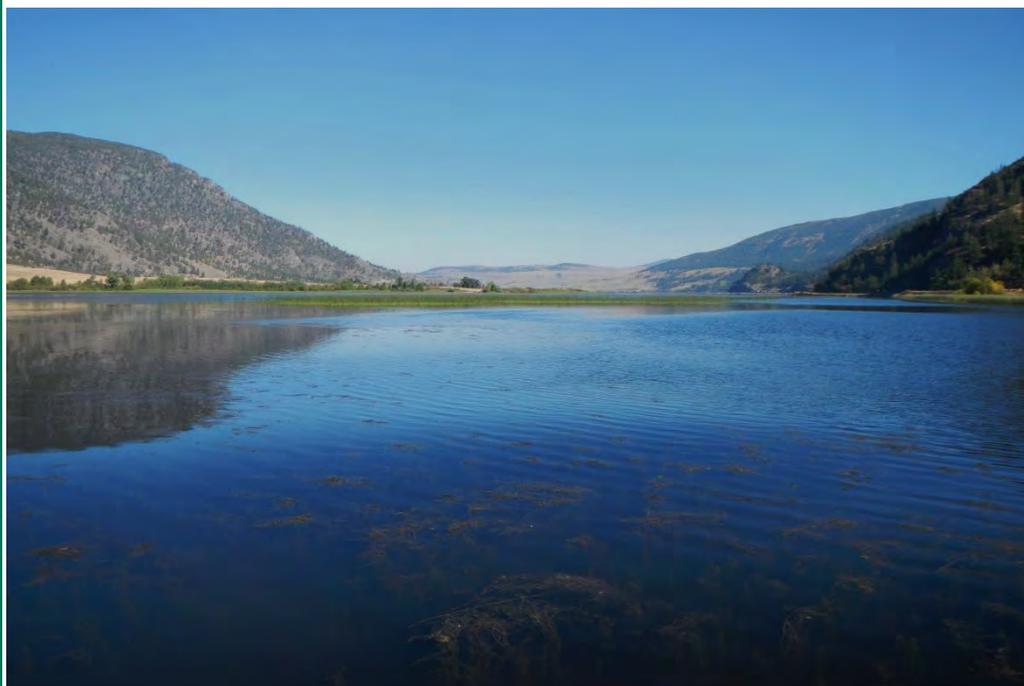


November 13, 2013

NICOLA LAKE PLANNING

Characterization of Macrophytes and Evaluation of the Prevalence of Eurasian Watermilfoil (*Myriophyllum spicatum* L.)

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REPORT





EXECUTIVE SUMMARY

In 2012, an integrated planning process was initiated for Nicola Lake. Through this process, the prevalence of Eurasian watermilfoil (*Myriophyllum spicatum*) (EWM) was identified as an important concern of residence and stakeholders. In order to inform management options, characterization of macrophyte (aquatic plants) communities throughout the littoral areas of the lake was conducted. Particular attention was paid to the abundance and distribution of EWM.

Between September 12 and 15, 2012 the entire perimeter of the lake was visually surveyed by boat. When substantial macrophyte beds were encountered, their extent was mapped and their composition determined by sampling one or more areas deemed representative. At each sample site percent composition of the dominant macrophyte species was estimated, water depth was recorded, substrate was characterized and potential constraints to mechanical harvesting (i.e., presence of boulders) were noted. Samples were collected with a long handled rake, or by snorkeling for in-hand identification. Species identification was primarily based on field observation of diagnostic phenotypic traits; however, occasional collections were made in order to verify species identification in the lab with use of dichotomous keys and a microscope.

As EWM can be easily confused with native watermilfoils, five samples with variable traits from different areas of the lake were sent to the Royal BC Museum curator of botany for independent verification. Verification was provided and the samples were added to the archives. When suspected hybridization was encountered, species determination was based on the dominant observable traits; alternatively, a 50:50 ratio was assigned to percent composition of the suspected hybrids. We purposefully avoided the common convention of only recording the genus as this did not provide adequate characterization, particularly for the commonly encountered genus *Potamogeton* which is highly variable.

EWM appears to have established within almost all areas suitable for macrophyte establishment within Nicola Lake; it was a common constituent of almost all macrophyte communities encountered with the exception of a few areas dominated by *Stuckenia pectinata*. Native watermilfoils identified during previous surveys (circa 1990) appear to be almost or entirely displaced. Of 70 sampled locations within 38 mapped macrophyte beds, 30 were categorized as having EWM as a 'Dominant' component (i.e. greater than 49% of the total cover), 24 as a 'Sub-dominant' component (i.e., between 21% and 49% of total cover), four as 'Present but Slight' (i.e., 5% to 20% of total cover), seven as a 'Trace' component (i.e., less than 5% of total cover) and five without detectable EWM. EWM was typically found to be mixed with native species, commonly at 1 to 3 m depth. The substrate in which it occurred was variable, ranging from fines to cobbles.

Many macrophyte beds had a typical pattern of prevalent EWM along near shore areas (commonly between 0.5 m and 3 m depth) with *Elodia canadenses* becoming more dominant in deeper water. This equates to the majority of EWM observed during the survey falling between the 620.8 m and 624.3 m elevation contours. EWM was commonly noted amongst emergent shoreline vegetation. It was also highly prevalent along a shallow off-shore shelf that is persistent around much of the lake. This feature is typically 5 to 15 m offshore and consists of a narrow (1 to 5 m wide), shallow (approximately 1 m) shelf, which hosts dense macrophyte communities often dominated by EWM. A large lake-spanning macrophyte bed dominated by EWM was identified at the west end of the lake which likely provides source populations eastward.

As eradication of EWM is likely an unrealistic expectation, it is recommended that a management plan be developed that concentrates efforts where they will produce the greatest benefits. Potential adverse effects to other resources (i.e., fisheries) must be considered in this planning. It is noted that the implementation of management options likely has the benefit of reducing the risk of other invasive introductions to the lake as well as the risk of further introduction of EWM to other aquatic systems in the region.



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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was commissioned by the Fraser Basin Council (FBC) to conduct an inventory of Eurasian Watermilfoil (*Myriophyllum spicatum*) (EWM) in Nicola Lake, approximately 12 km northeast of Merritt, British Columbia. This work was conducted in response to public concern regarding EWM in the lake articulated through the Nicola Lake Planning Process, which is facilitated by the FBC.

2.0 BACKGROUND

An action plan has been developed for Nicola Lake through two public meetings and the engagement of a multi-stakeholder working group. One of the key objectives identified in the plan is the control of invasive species. Specifically, to ...“begin a management regime for Eurasian watermilfoil (EWM) in high use areas” (FBC 2013).

One of the actions associated with this objective was to conduct a EWM inventory of the lake. This report describes the work conducted to address this action. The objective of this project was to map areas of substantial macrophyte cover and characterize the species composition with special attention to the distribution and abundance of EWM.

3.0 INFORMATION REVIEW

Two previous studies of macrophyte communities in Nicola Lake were identified on the EcoCat website (2013). They are briefly summarized below.

BC Ministry of Environment, Littoral Studies Section (1982)

This report summarized macrophyte species identified in field assessments conducted annually between 1978 and 1981. The report notes that the most commonly observed macrophytes during the 1980 and 1981 surveys were coontail (*Ceratophyllum demersum*), northern watermilfoil (*Myriophyllum sibiricum*)¹, fennel-leaved pondweed (*Stuckenia pectinata*)², white water-buttercup (*Ranunculus aquatilis*), and horned pondweed (*Zannichellia palustris*). They note that northern watermilfoil was predominant at depths of 0.5 to 1.5 m in early October. EWM was not identified during these surveys.

BC Ministry of Environmental, Lands and Parks, Littoral Resources Section (1992)

This report describes the discovery of EWM in Nicola Lake on September 10, 1991. A reported “intensive lake wide search” identified five locations comprising 682 m² of sparse to moderate infestation. These were located on the northern and western shores of the Nicola Bay Resort peninsula and along the northern most shore of the lake near the outlet of Moore Creek. Divers were employed to apply bottom barrier as a control strategy.

The report also identified 86.25 ha of macrophitic cover and notes that approximately 397 ha of Nicola Lake is considered to be within the depth range suitable for rooted aquatic plant growth. This estimate was based on the observation that the maximum depth of macrophyte growth in Nicola Lake was 3.5 m as measured on September 11, 1991. This corresponds to the 621.65 m contour.

¹ Note this name was reported as *Myriophyllum exalbescens*, it has been revised to reflect the latest naming convention as per the BC Conservation Data Center (2013).

² Note this name was reported as *Potamogeton pectinatus*, it has been revised to reflect the latest naming convention as per the BC Conservation Data Center (2013).



3.1 Eurasian Watermilfoil (*Myriophyllum spicatum*)

EWM ranks among the most aggressive invasive aquatic plants in North America (Reed 1977). It can form a nuisance surface canopy which interferes with recreation and may have adverse effects on native species. Potential adverse effects of the species in Nicola Lake include:

- Continued invasion of areas presently devoid of plant growth;
- Restricting navigability of the lake;
- Decreasing the quality of shoreline areas for recreational activities;
- Reduction of biological diversity through displacement of native species;
- Restriction of water flow in the outlet channel which may impair management of the lake and downstream water levels;
- Potential impacts to fish spawning habitat downstream of the lake;
- Changes to lake nutrient and oxygen levels; and,
- Increase risk of introduction into other aquatic systems in the region.

EWM can be difficult to distinguish from native watermilfoils, particularly northern watermilfoil (*Myriophyllum sibiricum*) as numerous phenotypic characteristics may overlap. Species identification is further confused by the recent discovery of hybridization between northern and Eurasian watermilfoils (pers. comm. Dr. D. Madsen; Moody and Les 2007).

Dr. Madsen provided genetically verified morphological data during a public presentation on EWM hosted by the Fraser Basin Council in February 2013. This data indicated the proportion of specific morphological characteristics between the two species. The most powerful discerning features of EWM according to this research are a flattened leaf end, a flattened apical meristem, and greater than 12 leaflet pairs.

Within Nicola Lake, the number of leaflet pairs was used as a primary indicator. Most samples had more than 14 leaflet pairs (see Appendix B photos 1-2) which distinguish it from both other species of *Myriophyllum* known in the lake. When an inflorescence (i.e., flowering head) is present, a thickened stem below the inflorescence is also a distinguishing characteristic.

Reproduction of EWM may occur sexually or asexually, with the latter being far more important. Colonization of EWM most commonly occurs by vegetative fragments during the growing season (autofragmentation) whereby abscising fragments develop roots at the nodes before separating from the parent plant. Fragments are then carried by wind and current and establish on suitable substrate when it is encountered. Fragments caused by mechanical means (i.e., boat propellers) are also commonly viable and are considered responsible for the very rapid spread of this species in many systems (Aiken *et al.* 1979, Johnstone *et al.* 1985, Madsen *et al.* 1988). However, Kimbel (1982) showed that naturally produced vegetative fragments grew better than artificially abscised fragments and were more likely to survive the winter. Within an established macrophyte bed, EWM also spreads via stolons (Madsen *et al.* 1988).

In the winter, small auxiliary buds are formed that detach from the root crowns establishing new plants early in the growing season. EWM may also disperse sexually by pollination of flowers and production of seeds (Aiken



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et al. 1979). In colder environments, EWM typically dies back in the fall and overwinters as a propagating root crown in which carbohydrates are stored (Grace and Wetzel 1978).

EWM flourishes in eutrophic lake systems (such as Nicola Lake). It is known to invade native communities and competitively displace most other aquatic plants within 2-3 years, often forming a bed larger than what was originally present (Aiken et al. 1979). Kimbel (1982) determined that EWM colonization success was highest during late summer in shallow water on rich organic sediments when light availability, temperature, and sediment nutrient levels were high.

4.0 METHODS

Between September 12 and 15, 2013, Kim Poupard (report author), a biologist with Golder in Kamloops, accompanied by a boat operator from the Kamloops Sailing Association (KSA), surveyed the entire shoreline of Nicola Lake by boat. They started at the KSA facility near Quilchena and worked clockwise around the lake over four consecutive days. The weather was calm and warm for the duration of the surveys.

The seasonality of the field work served a number of functions. Primarily, water levels were low so that macrophytes would be closer to the surface and easier to identify. Additionally, macrophyte beds were presumed to have reached their maximum annual extent. Finally, native *Myriophyllum* species (i.e., *M. sibiricum* and *M. verticillatum*) should have been more easily distinguishable as they should have been developing conspicuous winter buds (called turions) not formed by EWM.

The surveyor stood on the bow of the boat while the operator navigated the shoreline at slow speed (10-15 km/h). When a macrophyte bed was encountered, the perimeter was mapped with a mapping grade global positioning system (GPS) (Trimble™ Recon with a Pro XT receiver). The receiver was mounted on a pole so that it could be held over the bow as close to the edge of the macrophyte bed as possible while the surveyor instructed the operator to navigate along the edge of bed (Appendix B, photo 18).

As the field work was constrained somewhat by time, macrophyte beds had to be of a certain size and density in order to be mapped. This threshold had to be defined in the field once we had an understanding of the conditions in the lake. There are scattered plants along the vast majority of the shoreline; however, mapped beds generally had an estimated total cover greater than 30%. Exceptions were made when large areas of scattered plants with a high proportion of EWM were encountered, such as on the alluvial fan of Quilchena Creek. These were described in the field notes. It is also important to note that unless the bed was off shore and in deep enough water to safely navigate the boat around the entire perimeter, the near shore portions of the beds were not mapped. Generally, near shore areas were described with field notes and line work presented on Figure 1 was inferred from the notes in the office.

Each bed was characterized by sampling within representative areas. One or more sample locations were positioned within each bed in order to adequately characterize the bed. The number of sample sites depended on the size and uniformity of the bed. A total of 70 samples were completed; they were labelled to correspond with the mapped bed (i.e., line work) in sequential order. Each was assigned a letter to discern multiple sample sites within a single macrophyte bed. For example, 'Line 1' indicates the outer extent of the macrophyte bed in front of the KSA, it contains two sample locations: '1a' and '1b'.



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The western most portion of the lake (approximately 3.2 km from the outlet to the narrows) was lumped into a single bed at a coarser scale than the rest of the lake. This area is a complex matrix of macrophyte beds, many of which span the lake, and the effort required to map these at a useful scale was beyond the scope of this assessment. Six sample locations were placed within this area so that it could be described in general terms.

At each sample site, sampling was conducted by dragging a rake to attain a sample for species identification. Cover percentages were then visually estimated. Snorkel surveys were periodically employed to calibrate visual estimates and search for species more rigorously. This was particularly important where suspected hybrid watermilfoils were encountered or where water clarity was poor. The location of each sample site was recorded with the GPS. Additional information collected at each sample site included water depth, dominant substrate composition, and notable potential constraints to harvesting (i.e., presence of boulders).

As numerous macrophyte species are difficult to distinguish and/or readily hybridize (i.e., *Potamogeton*) samples were collected for verification in the laboratory employing a microscope and taxonomic keys. Though a number of informal keys were used, the most authoritative was *The Illustrated Flora of British Columbia* (Douglas et al. 1999). It should be noted that not every site was sampled and that only a few samples were keyed due to time constraints. Working through dichotomous keys is a highly time consuming process; therefore, the greatest attention was paid to ensuring proper identification of EWM. Other difficult to discern genus (i.e., *Potamogeton*), which were not the subject of this study, were not given the same attention. Data are based on field observations and readily discernible phenotypic traits. Where suspected hybrids were noted, which are common amongst the genus *Potamogeton* (e.g., hybrid *P. richardsonii* and *praelongus* were routinely observed), they were assigned a species based on dominant traits or assigned a 50:50 cover ratio. We wanted to avoid using '*Potamogeton sp.*' as this is an extremely diverse genus and only providing the genus in this case would not adequately describe the plant community.

An assortment of sampled specimens was verified by Mr. Darryl Arsenault, R.P.Bio., a Senior Aquatic Biologist in Golder's Kelowna office. Further, five samples of EWM with varying phenotypic traits from various location on the lake were sent to Dr. Ken Marr at the Royal Museum of British Columbia for independent verification. Verification was provided and the samples were pressed and added to the museum's archives.

GPS files were loaded into ArcGIS™. A review of the line work was conducted and anomalies were corrected or removed. Some line work had to be adjusted slightly in order to match available base imagery (i.e., one image appeared not to be properly geo-referenced and the GPS line file appeared on shore).

Members of the Nicola Lake Working Group (NLWG) were asked to provide input as to where there were perceived problems with EWM. Members indicated areas where they thought EWM was problematic by drawing on a map. This information was digitized and is included on Figure 1.

Species lists and cover estimates were entered into an Excel™ spreadsheet. In order to provide a useful visual illustration (Figure 1), sample sites were divided into arbitrary categories based on the proportion of EWM in the macrophyte composition of a bed (note that the total cover may vary considerably, however). The specific details of each sample site are provided in Appendix A; the definition of each category is provided in Table 1.



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Table 1: Definitions of Percent Composition Categories for EWM at Sample Sites

Category	Definition
Dominant	50% to 100% of the macrophytes within the sample site EWM
Sub-Dominant	21% to 49% of the macrophytes within the sample site are EWM
Present but Slight	5% to 20% of the macrophytes within the sample site are EWM
Trace	<5% of the macrophytes within the sample site are EWM
None	EWM was not detected

5.0 RESULTS

The extent of major macrophyte beds and the location of sample sites are shown on Figure 1. Appendix A provides a summary of the sampling data and can be cross referenced with the locations on Figure 1. A list of the macrophytes encountered during the survey is provided in Table 2 along with their provincial designations. No species listed under the federal *Species at Risk Act* (SARA) were observed.

Table 2: Dominant Macrophyte Species of Nicola Lake

Common Name(s)	Scientific Name	Provincial Status*
Common hornwort / Coontail	<i>Ceratophyllum demersum</i>	Yellow
Canadian waterweed	<i>Elodea canadensis</i>	Yellow
Northern watermilfoil / Siberian watermilfoil	<i>Myriophyllum sibiricum</i>	Yellow
Eurasian watermilfoil	<i>Myriophyllum spicatum</i>	Exotic
Wavy water nymph	<i>Najas flexilis</i>	Yellow
Curled pondweed	<i>Potamogeton crispus</i>	Exotic
Grass-leaved pondweed	<i>Potamogeton gramineus</i>	Yellow
Perfoliate pondweed	<i>Potamogeton perfoliatus</i>	Blue
Long-stalked pondweed	<i>Potamogeton praelongus</i>	Yellow
Richardson's pondweed	<i>Potamogeton richardsonii</i>	Yellow
Eel-grass pondweed	<i>Potamogeton zosteriformis</i>	Yellow
White-water buttercup	<i>Ranunculus aquatilis</i>	Yellow
Fennel-leaved pondweed	<i>Stuckenia pectinata</i>	Yellow
Sheathing pondweed	<i>Stuckenia vaginata</i>	Blue

*Yellow = Not at Risk; Blue = Sensitive; Exotic = Moved beyond their natural range due to human activity. More information is available on the BC Ecosystems Explorer Website at: www.env.gov.bc.ca/atrisk/toolintro.html

EWM is prevalent and pervasive throughout Nicola Lake; it is clear that the distribution of this species has increased considerably since it was last surveyed in 1991 and that efforts to control the plant at that time were unsuccessful.



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Of 70 sampled locations within 38 mapped macrophyte beds, 30 were categorized as having EWM as a 'dominant' species; 24 as 'sub-dominant', four as 'present but slight', seven with 'trace' amounts, and five where EWM was not detected (see Figure 1). EWM was generally found to be mixed with native species, commonly at 0.5 to 3 m depth. The substrate in which it occurred was variable, ranging from fines to cobbles (though likely with interstitial fines).

The BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) provided lake levels from gauging station 08LG046 over the survey period (September 12 to 15, 2013). The lake elevation varied little over this period ranging from 625.35 m on September 12 to 625.33 m on September 15. This suggests that much of the observed EWM within the lake over the survey period was between the 622.3 m and 624.8 m elevation contours.

Many near-shore macrophyte beds had a typical pattern of prevalent EWM along near shore areas (commonly within approximately 0.5 to 1.5 m depth) with *E. canadensis* becoming dominant in deeper water. EWM was commonly noted amongst emergent shoreline vegetation, generally dominated by bulrush (*Schoenoplectus* sp.). Also, much of the lake's shoreline has a shallow shelf, usually 5 to 15 m offshore and 1 to 5 m in width. This shelf hosts a dense cover of macrophytes and is typically dominated by EWM and *E. canadensis*.

More specific descriptions are provided in the following subsections.

5.1 Western Region

Along the southern shore (generally in the vicinity of samples sites 2a, 3a, and 4a) macrophytes are few and scattered. The shelf features is present but discontinuous. The shoreline tends to be steep (composed mostly of highway fill) and the area suitable for macrophyte establishment is limited and constrained near shore.

EWM was particularly prevalent amongst a large lake-spanning bed at the narrows near the west end of the lake (see Appendix B, photo 4). Samples 5c and 5d at this location had EWM making up 90% of the macrophyte community. This is a very large macrophyte bed with total cover estimates exceeding 95% in areas. A large component of EWM continues to be prevalent along the northern shore to sample site 7c in front of Harmon Estates (see Appendix B, photo 6). This spanning bed is problematic as prevailing winds from the east likely facilitate the spread of plant fragments eastward and would likely provide a source population.

The western most portion of the lake (i.e., sample sites 6b through 6g) is generally shallow with fine substrate making for excellent conditions for macrophyte establishment. As a result, macrophytes are highly prevalent in this area and much of the shoreline hosts emergent vegetation (see Appendix B, photo 5). Due to time considerations and the effort required to map this area in any kind of detail, this portion of the lake is described in general terms only.

Sample site 6a represents a small isolated macrophyte bed dominated by native species. The area around it was mostly open water. The line west of this location represents the western extent of the next spanning bed beyond which no attempt was made to map specific macrophyte beds. This area contains a complex of lake-spanning beds as well as isolated patches not associated with the shoreline. At the time of the survey there was a navigable channel all the way to the control structure at the western most point of the lake. *P. praelongus* and *S. pectinata* were dominant species in deeper water (>2 m); however, EWM was noted to be pervasive throughout this area and was dominant in two of the six sample locations representing this region. Macrophyte beds in this area are a hindrance to navigation.



It is suspected that this region is accreting sediment and becoming shallower over time; as a result, we expect this region to increase in macrophyte cover over time as conditions continue to become more conducive to their growth.

There are problematic macrophyte beds along the residence of Harmon Estates with EWM as a dominant or subdominant component of the communities (see Appendix B, photo 6).

5.2 Monck Park and Nicola Estates

EWM was noted to be dominant or sub-dominant within the scattered macrophyte beds along Monck Provincial Park, though the beds themselves had lower total cover densities than other areas of the lake. Further, many of these beds were noted to be somewhat off shore (Appendix B, photo 8). The pattern of *E. canadensis* being more dominant along the water-wards edge of the beds was noted here. The shallow shelf described above was also noted along this section, particularly at the south end near sample site 8a and around site 15a. At the latter site, EWM was the only species noted at an estimated cover of 15%.

Macrophytes do not extend to the shore at the swimming beach at Monck Park. EWM was noted to be dominant around the Monck Park boat launch and scattered boulders were noted on the substrate (Appendix B, photo 9).

The shoreline along Nicola Estates contains numerous areas of emergent vegetation and shoreline marsh (Appendix B, photo 10). EWM was noted in very low density among emergent plants but is considerably denser along the outside edges of these features. EWM is a prevalent constituent of species around private docks. It was also noted at the boat launch servicing these residences. The shelf feature was noted all the way along this shore to sample site 17a (Appendix B, photo 11). At sample site 16a, for example, a 2 to 4 m wide strip of macrophytes dominated by EWM was noted approximately 15 m from the shore.

5.3 Northern Region

The shoreline ridge was particularly prevalent along the northwest shoreline, from sample site 18a to 23a. It was typically 1 to 5 m wide, 3 to 8 m offshore, and at approximately 2 m depth. EWM was a dominant or sub-dominant component of the communities along this entire section, particularly along near shore areas with *E. canadensis* becoming more dominant along the water-ward edge of the shelf (Appendix B, photos 12-13). Much of these macrophyte beds did not extend to the shore with the exception of in the bay at sample site 21a. EWM was generally subdominant in front of the two small groups of residences accessed from Nicola Lake Road along this section.

The northernmost portion of the lake is generally shallow and sandy resulting from the alluvial fan of Moore Creek. Macrophytes are highly variable in this area and are loosely scattered throughout the area with a few more significant beds usually located somewhat off shore. Large beds of native *Potamogeton* were observed at the northwest and northeast corners of the lake, generally located along the outside of emergent vegetation at the shoreline (Appendix B, photos 14-16). Substrate on the alluvial fan is expected to be somewhat unstable due to annual patterns of deposition and erosion and therefore macrophyte establishment is highly variable.

The shelf once again becomes evident along the northeast shoreline starting at approximately sample site 28a and extending southwards. It is somewhat less prominent than on the western shore and is discontinuously



scattered along this entire shoreline. The delineated macrophyte beds and sample sites along this shore represent areas of prominent macrophyte growth along this feature.

Note that the *Myriophyllum* identified at sites 27e and 28a had traits more commonly associated with *M. sibiricum* (specifically, number of leaflet pairs and generally stiffer leaves) and was recorded as such. It is possible that these were hybridized with EWM, however.

5.4 Nicola Bay Resort

There is a dense macrophyte bed within the bay on the north side of the Nicola Bay peninsula (at sample sites 31a, 31b, and 31c), it is constrained fairly near shore and is evident between the numerous private docks (Appendix B, photo 17). The mean total cover percent of the three sample sites within the bay is 81% with EWM noted to be subdominant (mean of 33% of the total cover). The substrate is dominated by fines and most of the macrophytes were within 1.5 to 2.5 m of water. This macrophyte bed was noted to be fairly diverse with the typical pattern of *E. canadensis* becoming more prominent in deeper water.

Along the western shore of Nicola Bay the shelf becomes extremely prominent. It ranged from 1 to 5 m in width and was generally at approximately 2 m depth. At the north end it is sparse and approximately 5 m from shore, southwards it veers away from shore and becomes much denser around sample site 32b. There are few scattered macrophytes between the shelf and the shore but they are not a continuous bed (Appendix B, photos 18-19). The shelf becomes more fragmented between 32b and 32a.

5.5 Upper Nicola River and Quilchena

There are numerous scattered macrophyte beds along this section (from 33a to 1b) and EWM was a generally a dominant or sub-dominant component with the exception of the two northernmost beds (33a, 34b) which are dominated by *S. pectinata*. Macrophyte beds tended to be of lower density with a few exceptions. The bay at 36b had relatively high diversity and dense cover. The shoreline at this location is a natural wetland buffered somewhat from the lake by a sand bar. The mapped bed then comes around the point to the south. There is a dense line of macrophytes along the edge of a large shallow bench (outside of sample site 37a). The assemblage of macrophytes along this line is represented by sample site 37b; EWM is dominant. The area to the inside (represented by sample site 37a) is highly variable. There are macrophytes at low density throughout this area with occasional scattered areas of denser cover. Depths were generally 1.5 m with sandy substrate. Sample site 37b is at the north end of the alluvial fan of Quilchena Creek; the substrate is sandy and suspected to be unstable. Very few scattered plants were noted here. Generally, this area is a large expanse of sand with a few scattered patches dominated by *S. pectinata*. A very large patch of *S. pectinata* is noted at sample site 1a (Appendix B, photo 3).

At sample site 1b, within the docs and at the boat launch at the KSA, EWM was subdominant amongst a dense macrophyte community.



6.0 SUMMARY AND RECOMMENDATIONS

EWM appears to have established within almost all suitable areas for macrophyte establishment within Nicola Lake; it is a common constituent of almost all macrophyte communities encountered during the survey with the exception of a few areas dominated by *S. pectinata*, generally in deeper water. Native watermilfoils (*M. sibiricum* and *M. verticillatum*) identified during previous surveys appear to be almost or entirely displaced.

Areas indicated by the public to be of concern were generally verified and their boundaries were delineated in the field. Additional areas with high EWM prevalence on portions of the lake less utilized by the public were also identified. Given the distribution and abundance of EWM in Nicola Lake and the limited tools available for control of this species, management options should aim to improve and maintain areas of high importance to the public.

Areas of public concern with verified high prevalence of EWM should be prioritized in any management scheme. These areas are:

- All public boat launches;
- Areas used for recreation at Quilchena;
- Harmon Estates;
- Monck Provincial Park;
- Nicola Estates;
- The two communities along the northwest lake shore accessed from Nicola Lake Road: and,
- Nicola Bay Resort.

The lake-spanning bed at the narrows just west of Harmon Estates should also be considered in any management scheme as it will likely provide a source population to westward areas.

Management options for EWM have been explored by the Nicola Lake planning process as well as in many academic exercises. Control options include:

- Hand removal or dredging with divers;
- Mechanical harvesting;
- Mechanical rototilling;
- Lake drawdown;
- Biological control; and,
- Application of herbicide and/or fungal inoculation.

The breadth of control options is limited by the regulatory environment as well as by potential implication to fish and fish habitat. Further study will likely be required in order evaluate the potential impacts of a selected EWM management option to fisheries resources.

The Nicola Lake Working Group has discussed the idea of using the control structure at the outflow of Nicola Lake to drawdown the water level and expose shallow macrophyte communities to winter elements, which



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should theoretically kill the plants. Mr. Jephtha Ball (pers. comm. November 2013) of the MFLNRO provided maximum drawdown elevations for the Nicola Lake Dam as follows:

- The absolute lowest drawdown elevation (with zero outflow) is approximately 623.6 m; however, this is not operationally feasible in that adequate base flows downstream into the Nicola River would not be provided.
- The lowest operational draw down is approximately 624.1 m during periods of ice cover (generally late December to the end of February) in order to provide adequate downstream flows.
- Without ice cover (generally March to the end of April), the lowest draw down elevation is approximately 623.8 m.

Mr. Ball also notes that the minimum ice / no ice conditions are not written into the operational rule curves for the dam and are subject to review.

In considering the feasibility of using lake drawdown as a management tool for EWM, this information suggests that only approximately half of the observed depth range of EWM could be affected by the operational drawdown. Specifically, if one considers the no ice maximum drawdown of 623.8 m, this lake elevation would expose all plants noted between 0.5 m depth (624.8 m contour) and 1.5 m depth (623.8 m contour). There are considerable secondary impacts that would need to be considered in this approach. Much better bathometric information would be required to evaluate this method as well as further study into the implications for native species and fish.

Interaction of EWM with other components of the environment must also be considered. Anecdotal reports from residents along the lake suggest that the prevalence of algae has been much reduced over recent years. Aquatic plants compete with algae for nutrients and may greatly improve water clarity by preventing algae blooms (Davis et al. 1973); further, Nakei et al. (2000) showed that allelopathic polyphenols released by EWM inhibited the growth of blue-green algae *Microcystis aeruginosa* in controlled experiments.

Macrophyte beds (including those containing EWM) provide habitat for fish and invertebrates as well as areas of calm water for waterfowl to rest. There is conflicting information as to the palatability of EWM for waterfowl.

As eradication of EWM is highly unlikely and any meaningful attempt would be prohibitively expensive, it is recommended that a management plan be developed that defines specific goals in order that treatment efforts are concentrated where they will produce the greatest benefits. Examples of such goals include:

- Improving navigation for boat traffic;
- Keeping beaches free from plant growth;
- Restoring the diversity of macrophyte communities; and,
- Maintaining optimal cover for fish production.

Further, the management plan should include a strategy for minimizing the risk of additional EWM introductions in the region. Specific management strategies such as the mandatory cleaning of watercraft, boat inspections, public education, and mechanical harvesting at boat launches should be considered. Implementation of one or more of these strategies has the added benefit of reducing the risk of other potentially invasive species (i.e., quagga mussel) to the region.



7.0 CLOSURE

We trust that the above addresses your current requirements, should you have any further questions please contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

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KP/DH/ap

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Personal Communications

- Dr. D. Madsen. Mississippi State University. February 15, 2013. Workshop Presentation: Understanding Eurasian Milfoil.
- Mr. Jephtha Ball, P. Eng., Hydrotechnical Engineer with the Thompson Okanagan Water Stewardship Branch of the Ministry of Forests, Lands and Natural Resource Operations. Email Communication, November 5, 2013.



LEGEND

Sample Locations

% Cover Ranges of EWM

- Dominant: >49%
- Sub-dominant: 21-49%
- Present but slight: 5-20%
- Trace: <5%
- None

- Extent of Macrophyte Beds
- - - Approximated Boundary of Macrophyte Beds
- - - Edge of Shallow Shelf
- Areas of Concern as Indicated by the Public

REFERENCE

BASE IMAGERY FROM BING WEB MAPPING SERVICE



PROJECT		FRASER BASIN COUNCIL CHARACTERIZATION OF MACROPHYTES IN NICOLA LAKE, BC	
TITLE		DISTRIBUTION AND PREVALENCE OF EURASIAN WATER-MILFOIL	
PROJECT NO. 13-1492-0014		FILE No.	
DESIGN	KP	30 Sep. 2013	SCALE AS SHOWN
GIS	BKL	30 Sep. 2013	REV. 0
CHECK	KP	30 Sep. 2013	FIGURE: 1
REVIEW			



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Table 1: Sample Site Data Summary

Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
1a	2.5	fines	<i>Stuckenia pectinata</i> (60) <i>Stuckenia vaginata</i> (5)	65	0	Snorkel survey. Large bed off shore; may be of importance to migrating waterfowl. Downy feathers noted on surface daily. See Appendix B: photo 3.
1b	0.5 - 2.0	cobbles, fines	<i>Elodea canadensis</i> (10) <i>Myriophyllum spicatum</i> (15) <i>Najas flexilis</i> (5) <i>Potamogeton richardsonii</i> (10) <i>Stuckenia pectinata</i> (5)	45	33	Snorkel survey. Inside docks and along shoreline of Kamloops Sailing Association, including around boat launch. Old dock anchors and various other obstacles noted.
2a	variable	variable	<i>Myriophyllum spicatum</i> (60) <i>Stuckenia pectinata</i> (20)	80	75	Macrophytes are few and scattered along this shoreline, generally along a narrow shelf just off of the shore.
3a	variable	variable	<i>Ceratophyllum demersum</i> (5) <i>Elodea canadensis</i> (60) <i>Myriophyllum spicatum</i> (10)	75	13	Small bed along rocky shoreline.
4a	variable	variable	<i>Elodea canadensis</i> (80) <i>Myriophyllum spicatum</i> (20)	100	20	Small bed along rocky shoreline.
5a	1.2	cobbles, fines	<i>Myriophyllum sibiricum</i> (5) <i>Myriophyllum spicatum</i> (30) <i>Potamogeton praelongus</i> (5) <i>Stuckenia pectinata</i> (5) <i>Ceratophyllum demersum</i> (5)	50	60	Along marshy shoreline dominated by bulrush (<i>Schoenoplectus sp.</i>). EWM noted amongst emergent vegetation.
5b	variable	fines	<i>Myriophyllum spicatum</i> (8) <i>Potamogeton praelongus</i> (5) <i>Ceratophyllum demersum</i> (70)	83	10	Scattered boulders noted. Marshy shoreline.
5c	variable		<i>Elodea canadensis</i> (5) <i>Myriophyllum spicatum</i> (70) <i>Ceratophyllum demersum</i> (3)	78	90	EWM is pervasive and dominant in this area.



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
5d	3.2	fines	<i>Ceratophyllum demersum</i> (1) <i>Elodea canadensis</i> (<1) <i>Myriophyllum sibiricum</i> (<1) <i>Myriophyllum spicatum</i> (90) <i>Potamogeton praelongus</i> (2) <i>Stuckenia pectinata</i> (2)	95	90	EWM is pervasive and dominant in this area. Macrophyte bed spans the lake and is dense enough to limit navigation. See Appendix B: photo 4.
5e	2.1	fines	<i>Ceratophyllum demersum</i> (2) <i>Myriophyllum spicatum</i> (35) <i>Potamogeton praelongus</i> (15) <i>Stuckenia pectinata</i> (25)	77	35	Macrophyte bed spans lake in this area, this is along the western edge of the spanning bed. Boulders were noted to south at boat launch area and EWM was present within the macrophytes in this area.
6a	2.5	unknown	<i>Ceratophyllum demersum</i> (1) <i>Myriophyllum spicatum</i> (3) <i>Potamogeton praelongus</i> (90)	94	3	Small isolated patch near middle of lake.
6b	1.5	fines	<i>Myriophyllum spicatum</i> (T) <i>Potamogeton praelongus</i> (D) <i>Stuckenia pectinata</i> (D) <i>Ceratophyllum demersum</i> (SD)	60	<5	At western most point of lake near control structure along southern shore. Small navigable channel 2-5m in width is present along this section of the lake. Shoreline is mostly marshy or herbaceous. EWM noted in trace amounts only.
6c	2	fines	<i>Myriophyllum spicatum</i> (35) <i>Myriophyllum sibiricum</i> (30) <i>Potamogeton gramineus</i> (5) <i>Potamogeton richardsonii</i> (5) <i>Stuckenia pectinata</i> (5)	80	44	Channel between 6b and 6c is has few scattered macrophytes, mostly confined to the shoreline. Macrophytes at this sample location are denser. Shoreline is marsh to west and steep, rocky, highway fill to east.
6d	0.5	fines	<i>Myriophyllum spicatum</i> (35) <i>Potamogeton gramineus</i> (2) <i>Potamogeton richardsonii</i> (20)	57	61	Wide channel with little macrophyte growth at center, sample is representative of conditions along both shorelines. Shorelines are marsh dominated by bulrush.



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
6e	2.5	unknown	<i>Ceratophyllum demersum</i> (<1) <i>Myriophyllum spicatum</i> (5) <i>Potamogeton praelongus</i> (30) <i>Stuckenia pectinata</i> (5)	40	5	Macrophytes are scattered at low density throughout center portion of the lake in the area. Turbid water limited ability to assess substrate.
6f	1.5	fines	<i>Ceratophyllum demersum</i> (<1) <i>Myriophyllum spicatum</i> (25) <i>Potamogeton praelongus</i> (2) <i>Stuckenia pectinata</i> (5)	32	78	Along bulrush dominated marshy shoreline. Macrophytes dense along shoreline becoming scattered towards center of lake. See Appendix B: photo 5.
6g	1	fines	<i>Myriophyllum spicatum</i> (15) <i>Potamogeton praelongus</i> (10) <i>Stuckenia pectinata</i> (10)	35	43	Along outside edge of bulrush dominated marshy shoreline. Trace EWM noted amongst emergent vegetation.
7a	1.5	unknown	<i>Elodea canadensis</i> (25) <i>Ceratophyllum demersum</i> (2) <i>Myriophyllum spicatum</i> (20) <i>Potamogeton praelongus</i> (2) <i>Stuckenia pectinata</i> (2)	51	39	Along rocky, treed shoreline in front of residences. Dense algae noted, covering macrophytes and substrate.
7b	1.5	fines	<i>Ceratophyllum demersum</i> (<1) <i>Elodea canadensis</i> (40) <i>Myriophyllum sibiricum</i> (10) <i>Myriophyllum spicatum</i> (25) <i>Stuckenia pectinata</i> (1)	76	33	Snorkel survey in this location. Turbid water due to algae. Sampled just outside of private docks. See Appendix B: photo 6 and 7.
7c	1.5 - 2.0	fines	<i>Elodea canadensis</i> (4) <i>Myriophyllum spicatum</i> (65) <i>Stuckenia pectinata</i> (1)	70	93	Dock and boat anchors noted. Rock gabions as erosion control structures along shoreline in front of private residences.
8a	1.0 - 2.0	cobbles, fines	<i>Elodea canadensis</i> (1) <i>Myriophyllum spicatum</i> (10) <i>Potamogeton praelongus</i> (10)	21	48	Narrow band along shallow shelf, does not extend to shore. Generally macrophytes are at low density.



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
9a	1.0 - 2.0	finer	<i>Elodea canadensis</i> (45) <i>Myriophyllum spicatum</i> (45) <i>Potamogeton praelongus</i> (<1)	90	50	West end of Monck Park. Scattered boulders noted. Algae present at time of survey. Macrophyte cover is very dense with EWM dominant towards shoreline and <i>E. canadensis</i> dominant in deeper water. See Appendix B: photo 8.
10a	1.5	cobbles, stones	<i>Ceratophyllum demersum</i> (T) <i>Elodea canadensis</i> (2) <i>Myriophyllum sibiricum</i> (15) <i>Myriophyllum spicatum</i> (15) <i>Najas flexilis</i> (T) <i>Potamogeton praelongus</i> (2) <i>Stuckenia vaginata</i> (T)	34	44	Monck Park boat launch. Boulders noted just north of launch. Generally moderate density of macrophytes. EWM is scattered in this area but becomes more prevalent immediately north towards sample site 10b. See Appendix B: photo 9.
10b	1.5	cobbles	<i>Elodea canadensis</i> (2) <i>Myriophyllum spicatum</i> (30) <i>Potamogeton praelongus</i> (10) <i>Stuckenia vaginata</i> (1)	42	71	<i>E. canadensis</i> more prevalent in deeper water.
11a	1.0 - 2.0	cobbles	<i>Elodea canadensis</i> (2) <i>Myriophyllum spicatum</i> (60) <i>Potamogeton praelongus</i> (10)	72	83	Small patch of macrophytes along bulrush shoreline.
12a	1.5	cobbles	<i>Elodea canadensis</i> (2) <i>Myriophyllum spicatum</i> (40) <i>Potamogeton praelongus</i> (T) <i>Stuckenia pectinata</i> (T)	42	95	Along margin of marshy shoreline dominated by bulrush. Macrophyte density varies greatly in this area; however, EWM is generally dominant and is scattered along the shoreline from the Monck Park boat launch to this location.
13a	2	finer	<i>Elodea canadensis</i> (20) <i>Myriophyllum sibiricum</i> (15) <i>Myriophyllum spicatum</i> (30) <i>Potamogeton richardsonii</i> (5) <i>Stuckenia pectinata</i> (2)	72	42	Scattered boulders noted. Macrophyte density is highly variable in this area; EWM is common and occasionally dominant. Macrophytes are mostly located along the margin of the bulrush dominated marshy shore. EWM was noted amongst emergent vegetation.



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
13b	2	fines, scattered cobbles	<i>Ceratophyllum demersum</i> (10) <i>Elodea canadensis</i> (20) <i>Myriophyllum spicatum</i> (20) <i>Najas flexilis</i> (1) <i>Potamogeton richardsonii</i> (5) <i>Stuckenia pectinata</i> (1)	57	36	Narrow strip along margin of bulrush dominated marshy shore. See Appendix B: photo 10.
14a	2.0-3.0	fines	<i>Myriophyllum spicatum</i> (25) <i>Potamogeton richardsonii</i> (10) <i>Stuckenia pectinata</i> (2)	37	68	Narrow strip along margin of bulrush dominated marshy shoreline.
15a	2.5-3.0	unknown	<i>Myriophyllum spicatum</i> (40)	40	100	Exclusively EWM on narrow band along shallow shelf off shore, 1 to 5 m in width.
16a	2	sands, cobbles	<i>Myriophyllum spicatum</i> (60) <i>Potamogeton richardsonii</i> (5) <i>Stuckenia pectinata</i> (5)	70	86	EWM dominant in an approximately 2 to 4 m wide strip approximately 15 m off shore. EWM noted within emergent vegetation along shoreline.
16b	1.5	cobbles	<i>Myriophyllum spicatum</i> (20) <i>Potamogeton richardsonii</i> (20)	40	50	Small bed at boat launch, ~ 20m ² . EWM very common amongst macrophyte beds in this area. <i>E. Canadensis</i> occurs as pure colonies off shore with mixed species near shore.
17a	1.5 - 2	sand	<i>Elodea canadensis</i> (40) <i>Myriophyllum spicatum</i> (40)	80	50	1 - 2 m wide strip along shallow shelf approximately 2 to 3 m from shore. EWM dominant near shore, and <i>E. canadensis</i> dominant offshore. Nice sandy beach at this location. See Appendix B: photo 11.
18a	2.0 - 3.0	fines, sand	<i>Elodea canadensis</i> (40) <i>Myriophyllum spicatum</i> (40)	80	50	Large boulders noted. Macrophytes constrained to shallow bench 3 to 8 m from shore, 1 -2 m wide



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
19a	1.8	coarse sand	<i>Elodea canadensis</i> (50) <i>Myriophyllum spicatum</i> (25) <i>Potamogeton praelongus</i> (10) <i>Stuckenia pectinata</i> (T)	85	29	Snorkel survey conducted. Algae coating macrophytes. EWM noted as dominant component of much of this macrophyte bed, particularly in the southern portion. Shore is a gently sloping sandy beach. See Appendix B: photo 12.
20a	2.0	gravel, fines	<i>Elodea canadensis</i> (15) <i>Myriophyllum spicatum</i> (15) <i>Potamogeton praelongus</i> (5) <i>Stuckenia pectinata</i> (T)	35	43	Macrophytes constrained to shallow shelf approximately 5m from shore.
21a	2.0	fines	<i>Elodea canadensis</i> (10) <i>Myriophyllum spicatum</i> (30) <i>Najas flexilis</i> (T) <i>Potamogeton praelongus</i> (5) <i>Stuckenia pectinata</i> (2)	47	64	Macrophytes constrained to shallow shelf approximately 5m from shore, more prolific in the bay.
21b	1.5-2.5	cobbles	<i>Myriophyllum spicatum</i> (15) <i>Potamogeton praelongus</i> (25) <i>Stuckenia pectinata</i> (5)	45	33	Mactophytes constrained to a narrow strip on a shallow shelf just off shore.
22a	1 - 2.5	sand, cobbles	<i>Elodea canadensis</i> (SD) <i>Myriophyllum spicatum</i> (D) <i>Potamogeton praelongus</i> (SD) <i>Stuckenia pectinata</i> (SD)	70	D	Moderate density of EWM along shelf and between wharfs.
23a	1.5	small cobble	<i>Elodea canadensis</i> (2) <i>Myriophyllum spicatum</i> (40) <i>Potamogeton praelongus</i> (10) <i>Stuckenia pectinata</i> (1)	53	75	Pure low density <i>P. praelongus</i> at south end of bed transitioning to a mix with EWM, this location representative of highest EWM percentage.
23b	3.2	large cobbles	<i>Potamogeton praelongus</i> (15)	15	0	Low density scattered <i>P. praelongus</i> , macrophytes are loosely scattered throughout this area.



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
24a	2.7	unknown	<i>Myriophyllum spicatum</i> (2) <i>Potamogeton praelongus</i> (20)	22	9	Loosely scattered macrophytes in this area. See Appendix B: photo 14.
24b	1	fines	<i>Elodea canadensis</i> (1) <i>Myriophyllum spicatum</i> (20) <i>Potamogeton praelongus</i> (2) <i>Potamogeton richardsonii</i> (3)	26	77	Location is amongst low density of scattered bulrush.
25a	1.5	sand	<i>Myriophyllum spicatum</i> (D) <i>Najas flexilis</i> (SD) <i>Stuckenia pectinata</i> (SD)	variable	D	Macrophytes highly variable in this area, scattered patches present along the alluvial fan of Moore Creek. Shore has very low relief with pure sandy substrate. EWM noted to be dominant along narrow band at edge of shelf approximately 30 m from shore.
25b	2	sand	<i>Elodea canadensis</i> (5) <i>Myriophyllum spicatum</i> (30) <i>Potamogeton praelongus</i> (10)	45	67	Isolated patch approximately 50 m ² near the mouth of Moore Creek. This is located on the alluvial fan created by the stream. Suspect that instability in the substrate limits macrophyte growth. Abundance of adult fish noted.
26a	2.5	gravels, sand	<i>Elodea canadensis</i> (5) <i>Myriophyllum spicatum</i> (10) <i>Najas flexilis</i> (2) <i>Potamogeton richardsonii</i> (5) <i>Stuckenia pectinata</i> (15)	37	27	Density of macrophytes are highly variable in the area. See Appendix B: photo 15.
27a	2.0	sand, fines	<i>Elodea canadensis</i> (25) <i>Myriophyllum spicatum</i> (15) <i>Potamogeton richardsonii</i> (10) <i>Stuckenia pectinata</i> (15)	65	23	<i>P. praelongus</i> dominant in deeper water. Lots of adult fish noted.
27b	2.0	sand, fines	<i>Myriophyllum spicatum</i> (T) <i>Potamogeton praelongus</i> (10) <i>Potamogeton richardsonii</i> (10)	20	T	Trace EWM noted near shore.



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
27c	2.0	fines	<i>Ceratophyllum demersum</i> (2) <i>Elodea canadensis</i> (5) <i>Myriophyllum sibiricum</i> (15) <i>Potamogeton praelongus</i> (15) <i>Potamogeton richardsonii</i> (5) <i>Potamogeton zosteriformis</i> (5) <i>Stuckenia pectinata</i> (10)	57	0	Snorkel survey. <i>Myriophyllum</i> suspected to be hybrid EWM x <i>M. sibiricum</i> : however phenotypic characteristic more closely resemble <i>M. sibiricum</i> . At margin of bulrush dominated marshy shore.
27d	2.5	fines	<i>Myriophyllum sibiricum</i> (15) <i>Najas flexilis</i> (2) <i>Potamogeton richardsonii</i> (5) <i>Ranunculus aquatilis</i> (T) <i>Stuckenia pectinata</i> (10)	24	0	Located just north of boat launch. <i>Myriophyllum</i> suspected to be hybrid EWM; however, phenotypic characteristic more closely resemble <i>M. sibiricum</i> . Large bed expanding from margin of bulrush dominated marshy shore. See Appendix B: photo 16. Note that macrophyte density is highly variable and areas off shore appeared to have considerably higher cover.
28a	1	fines	<i>Myriophyllum sibiricum</i> (15) <i>Najas flexilis</i> (5) <i>Potamogeton richardsonii</i> (15) <i>Stuckenia pectinata</i> (15) <i>Stuckenia vaginata</i> (T)	50	0	Macrophytes highly variable along narrow shelf off shore.
29a	2 - 3.5	fines	<i>Elodea canadensis</i> (50) <i>Myriophyllum spicatum</i> (50) <i>Potamogeton praelongus</i> (T)	100	50	Representative only of 1 to 3 m wide shelf slightly off shore. Macrophytes few and scattered to shore. Shoreline is highway fill.
30a	2 - 3.5	fines	<i>Elodea canadensis</i> (50) <i>Myriophyllum spicatum</i> (50) <i>Potamogeton praelongus</i> (T)	100	50	Representative only of 1 to 3 m wide shelf slightly off shore. Macrophytes few and scattered to shore and between this location and 30a. Shoreline is highway fill.



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Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
31a	2.5	fines	<i>Ceratophyllum demersum</i> (15) <i>Elodea canadensis</i> (25) <i>Myriophyllum sibiricum</i> (5) <i>Myriophyllum spicatum</i> (30) <i>Potamogeton richardsonii</i> (5) <i>Stuckenia pectinata</i> (5)	85	35	Snorkel survey. Dense macrophytes along shoreline between docs, constrained to shallow areas near shore. <i>E. canadensis</i> dominant in deeper water.
31b	2.5	fines	<i>Ceratophyllum demersum</i> (1) <i>Elodea canadensis</i> (25) <i>Myriophyllum sibiricum</i> (25) <i>Myriophyllum spicatum</i> (25) <i>Potamogeton richardsonii</i> (2) <i>Stuckenia pectinata</i> (1)	79	32	Snorkel survey. Dense macrophytes along shoreline between docks, constrained to shallow areas near shore. See Appendix B: photo 17.
31c	2	fines	<i>Ceratophyllum demersum</i> (1) <i>Elodea canadensis</i> (25) <i>Myriophyllum sibiricum</i> (25) <i>Myriophyllum spicatum</i> (25) <i>Potamogeton gramineus</i> (1) <i>Potamogeton richardsonii</i> (2) <i>Stuckenia pectinata</i> (1)	80	31	Snorkel survey. Dense macrophytes along shoreline between docks, constrained to shallow areas near shore. <i>E. canadensis</i> dominant in deeper water.
32a	2	sand, fines	<i>Myriophyllum spicatum</i> (5) <i>Potamogeton richardsonii</i> (2) <i>Stuckenia pectinata</i> (15)	22	23	Macrophytes constrained to 1 to 3 m wide band along the western shore of Nicola Bay Estates, generally 5-6 m off of the shore.
32b	1.0 - 3.0	sand	<i>Elodea canadensis</i> (25) <i>Myriophyllum spicatum</i> (25) <i>Potamogeton zosteriformis</i> (5) <i>Stuckenia pectinata</i> (30)	95	53	Dense macrophytes cover in a 2 m wide strip off shore, few and scattered to shore. Sample site higher than average EWM component than adjacent areas. See Appendix B: photo 18.



APPENDIX A

Data Summary and Map Legend

Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
32c	1.5 - 2.5	gravels, fines	<i>Myriophyllum spicatum</i> (30) <i>Potamogeton gramineus</i> (60) <i>Stuckenia pectinata</i> (1)	91	33	Approximate 2m wide strip of macrophytes off shore. See Appendix B: photo 19.
33a	2.5	gravel	<i>Myriophyllum spicatum</i> (T) <i>Potamogeton richardsonii</i> (T) <i>Stuckenia pectinata</i> (60)	60	T	Large, off-shore bed. Mapped the circumference. Does not extend to shore.
34a	1.0 - 3.0	gravels, fines	<i>Myriophyllum spicatum</i> (15) <i>Potamogeton richardsonii</i> (1)	16	94	Scattered, low density macrophyte cover dominated by EWM in this area. Transitioning to dense <i>S. pectinata</i> northwards to 34b.
34b	1.0 - 3.0	gravels, fines	<i>Elodea canadensis</i> (1) <i>Myriophyllum spicatum</i> (3) <i>Potamogeton gramineus</i> (5) <i>Potamogeton zosteriformis</i> (2) <i>Stuckenia pectinata</i> (60)	71	4	Dense <i>S. pectinata</i> observable on surface. See Appendix B: photo 20.
35a	2	gravel, fines	<i>Myriophyllum spicatum</i> (15) <i>Potamogeton richardsonii</i> (1)	16	94	Inconspicuous private launch at this location. High turbidity at time of survey.
35b	1.0 - 3.0	fines	<i>Myriophyllum spicatum</i> (10) <i>Potamogeton gramineus</i> (10) <i>Potamogeton richardsonii</i> (10)	30	33	Representative of northern portion of this bed to 35c.
35c	1.5 - 2	fines	<i>Elodea canadensis</i> (20) <i>Myriophyllum spicatum</i> (60) <i>Potamogeton richardsonii</i> (1) <i>Stuckenia pectinata</i> (5)	86	70	Macrophytes are somewhat low growing, few at surface.
36a	2	fines, cobbles	<i>Ceratophyllum demersum</i> (1) <i>Myriophyllum spicatum</i> (15) <i>Potamogeton praelongus</i> (15) <i>Stuckenia pectinata</i> (2)	33	45	EWM dominant near shore, <i>P. Praelongus</i> offshore. Bulrush dominated marshy shore.



APPENDIX A

Data Summary and Map Legend

Site	Depth	Substrate	Species (% Cover)*	Total Cover (%)	% EWM of Total Cover*	Comments
36b	2	fines	<i>Ceratophyllum demersum</i> (2) <i>Elodea canadensis</i> (30) <i>Myriophyllum spicatum</i> (25) <i>Potamogeton praelongus</i> (10) <i>Potamogeton richardsonii</i> (15) <i>Stuckenia pectinata</i> (5)	57	29	Snorkel survey. Wetland area to southeast of this location, at corner of bay.
37a	1.4	sand	<i>Ceratophyllum demersum</i> (2) <i>Elodea canadensis</i> (30) <i>Myriophyllum spicatum</i> (25) <i>Potamogeton praelongus</i> (10) <i>Potamogeton richardsonii</i> (15) <i>Stuckenia pectinata</i> (5)	9	44	Macrophytes scattered at very low density with occasional dense clump and large expanses of bare sand. Narrow strip (approximately 2 m wide, represented by 37b) of dense macrophyte cover dominated by EWM extends off of point to the north well into the lake along the delineated boundary. This sample site represents conditions inside of the strip.
37b	1.5	sand	<i>Myriophyllum spicatum</i> (80) <i>Stuckenia pectinata</i> (15)	95	84	Narrow strip of dens cover along margin of shallow bench (alluvial fan of Quilchena Creek). Shallow bench towards shore has very little macrophyte growth (represented by 37a).
38a	2.0 - 3.0	sand	<i>Myriophyllum spicatum</i> (T) <i>Stuckenia pectinata</i> (60)	60	0	Scattered patches of pure <i>S. pectinata</i> on large sandy shelf (alluvial fan of Quilchena Creek). Suspect substrate is unstable and limits establishment of macrophytes.

*D = Dominant (>49%), SD = Sub-dominant (21–49%), P = Present but Slight (5-20%), T = Trace (<5%)

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APPENDIX B

Photoplates



Photo 1: *Myriophyllum spicatum* (EWM) collected from sample site 1b at the Kamloops Sailing Association. Photo taken September 15, 2013.

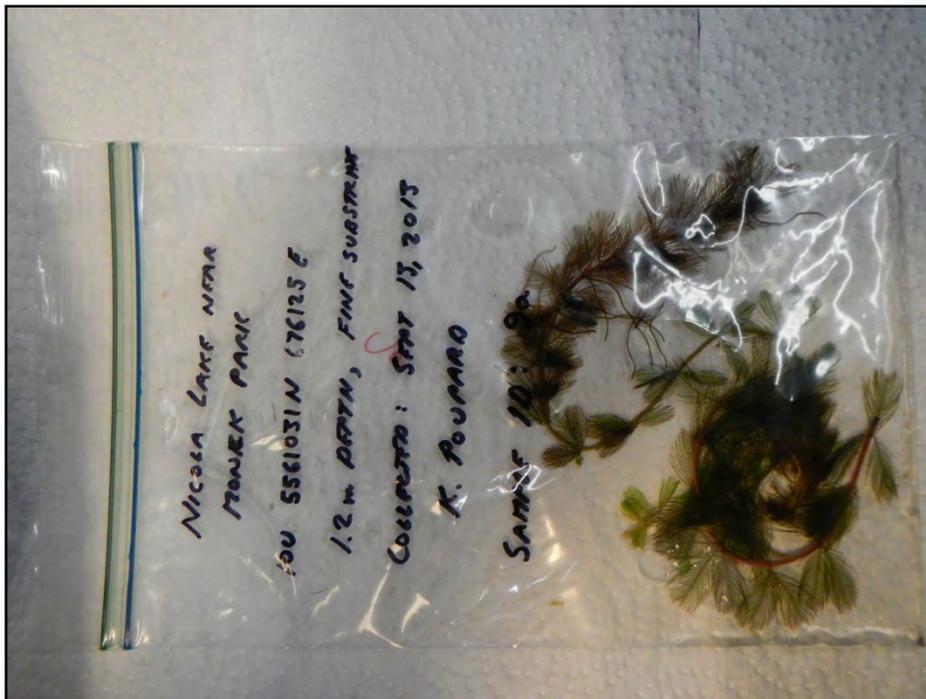


Photo 2: Showing an example of a EWM sample shipped for independent verification by Dr. Ken Marr at the Royal BC Museum in Victoria, BC.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014	SCALE: None	REV. 0
DRAWN KP	Oct. 3 2013	PLATE 1
CHECK BC	Oct. 3 2013	
REVIEW BC	Oct. 3 2013	



Photo 3: *Stuckenia pectinata* on water surface at sample site 1a, facing Kamloops Sailing Association. Photo taken September 13, 2013.



Photo 4: Spanning macrophyte bed dominated by EWM at sample site 5d, facing south. Photo taken September 12, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 2	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 5: Showing typical conditions along the southern shoreline at the west end of the lake, at sample site 6f. Photo taken September 12, 2013.

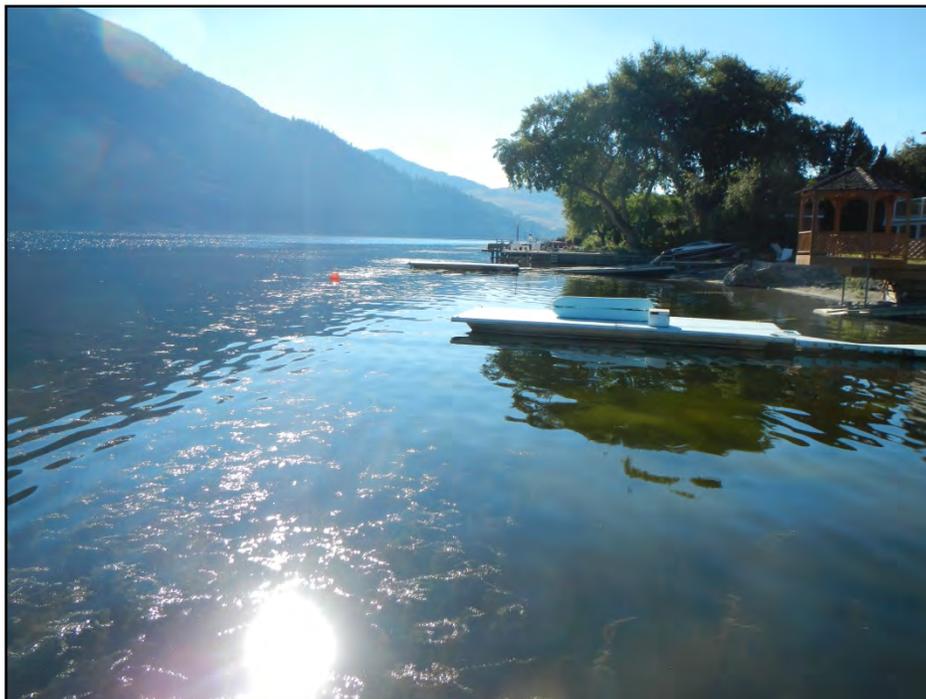


Photo 6: Macrophyte growth along residence at sample site 7b. Photo taken September 12, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 3	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 7: Snorkel survey at sample site 7b showing condition of macrophytes. Note most of what is visible in this photo is EWM, the leaves are obscured by algae growth. Photo taken September 12, 2013.

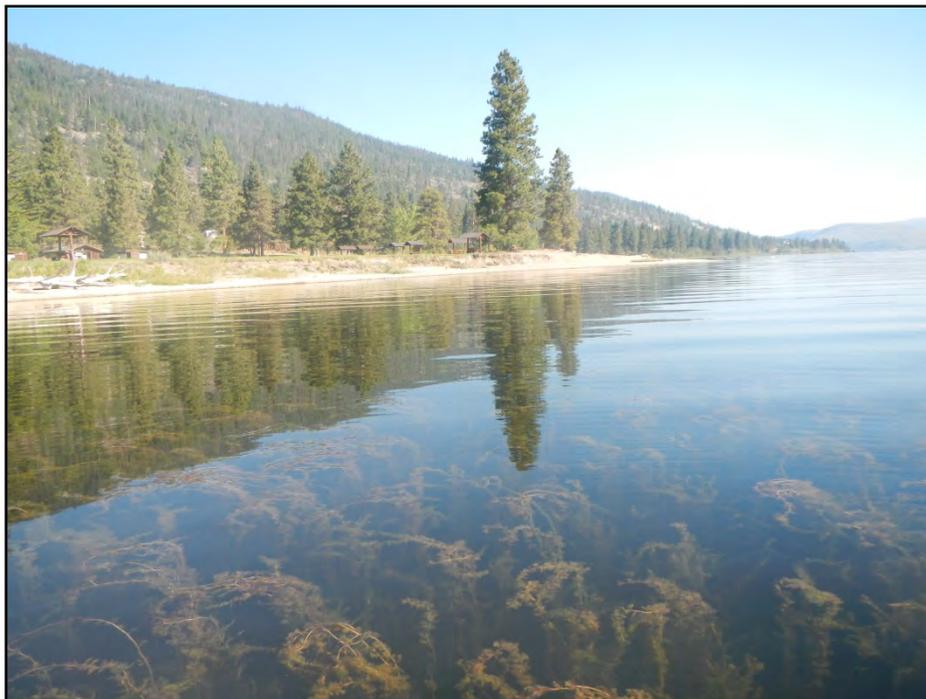


Photo 8: Macrophyte growth just off of the south end of Monck Park at sample site 9a. Photo taken September 13, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 4	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 9: Moderate density of macrophytes at the Monck Park boat launch at sample site 10a. Photo taken September 13, 2013.



Photo 10: Macrophyte growth along marshy shoreline and private docks just north of Monck Park at sample site 13b; facing north. Photo taken September 13, 2013.

File Location: N:\Common\Templates\Powerpoint\Photo_Template.ppt

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 5	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 11: Macrophytes dominated by EWM present in a narrow strip just off of shore at sample site 17a. Photo taken September 13, 2013.



Photo 12: Showing strip of macrophyte growth just off shore with sandy shoreline at sample site 19a; facing west. Photo taken September 13, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 6	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 13: Shoreline at sample site 20a. Macrophytes are constrained to shelf feature approximately 5m from shore. Photo taken September 13, 2013.



Photo 14: Showing loosely scattered *P. praelongus* at sample site 24a. EWM was noted between these plants. Photo is facing north. Photo taken September 13, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 7	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 15: Scattered macrophytes in the vicinity of sample site 26a at north end of lake. Photo taken September 14, 2013.

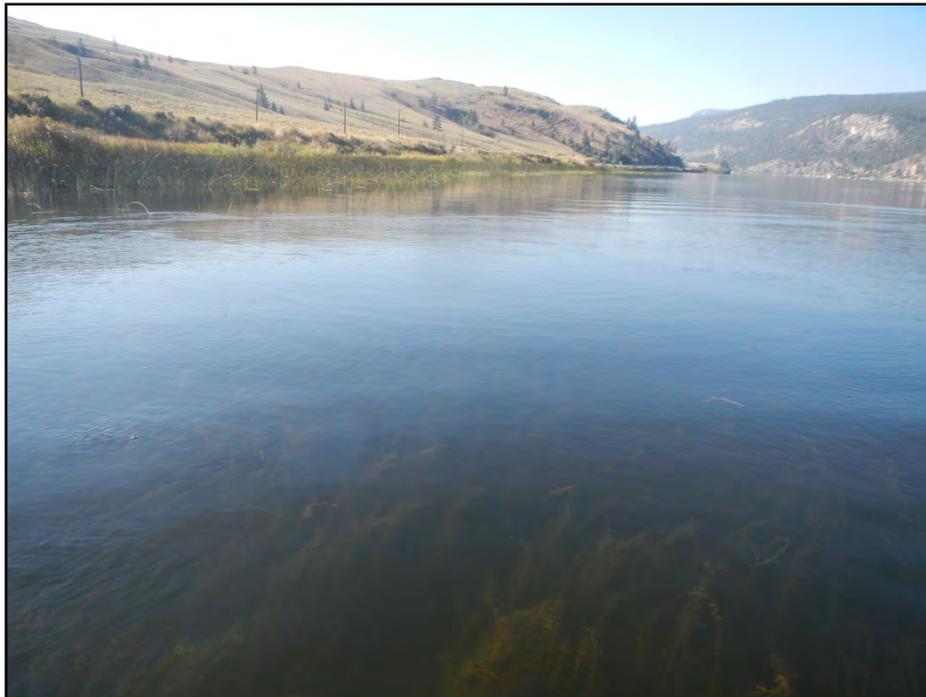


Photo 16: Showing expansive beds near sample sample site 27d. Photo is facing south. Photo taken September 14, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 8	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 17: Macrophytes among docs on the north side of Nicola Bay Estates at sample site 31b. Photo taken September 24, 2013.



Photo 18: Showing strip of macrophytes along western side of Nicola Bay Estates at sample site 32c. Also showing GPS used for mapping. Photo taken September 14, 2013.

File Location: N:\Common\Templates\Powerpoint\Photo_Template.ppt

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 9	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 19: Showing strip of macrophytes along western side of Nicola Bay Estates at sample site 32c. September 14, 2013.

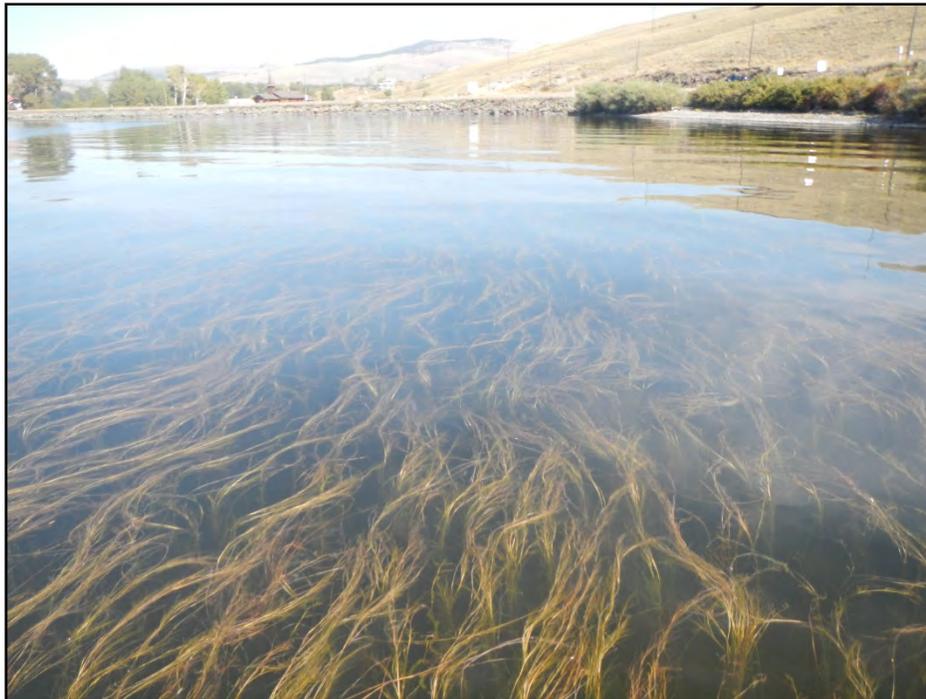


Photo 20: Showing dense cover of *S. pectinata* at sample site 34b. Photo taken September 14, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014			SCALE: None	REV. 0
DRAWN	KP	Oct. 3 2013	PLATE 10	
CHECK	BC	Oct. 3 2013		
REVIEW	BC	Oct. 3 2013		



Photo 21: Showing *C. demersum* collected from Nicola Lake, September 15, 2013.



Photo 22: Showing *E. canadensis* collected from Nicola Lake, September 14, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014	SCALE: None	REV. 0
DRAWN KP	Oct. 3 2013	PLATE 11
CHECK BC	Oct. 3 2013	
REVIEW BC	Oct. 3 2013	



Photo 23: Showing *P. richardsonii* collected from Nicola Lake, September 15, 2013.

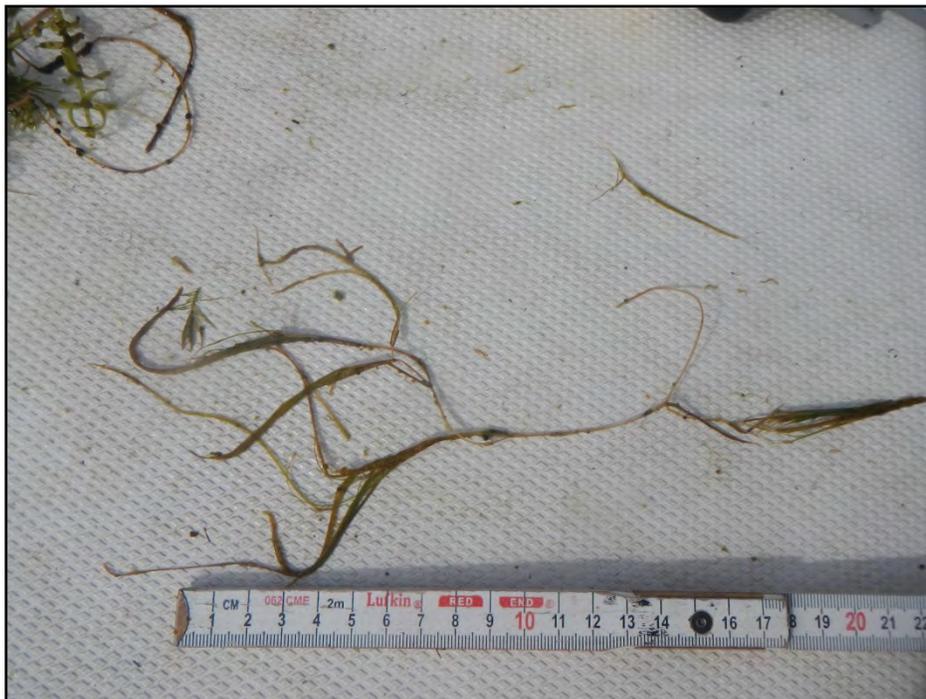


Photo 24: Showing *S. pectinata* collected from Nicola Lake, September 15, 2013.

SELECTED SITE PHOTOGRAPHS



PROJECT No. 13-1492-0014	SCALE: None	REV. 0
DRAWN KP	Oct. 3 2013	PLATE 12
CHECK BC	Oct. 3 2013	
REVIEW BC	Oct. 3 2013	

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