Narrows Inlet Hydro Project

Ramona Creek Component

Aquatic Breeding Salamander Baseline and Effects Assessment

Prepared for:

Narrows Inlet Hydro Holding Corp.
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EXECUTIVE SUMMARY

The Narrows Inlet Hydro Project (the Project) is a hydroelectric development located within shíshálh Nation territory at the northern end of Narrows Inlet in the Tzoonie River and Ramona Creek valleys, approximately 50 km north of the town of Sechelt, British Columbia. The Project will be developed by Narrows Inlet Hydro Holding Corp. (NIHHC) and will consist of three hydroelectric generating stations or "Components", Chickwat, Upper Ramona, and Lower Ramona, that will have the combined capacity to generate 33 MW of power. The Upper Ramona Component, the subject area of this report, is a 7 MW design that uses Ramona Lake as a storage lake. Ramona Lake is located at the headwaters of Ramona Creek. During the original Environmental Assessment (EA), Long-toed Salamanders (*Ambystoma macrodactylum*) were found to breed in Ramona Lake and proposed use of Ramona Lake as a storage lake by the Project indicates that Project development and operations may have adverse effects on this amphibian species, which represent the Aquatic Breeding Salamander key indicator of the Amphibians & Reptiles Valued Component (VC) identified in the original EA. Further, design modifications have been proposed to the intake design and operational regime for Ramona Lake that may change conclusions for the original EA.

This report has two objectives. The first is to conduct additional baseline inventory studies for the Aquatic Breeding Salamanders VC assessed during the original EA. This is a requirement specified by Condition #2 of Schedule B (Table of Conditions (TOC) of the Project's Environmental Assessment Certificate (EAC) in order to fill important data gaps. The second objective is to re-evaluate potential adverse Project effects in light of results from additional inventory surveys and in consideration of the recently proposed changes in intake design and operational regime.

Baseline Inventory

Baseline inventory surveys involved evaluation and mapping of aquatic and terrestrial Long-toed Salamander habitat and reconnaissance and systematic targeted inventory surveys for egg masses, larvae, and adults in the Ramona Lake basin, which includes Ramona Lake, two small lakes upstream of Ramona Lake (Ramona 1 and Ramona 2), and several small pools adjacent to these lakes. All habitat mapping and inventory surveys were conducted in 2015.

Habitat mapping was conducted for aquatic and terrestrial salamander habitat by Qualified Professionals (QPs) through a combination of desktop mapping and field verification. Habitat quality evaluation was based on habitat suitability models, professional experience, literature reviews, and expert consultation. Habitat attributes and habitat types which were considered indicators of habitat quality were identified, mapped, and field verified. Dominant habitat types were categorized into broad categories that were correlated with important habitat features such as substrate and cover, and habitat polygons were delineated that identified areas with high, moderate, low, and nil quality habitats.

Aquatic habitat mapping indicated that Ramona Lake contained most (70%) of the total aquatic habitat area and the majority (96%) of the high quality habitat in the Ramona Lake basin. Approximately half of the total aquatic habitat in the Ramona basin and within Ramona Lake was classified as low quality habitat. The small pools contained only nil quality habitat. High quality aquatic habitat was associated with small bays and small talus dominant habitat types and with shallow water depth and abundant CWD. Low quality habitats were typically found in large scale balds and large talus dominant habitat types, and in large bays with cold inflows. Habitat quality was also affected by microhabitat characteristics such as cracks in smaller-scale balds, and the presence of cobbles, that could provide cover and egg-mass attachment sites. High quality terrestrial breeding habitat was associated with forested and parkland habitat types and tree and shrub structural stages, given that treed and other vegetated habitats retain more moisture, provide more cover, and have more moderated climates than exposed rocky habitats. High quality terrestrial breeding habitat was distributed throughout the Ramona Lake basin and represented about a quarter of the habitat classified.

Reconnaissance inventory surveys were conducted during three field visits (May 28, June 9-11, and July 23) and systematic surveys were conducted on the June and July field visits. Results from reconnaissance and systematic inventory surveys indicated that Long-toed Salamanders are the only species of salamander that breed in the Ramona Lake basin, and consistent with habitat mapping results, inventory surveys indicated that Ramona Lake is the primary breeding pond for the population. Breeding was also observed in Ramona 1 and Ramona 2, but no evidence of breeding was found in the small pools consistent with their nil quality habitat classification. Breeding began on the southwest side of the Ramona Lake, likely owing to habitat conditions in nearby overwintering areas.

Systematic breeding surveys were conducted by surveying 21 transects distributed around Ramona Lake to estimate the relative abundance and distribution of salamanders. One transect was established in each Ramona 1 and 2 to evaluate their use for breeding. Transects were 50 m long, ran parallel to the shoreline, were placed at equal intervals following a random start point, and sampled both terrestrial (5 m from shore) and aquatic (to 2 m water depth) breeding habitat. Long-toed Salamanders were detected at all 23 transects. Egg-masses were detected only in June and were detected at five of the 23 transects, and larvae were detected in all except one transect in both June and July. Newly hatched larvae were detected during the July survey, indicating that late laid eggs had likely hatched around July 10. This information, along with results from reconnaissance surveys, indicated that the estimated egg-laying period in Ramona Lake was between May 25 and June 15 and that the egg residency period was therefore estimated to occur in Ramona Lake in 2015 from approximately May 25 to July 10.

In Ramona Lake, egg-masses were detected at depths of 4-160 cm (average 61.1 cm), resided in water temperatures of 12-17ºC (average 15.1ºC), were most often laid on fine coarse woody debris (79.4%), and commonly detected in small bays (52.9%) and on balds (35.3%). Larvae were typically detected at depths of 2-96 cm, temperatures of 9-19.5ºC, and were most often detected under, between, or on cobble sized rocks in small bays, on balds, and among large and small talus. In the upper lakes, larvae were detected on the sediment bottom or on or under rocks in warm coves in the larger bays. Adults were detected along the shoreline under rocks and swimming in the water column at depths up to approximately one meter, with surface water temperatures recorded as 14-17ºC.

Search effort was evaluated relative to total available shoreline. Search effort was high and well distributed among habitat quality ranks and dominant habitat types (10% to 17% of habitat quality ranks surveyed, 15-24% of the most common habitat types surveyed) and conclusions are considered representative of the available habitat in Ramona Lake.

Densities of detected individuals (egg-masses, larvae, and adults) were calculated for each habitat quality rank to estimate relative abundance. Although some biases in density estimates, both over and under estimates, were identified these would not differ among habitat quality ranks or time periods and therefore provide useful indicators of relative abundance for comparative purposes. Average density of salamander egg-masses, larvae, and adults, estimated from results of systematic surveys in June, were 0.02, 0.19, and 0.02 detections per meter, respectively, for all habitat qualities combined. The density of egg-masses was twice as high in high quality aquatic habitat as in moderate and low quality habitats, and egg masses were not observed in nil quality habitat. However, egg-masses were more common in moderate and low quality habitats because these habitat ranks were more abundant. Adult density was also twice that in high quality aquatic habitat as in the other habitat quality ranks in June but not in July, after egg laying, when only two transects were surveyed. Larvae density was less closely associated with habitat quality ranks than egg-masses and adults because habitat quality was categorized specifically for breeding attributes. Results of egg mass density in relation to pre-assigned habitat quality rank provided verification that the habitat quality classification was generally associated with habitat selection by salamanders for egg laying.

Effects Assessment

The objective of the effects assessment was to re-evaluate the potential adverse effects of Project construction and operations on Aquatic Breeding Salamanders. An updated EA was conducted because: 1) Condition #2 of the TOC requires that additional inventory studies are conducted and that Project effects are evaluated in light of the results of these studies; and 2) modifications to Project design was proposed that had the potential to affect the conclusions of the original EA. Condition #2 of the TOC requires that aquatic habitat availability and loss, as well as risk of egg mass stranding, is evaluated, that population-level impacts from Project operations are assessed, and that a compensation plan be developed and implemented. Proposed design modifications include changing the intake from a floating to a lake tap design (26 m below the water surface) and modifying the operational regime. The changed operational regime affects seasonal water level patterns such that maximum drawdown is decreased from 45 to 23 m (although there is little change in average drawdown) and no flooding of riparian/terrestrial habitat, as the 3 m dam at the lake outlet is no longer required.

Three potential Project effects on Aquatic Breeding Salamanders were identified: (1) habitat loss and change, (2) change in behaviour, and (3) increased mortality. Identification and evaluation of these effects followed the approach of the original EA with two exceptions: habitat loss and habitat change were combined into a single effect, and change in behaviour was assessed as a potential adverse effect.

Habitat loss and change was assessed for Project construction and operations and for aquatic and terrestrial breeding habitat. Aquatic habitat loss and change is anticipated during construction due to water quality reduction (sedimentation and water chemistry effects) caused by the breakthrough blast that will occur when the lake bed is pierced to allow water to enter the water conveyance tunnel. Aquatic habitat loss and change was not identified for the original design during construction. However, construction of the floating intake would have likely resulted in some effect. Habitat loss and change is also anticipated for operations due to flooding of egg-laying habitat by at least 5 m of water throughout the egg laying period, shrinkage of habitat for larvae with lake drawdown due to lake topography (loss of 52% of aquatic habitat available in the Ramona Lake basin at a 23 m drawdown), reduced habitat quality for larvae within the lake drawdown zone due to scouring and loss of microhabitat features, and water quality reduction due to scouring and erosion of the lake sides during water level fluctuations. The effect was expected to be similar between the original and the new design because the general pattern of water level fluctuation is similar, although in some cases a less severe effect would be expected with the new design because no riparian habitat will be flooded and because the magnitude of water level fluctuations would have been greater with the original design.

Terrestrial breeding habitat loss and change is not anticipated during construction for the new design provided that the Alimak building footprint is located further than 5 m from the lake shore. Terrestrial breeding habitat loss and change is anticipated during operations due to shrinkage of habitat for larvae with lake drawdown due to lake topography (loss of 20% of that available in the Ramona Lake basin at 12 m drawdown) and reduced habitat quality for adults within the lake drawdown zone due to scouring and loss of microhabitat features. Similar to aquatic habitat loss and change, the effect would be expected to be similar between the original and the new design because the general pattern of water level fluctuation is similar, although in some cases a less severe effect would be expected with the new design because no riparian habitat will be flooded with the new design and because the magnitude of water level fluctuation was expected to be greater with the original design.

In spite of prescribed mitigation, which include development and implementation of a Care of Water Plan, as part of the Construction Environmental Management Plan (CEMP), restrictions on blasting methods, installation of a silt curtain surrounding the approximate location of the breakthrough plume during intake construction, and locating the entire Alimak building footprint greater than 5 m from the lake shore, non-significant residual effects are anticipated for habitat loss and change during Project construction due to effects of sedimentation and potential contamination from the breakthrough blast. Residual effects are characterized to be low in magnitude, within the

Ramona Lake basin, short-term in duration, acting once, reversible, and acting in an undisturbed ecological context. These differ from those of the original EA because construction with the original design was not anticipated to affect water quality. Residual effects are also anticipated during operations, given that effects associated with water level fluctuations cannot be mitigated. Characterization of residual effects has changed relative to the original EA such that magnitude is increased from moderate to high and the residual effect is now considered significant. This evaluation is based on the proportion of total egg-laying habitat loss anticipated for the Ramona Lake basin due to flooding in Ramona Lake during the egg laying period and the likely consequence of such effects to the population. Residual effects of habitat loss and change during operations were therefore characterized to be significant, high in magnitude, within the Ramona Lake basin, long-term in duration, on a regular basis, reversible, and acting in an undisturbed ecological context. This evaluation of significance was made with moderate likelihood and confidence. In the original EA, residual effects were evaluated to be non-significant and moderate in magnitude because the habitat in the Ramona Lake basin had not been evaluated and quantified through habitat mapping and systematic surveys.

Change in behaviour was not identified as an adverse effect in the original EA, thus residual effects were not evaluated for either construction or operations although the effects identified would have equally applied to the original design. The potential for change in behaviour due to disturbance was anticipated during construction owing to construction of the Alimak building; however, given mitigation that the entire Alimak building footprint is located greater than 5 m from the lake shore, no residual effects are anticipated. The potential for change in behaviour was anticipated during operations due to constantly shifting water levels that would force adults and larvae out of established home ranges, potentially affecting survival rates and reproductive success, and concentrating individuals into smaller areas, potentially resulting in competition for resources. These effects cannot be mitigated because water level changes are unavoidable impacts of drawdown. Non-significant residual effects were characterized to be moderate in magnitude, within the Ramona Lake basin, long-term in duration, on a regular basis, reversible, and acting in an undisturbed ecological context.

Increased mortality was assessed for Project construction due to vibrations associated with the breakthrough blast. In spite of mitigation, which included preferentially timing the breakthrough blast to periods outside of the egg residency period, unless otherwise approved by a QP, installing a silt curtain prior to the blast, and conducting salvage of salamander larvae within the curtain area prior to the blast, non-significant residual effects are anticipated. These are characterized to be low in magnitude, within the Ramona Lake basin, short-term in duration, acting once, reversible, and acting in an undisturbed ecological context Conclusions differed from those of the original EA because a breakthrough blast was not required with the original design. During operations, increased mortality effects were assessed due to inundation of eggs by at least 5 m of water, mortality of overwintering larvae due to water level drop during winter, and potential mortality of adults due to stranding and drowning in some locations. Among these, inundation of eggs was assessed to have by far the greatest impact on mortality risk given that Ramona Lake contains most (70%) of the total aquatic habitat area and the great majority (96%) of the high quality aquatic habitat in the Ramona Lake basin. For this reason, and because mortality risk associated with water level changes cannot be mitigated, significant and irreversible residual effects of high magnitude are anticipated for increased mortality during operations. This evaluation is based on the proportion of total egg loss anticipated for the Ramona Lake basin due to flooding in Ramona Lake and the likely consequence of such effects to the population. Residual effects of increased mortality during operations were therefore characterized to be significant, high in magnitude, within the Ramona Lake basin, long-term in duration, on a regular basis, irreversible, and acting in an undisturbed ecological context. This evaluation of significance was made with high likelihood and moderate confidence. These conclusions differ from the original EA where residual effects were considered non-significant, moderate in magnitude, and reversible because the value of Ramona Lake to the population had not been quantified through habitat mapping and systematic surveys.

Population-level effects of Project operations were evaluated in light of residual effects identified in the updated EA and in accordance with requirements of Condition #2 of the TOC. Based on the magnitude of predicted egg-mass mortality, the inability to mitigate Project effects, and the current size and isolation of the population of Long-toed Salamanders in the Ramona Lake basin, the population is not expected to persist after the Project becomes operational. This prediction is only for the Ramona Lake basin population, and populations in broader spatial context will not be put at risk by Project development; however, the contribution of genetic diversity by the isolated Ramona Lake population is unknown.

Following completion of baseline inventory studies and the effects assessment, the status of the requirements specified in Condition #2 of the TOC were evaluated. Of the five parts in Condition #2, requirements specified in the first four (2a through 2d) have now been met. These require the determination of habitat quality and quantity for Aquatic Breeding Salamanders, assessing the risk of egg mortality, evaluation of population-level impacts, and submitting a report to the Ministry of Forests, Lands and Natural Resource Operations (FLNR) to document these effects. The fifth part, which requires that a compensation plan is developed and implemented, is outstanding and will be completed in collaboration with the FLNR.

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1. INTRODUCTION

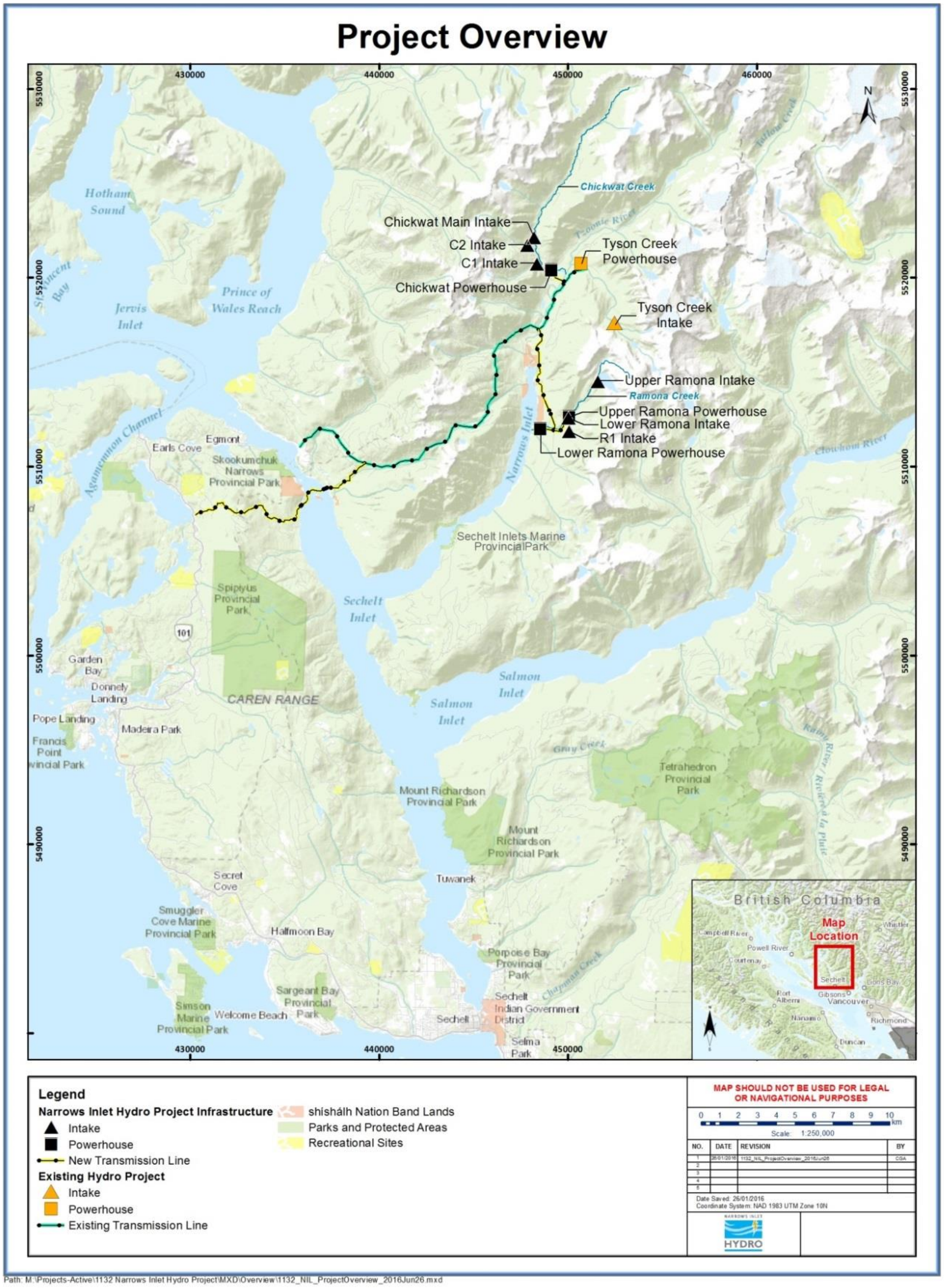
The Narrows Inlet Hydro Project (the Project) is a hydroelectric development located within the shíshálh Nation territory at the northern end of Narrows Inlet in the Tzoonie River and Ramona Creek valleys, approximately 50 km north of the town of Sechelt, British Columbia (BC) (Map 1). The Project will be developed by Narrows Inlet Hydro Holding Corp. (NIHHC) and will consist of three hydroelectric generating stations or "Components", Chickwat, Upper Ramona, and Lower Ramona, that will have the combined capacity to generate 33 MW of electricity (EAO 2014a). The Project was granted an Environmental Assessment Certificate (EAC) (E13-04) in 2014 (EAO 2014a, b).

The Upper Ramona Component, the subject area of this report, is a 7 MW hydroelectric facility that uses Ramona Lake as storage. Ramona Lake is located at the headwaters of Ramona Creek and drains an area of 5.5 km^2 (Map 2). Ramona Lake drains into Ramona Creek for a length of 5.1 km before discharging into Narrows Inlet, roughly 6 km upstream of the Sechelt Inlets Marine Provincial Park (Robertson 2012a) (Map 1, Map 2). This component of the Project is comprised of an intake located in Ramona Lake, a water conveyance system that will divert water from the intake to the powerhouse, located above the main intake of the Lower Ramona Component, approximately 2.5 km upstream of the confluence of Ramona Creek with Narrows Inlet. The electricity generated will be transmitted to the collector 138 kV substation at the head of Narrows Inlet via a new 8 km single pole 25 kV transmission line.

Condition #2 of Schedule B of the Project's EAC (also referred to as the Table of Conditions (TOC)) specifies that the Certificate Holder must obtain additional baseline data on aquatic breeding salamanders in Ramona Lake. Long-toed Salamanders (*Ambystoma macrodactylum*) were found to breed in Ramona Lake during original baseline inventory studies (Wind 2010, 2015 pers. comm.). The use of Ramona Lake as a storage for the Project has the potential to adversely affect the species during construction and operations. The EAC Condition also requires that the additional baseline studies and data be used to improve our understanding of Project effects on aquatic breeding salamanders, specifically potential habitat losses and the risk of egg mass stranding (EAO 2016).

In addition, since the issuance of the EAC, additional site investigations and technical reviews identified a number of design modifications to the Upper Ramona Component that provide opportunities to improve construction logistics, reduce construction risk and cost, and improve operating efficiency while aiming to reduce operational environmental effects. Proposed changes include: (1) modifications to the intake design from a floating intake to a lake tap; (2) changes to the water conveyance system from a buried and above ground penstock to a tunnel and buried penstock combination, and (3) adjustments to the operational regime by reducing the overall depth of drawdown to 23 m from 45 m and eliminating the requirement of flooding to increase storage capacity. Consequently, the potential adverse construction and operational effects must be re-evaluated in light of these design changes.

Map 1. Overview map showing the location of the three Components of the Narrows Inlet Hydro Project.



2. OBJECTIVES

Ecofish Research Ltd. (Ecofish) was retained by Narrows Inlet Hydro Holding Corp., as the Qualified Professional (QP), to develop and recommend a study design that will address the requirements of Condition #2 of Schedule B of the Project's EAC (EAO 2016) and provide baseline information from which to evaluate potential adverse effects of the Project on Aquatic Breeding Salamanders, that breed in Ramona Lake, during the period from egg-laying to hatching. Long-toed Salamanders are the only salamander species that is known to breed in Ramona Lake. Long-toed Salamander larvae and adults were detected in Ramona Lake during baseline studies conducted for the Tyson Creek Project in 2008 (Wind 2009) and for the Narrows Inlet Hydro Project in 2010 (Wind 2010). Egg mass surveys had not been conducted in these waterbodies, thus data on the relative abundance of egg masses, specific breeding locations, and potential breeding habitat did not previously exist.

Specifically, Condition #2 of Schedule B of the EAC stipulates:

Prior to starting construction on the Ramona Lake component, the Holder must:

(a) Determine the habitat for aquatic breeding salamanders using a QP;

(b) Evaluate the risk of egg mass stranding resulting from lake drawdown during the period from egg-laying to hatching for that area using a QP;

(c) Submit a report to FLNR documenting habitat quantity and quality for salamanders, and potential habitat loss resulting from lake drawdown and lake surcharge;

(d) Submit a report to FLNR documenting risk of egg mass mortality and related population-level impacts from project operations; and

(e) Develop and implement a compensation plan for the loss of high quality habitat for aquatic breeding salamanders, and for impact from egg mass mortality. The plan, including any proposed changes, must be prepared and implemented to the satisfaction of FLNR.

The first objective of this report is to present the baseline inventory study work conducted within the Ramona Lake basin to fulfil data gaps identified by the Province and thereby address the requirements of Condition #2a of Schedule B. The species and habitat surveys provide a baseline pre-construction database that includes an estimate of the distribution and relative abundance of Long-toed Salamander eggs, and other salamander age classes in Ramona Lake and the two upstream lakes and surrounding small pools (the Ramona Lake basin), and identifies the locations of valuable breeding habitat.

The second objective of this report is to re-evaluate potential Project adverse effects (habitat loss and mortality) in light of the additional data and thereby addressing the requirements of Condition #2b, c, and d of Schedule B. The study assesses potential effects of Project construction and operations, and will assist in developing appropriate mitigation measures or compensation, if required.

The last objective of this report is to evaluate the potential adverse effects from the proposed modifications to the Upper Ramona Component (see Section 5.2). As previously noted, a number of design modifications have been proposed for the Component. The proposed infrastructure and operational changes have the potential to affect Aquatic Breeding Salamanders and their habitat within and in the vicinity of Ramona Lake and thus may alter the conclusions of the original Application for an EAC.

3. BACKGROUND

3.1. Study Area

The respective aquatic breeding salamander baseline and effects assessment study area lies fully within the Ramona Lake watershed (Map 2) and includes Ramona Lake, two small lakes upstream of Ramona Lake, and several small pools adjacent to these lakes (Map 3). Ramona Lake is a 67 ha headwater subalpine lake with an elevation of 1,363 m that is approximately 1,500 m in length and a maximum of 750 m wide and 135 m deep. Ramona 1, the closest upstream lake, is approximately 400 m long and 75 m wide, and Ramona 2, the furthest upstream lake, is approximately 250 m long and 150 m wide. The upper two lakes are much shallower than Ramona Lake and have an estimated maximum depth of eight metres. The small pools in the study area are generally 5-13 m long, 2-6 m wide, and 30-60 cm deep. Ramona Lake is ice-covered for approximately six to eight months a year, from fall until freshet in late spring or early summer. During this period, ice extends to a depth of less than 6 m, overlying water that is 1–4°C. Ice-off occurs during May through July and the lake then becomes thermally-stratified throughout the summer. The thermocline progressively deepens throughout this stratified period to a maximum depth of approximately 10–15 m until mixing occurs in late October or November (West *et al.* 2016).

3.2. Species Information

3.2.1. Long-toed Salamanders

Long-toed Salamanders are in the mole salamander family and spend much of their lives in underground burrows. Above ground terrestrial habitats generally include moist (not saturated) areas in forests and meadows near water, where salamanders take cover under objects such as decaying logs, rocks, tree bark, and leaf litter (Graham *et al.* 1999, Matsuda *et al.* 2006, Mattfeldt and Grant 2007, Pagnucco *et al.* 2012). *Ambystoma* salamanders have demonstrated preferential use of forest habitats with high canopy cover, low ambient light, abundant wood-based cover and litter (DeMaynadier and Hunter 1998). Adults prey on a variety of invertebrates (Graham *et al.* 1999, Sheppard 1977). A variety of habitats may provide valuable breeding habitat for Long-toed Salamanders and other pond-breeding amphibians including small and isolated high-elevation lakes, such as those at Ramona Lake, small temporal pools, and slower backwaters of streams (Lannoo 2005, DeLisle and Grayston 2011). However, in Alberta, in more northern populations adults are not known to breed in ephemeral pools (Graham *et al.* 1999). Abundance and size of breeding pond can vary substantially. Breeding populations in the Rocky Mountain foothills in Alberta ranged from 1 breeding female in a 0.1 ha pond to 838 breeding females in a 5 ha pond (Graham *et al.* 1999).

Adult *Ambystoma* salamanders demonstrate high site fidelity to both terrestrial and aquatic breeding habitats (Anderson 1967, Orloff 2011, Pagnucco 2012). Terrestrial habitat includes breeding habitat, which is occupied during the summer and is close to the shore of the breeding pond, and overwintering habitat which is typically more distant from shore (Pilliod and Fronzuto 2005). Individuals are typically located closer than 250 meters to the breeding pond at all times, with juveniles often being detected further away than adults (Graham *et al.* 1999, Hawkes and Tuttle 2008). It has been recommended that habitat conservation areas extend 630 m from the breeding pond, although habitat use in relation to distance from the breeding pond may extend further and one study found the majority of salamanders to be 800 m, and up to 2.2 km, from the breeding pond (Orloff 2011, Amphibiaweb 2015). In contrast, a comprehensive survey at three high elevation lakes in Idaho found that 82% of adults were located within 5 m of water in August (Pilliod and Fronzuto 2005).

Long-toed Salamanders are the earliest breeding amphibians in British Columbia (BC), with eggs typically laid in early spring, often when ice remains on the breeding pond. The timing of migration to breeding ponds is related to temperature and moisture. Beneski *et al.* (1986) found that 95% of adults migrated to breeding ponds when minimum air temperatures were above 0ºC and 78% migrated on days with measurable precipitation. At high elevations where spring is delayed, breeding may occur as late as July (Howard and Wallace 1985, Matsuda *et al.* 2006). Males are the first to arrive at breeding sites. Females arrive soon after and some studies have found them to be at the breeding site for approximately three weeks (Amphibiaweb 2015) with individual females mating and depositing eggs over a six to seven day period (Amphibiaweb 2015). Long-toed Salamanders deposit brown and cream coloured eggs singly or in egg-masses of up to 60 eggs, with a total of up to 400 eggs laid by each female over the breeding period. Total egg numbers are dependent on latitude and elevation; at higher elevations and more northerly latitudes fewer eggs are often laid. Eggs are laid in shallow water (< 0.5 m), preferably on emergent vegetation or coarse wood, but also on silt-mud substrates or directly on rock along rocky shorelines (Howard and Wallace 1985, Graham *et al.* 1999, Matsuda *et al.* 2006, B.C. Frogwatch 2015). Eggs hatch in 5-35 days, with those from northern and high elevation populations taking a longer time to hatch (approximately 2-3 weeks). Salamander mean size at hatching is larger and larval growth is typically faster in high-elevation populations than in lower elevation populations. Larvae are carnivorous and prey on a variety of invertebrates. They grow fastest and are largest at metamorphosis in ponds with low densities, constant water levels, and an abundance of food (Semlitsch 1987). Aquatic larvae typically metamorphose to terrestrial juveniles late in the first summer when they have reached 7-7.5 cm; however, high elevation and northern populations may stay in an aquatic larval state for up to three years (Howard and Wallace 1985, Amphibiaweb 2015, Matsuda *et al.* 2006, BC Frogwatch Program 2015). Long-toed Salamanders typically reach sexual maturity at three years old when they have reached a size of 10-20 cm. *Ambystoma* larval size is largely correlated with adult body size, which in turn is positively correlated with numbers of eggs produced (Semlitsch 1987). They have an average lifespan of six years but have been reported surviving for up to 10 years of age (Russell *et al.* 1996).

3.2.2. High Elevation Salamander Populations

Ramona Lake is a subalpine lake with an elevation of 1,330 m that supports a relatively high elevation population of Long-toed Salamanders. It is expected that Ramona Lake and the surrounding ponds are the only breeding habitat for the respective high elevation Long-toed Salamander population, although, occasional immigration and emigration over alpine cirques to nearby alpine lakes (located a minimum of 2 km away) may be possible. Although Long-toed Salamanders are not classified as a species at risk in BC (Yellow-listed provincially and Not At Risk federally (CDC 2015)), population size and degree of isolation, which are associated with population viability and genetic diversity, may impart particular risk and value to small and isolated populations. Populations in high elevation lakes are typically relatively small (Howard and Wallace 1985, Funk *et al.* 1999) and less genetically diverse than those found in lower elevations because the latter are usually associated with topographic and aquatic features more favourable to dispersal (Giordano *et al.* 2007). High elevation small salamander populations are therefore more vulnerable to extirpation, as has been demonstrated by studies where fish have been introduced into alpine lakes (Graham 1997, Funk and Dunlap 1999, Pearson 2003).

The stability of water bodies has also been linked to population viability for northern and small, high elevation salamander populations (Semlitsch 1987, Graham *et al.* 1999). Populations that breed in ephemeral ponds, typical in lower elevation populations that tend to be larger, may have years of unsuccessful breeding when ponds dry up before larvae metamorphose (Buskirk and Smith 1991). The risk to population viability from such breeding failure is therefore less for larger populations than for small ones because larger populations may be able to withstand years of unsuccessful breeding (Buskirk and Smith 1991), whereas small ones may not be able to persist through periods of unfavourable breeding conditions.

4. BASELINE INVENTORY

Baseline inventory surveys involved evaluation and mapping of aquatic and terrestrial Long-tailed Salamander habitat and reconnaissance and systematic targeted inventory surveys for egg-masses, larvae, and adults in Ramona Lake basin, which includes Ramona Lake, two small lakes upstream of Ramona Lake (Ramona 1 and Ramona 2), and several small pools adjacent to these lakes (Map 3, Map 4).

4.1. Methods

4.1.1. Habitat Mapping

Long-toed Salamander aquatic and terrestrial breeding habitat in the Ramona Lake basin, including the two upper lakes (Ramona 1 and Ramona 2), was mapped through a combination of desk-top mapping and field verification. Following an initial reconnaissance field survey to provide general information, a habitat mapping scheme was developed that included identification of important habitat attributes and habitat types which were considered indicators of habitat quality. These habitat attributes and types were then used to delineate polygons of similar habitat quality. Habitat quality was first mapped in the office using orthophotographs and ArcGIS (vers. 10.). Habitat polygons and types were then verified in the field while conducting inventory surveys (Section 4.1.2). Field habitat mapping and verification was conducted using an iPad (with GISPro and GPSKit) in combination with drawing on paper maps to capture additional information. Habitats were described, key attributes recorded, and georeferenced photographs of mapped polygons were taken. Finally, results from inventory surveys (Section 4.2.2) were compiled and used to verify that measures of breeding were correlated with habitat mapping decisions.

The fine scale nature of salamander habitat selection limits the ability to evaluate habitat quality from broad scale habitat attributes. Thus, in order to accommodate the effect of scale on habitat quality, habitat data were collected and observations were made at three spatial scales: (1) polygon, (2) transect, and (3) detection. The broadest spatial scale was the polygon scale. Habitat polygons were delineated to represent areas of similar habitat quality. Habitat quality rank assignments were field verified during reconnaissance and systematic inventory surveys. Finer scale habitat mapping was also conducted during inventory surveys. Systematic surveys required establishing transects within the study area and recording detections along transects (Section 4.1.2.2). The transect scale therefore pertains to observations and data collected for each transect surveyed. The detection scale represents fine-scale habitat data collected whenever a salamander individual or egg-mass was encountered during both reconnaissance and systematic surveys and therefore represents microhabitat site characteristics. For example, adult salamanders were found to use moist cracks in otherwise dry and exposed bedrock balds located between upslope forested habitats and aquatic breeding habitats.

Aquatic and terrestrial breeding habitat was evaluated by Qualified Professionals with a good understanding of Long-toed Salamander breeding habitat. Existing Long-toed Salamander habitat suitability models (Graham *et al.* 1999) were additionally consulted as was literature on high elevation populations of Long-toed Salamanders and Ambystoma salamanders in general. Habitat mapping was conducted in consultation with our team of professional wildlife biologists and with amphibian expert Elke Wind. All data were verified for quality assurance. All raw habitat data recorded during reconnaissance and systematic surveys were archived for additional potential future use and are available upon request.

4.1.1.1. Aquatic Breeding Habitat

Aquatic habitat considered habitat used for egg-laying and for larval maturation. Habitat quality ranking was, however, focused on egg-laying habitat for three principal reasons. Firstly, habitat characteristics for egg-laying are more specific than those for larvae; secondly, egg masses are not mobile and thus are more representative specific site selection; an thirdly, Condition #2 of Schedule B of the EAC (Section 2) focused on Project effects to egg-masses.

Aquatic habitat was ranked as high, moderate, low, and nil quality based on a combination of desk-top mapping and field verification (described above in Section 4.1.1). A number of habitat characteristics were assessed to evaluate habitat quality based on habitat suitability models (Graham *et al*. 1999), professional experience, literature reviews, and expert consultation. A key habitat attribute defined was dominant habitat type. Eight dominant habitat type categories were identified that classified habitat by geographical and substrate features (Table 1). Dominant habitat type was correlated with important aquatic habitat characteristics such as substrate and cover. These habitat type categories were easily distinguishable and were visible from shore. Other habitat characteristics that were measured or categorized and considered for the evaluation of habitat quality included presence of emergent vegetation, the estimated water depth one meter from shore, the abundance and type of coarse woody debris (CWD), aspect, and proximity of inflows and outflows. Any other habitat features considered important for evaluating aquatic habitat quality were also recorded. Aquatic habitat mapping and verification was conducted from the shore and from a boat with a mask and snorkel. Photographs were taken of adjacent terrestrial habitats and of the lake bottom from underwater.

The mapped aquatic area extended as far as observers could see the bottom of Ramona Lake, and was later clipped to 0-1.75 m depth (the range of depths within which egg-masses were expected to occur). This depth band was considered the zone of egg occupancy although it extended to slightly deeper depths than expected based on data collected in Ramona Lake. This habitat band was defined to allow comparison between baseline habitat and that available during operational drawdown or surcharge.

The area of aquatic habitat available was calculated by creating a digital elevation model (DEM) clipped to 0-1.75 m elevation below the water surface (mapped at 1362.75 m). The 1 m resolution DEM was created with lake bathymetry (10 m contours) and detailed terrestrial contours (1 m contour derived from LiDAR data). The entirety of the aquatic habitat in the upper two lakes as well as small pools was included in habitat area calculations.

Table 1. Classification of aquatic dominant habitat types.

Habitat Type	Description
Bald	Bedrock surface generally rounded. Occupies various slopes and density and depth of cracks.
Small talus	Talus slopes with cobble to exercise ball sized fragments. Variable stability.
Large talus	Black bear to small car sized fragments. Moderately stable.
Small bay	Mouth of bay is up to 25 m wide. Small bays generally occur at the aquatic edge of moist draws or small creeks. Substrates are most often bedrock, although there are often accumulations of angular cobbles and CWD on the substrate.
Large bay	Mouth of bay over 25 m. Occur in deltas and smaller lakes. Generally low gradient slope and accumulation of fines.
Creek	Moving water with a slow to rapid velocity.
Inflow/Outflow	Area of noticeable influence from inflows or outflows that have a current. Inflows had cooler water than the
Small pool	Tarn, permanent small shallow pools of water approximately 30 cm deep with a sestin bottom and no coarse fragments or CWD.

4.1.1.2. Terrestrial Breeding Habitat

Long-toed Salamanders use terrestrial habitat not only for breeding, when they are found close to the lake shore, but also when overwintering or migrating to and from breeding ponds. Terrestrial habitat mapping therefore extended over most of the Ramona Lake basin. However, breeding habitat was the focus of terrestrial habitat mapping and was defined as the 5 m wide band of habitat adjacent to the lake shore where salamanders are typically located during the breeding season (Pilliod and Fronzuto 2005).

Similar to classification of aquatic breeding habitat (Section 4.1.1.1), terrestrial breeding habitat surrounding Ramona Lake and the upper lakes were ranked as high, moderate, low, and nil quality based on a combination of desk-top mapping and field verification. Habitat was also classified by dominant habitat type to broadly categorize habitats that were correlated with important habitat features such as substrate and cover (Table 2). Other habitat characteristics that were measured or categorized and considered for the evaluation of habitat quality included structural stage and aspect. Observations pertaining to landscape context, moist or wetted draws or cool influence, were noted and photographs were taken.

Table 2. Classification of terrestrial dominant habitat types.

Habitat Type	Description
Forested	Mountain hemlock, subalpine fir, yellow cedar forest with a thick understory of vacciniums and moss.
Parkland	Subalpine forest with less than 35% cover of trees.
Bald - Parkland	Bald with patches or variably distributed trees.
Bald - many cracks	Unvegetated bedrock with abundant cracks that could provide cover and movement corridors.
Bald - few cracks	Unvegetated bedrock with few cracks or suitable cover.
Bald - pocket meadow	Bald with patchy soil accumulations that support short shrubs and herbs.
Large talus	Talus slope with fragments the size of large bears to VW Beetles. Moderately stable. More stable areas support mature trees.
Small talus	Talus slopes with cobble to exercise ball sized fragments. Variable stability. More stable slopes may have accumulations of soil and patches of vegetation.

4.1.2. Salamander Reconnaissance and Systematic Surveys

Aquatic breeding salamander inventory surveys consisted of: (1) reconnaissance-level surveys of Ramona Lake, the two upstream small lakes (Ramona 1 and 2), and surrounding small pools; and (2) intensive systematic pond-breeding amphibian relative abundance surveys of Ramona Lake and two upstream small lakes. Systematic surveys provide repeatable and comparable data and are valuable for monitoring and comparative studies. However, incidental observations from reconnaissance surveys contribute to data collected with systematic survey by increasing the size of the dataset for habitat-detection associations.

Inventory surveys were conducted over three field visits during a single breeding season in 2015. The first visit was on May 28 (reconnaissance surveys only), the second between June 9 and 11 (reconnaissance surveys and a full set of systematic surveys), and the third on July 23 (reconnaissance surveys and a subset of systematic surveys). Surveys were timed to capture the beginning of the Long-toed Salamander breeding period (first visit), to conduct repeatable systematic surveys and reconnaissance surveys in the middle of the egg residency period (second visit), and to capture the end of the breeding period (third visit).

4.1.2.1. Reconnaissance Survey

Reconnaissance surveys were conducted in aquatic and riparian habitats. Surveys examined all types of habitats and included more intensive spot checks of habitats expected to be of high breeding value. Reconnaissance surveys were planned to allow determination of the timing of the breeding season. As such the first survey was intended to allow evaluation of the start of breeding and the second and third was intended to assess developmental stage of eggs and breeding completion. Unfortunately, the third survey was delayed due to forest fire access limitations (see Section 4.2.2.1).

The survey method provided the opportunity to survey a variety of habitat types and locations rapidly so that a larger area could be searched than what would be achievable through intensive systematic surveys. Reconnaissance surveys were also used to guide the timing of subsequent systematic surveys, and were conducted while travelling between systematic survey stations. Observations of egg-masses, larvae, and adults made during reconnaissance surveys were recorded as incidental observations.

4.1.2.2. Systematic Survey

Field Inventory Survey

Systematic pond-breeding amphibian relative abundance surveys followed provincial protocols (RIC 1998a). These surveys involved intensive systematic searches for egg-masses, larvae, and adults in Ramona Lake and the upstream lakes using a clearly defined study design. The surveys were designed to provide baseline data on the abundance of different salamander life stages in various habitats around the lakes and to allow repeatability and comparability among locations and time periods. Surveys sampled all mapped dominant habitat types (except for small pools which were only examined in reconnaissance surveys) to gain an understanding of the use of optimal and sub-optimal habitats and the relationship between egg presence and habitat characteristics.

A total of 21 transects, each 50 m long, were established parallel to the shoreline of Ramona Lake to investigate breeding use in Ramona Lake (Map 5). One transect was also established in each of the two upstream small lakes (Ramona 1 and 2) to determine if these lakes were also used as breeding habitat (Table 3). Transects were placed at equal intervals following a random start point. The area surveyed for each transect included a band of terrestrial habitat adjacent to the lake spanning five meters from the shoreline and the aquatic habitat from the shoreline to two meters of water depth.

Systematic surveys were conducted on calm days to obtain optimal visibility by two surveyors experienced in amphibian identification and handling. For each transect surveyed, one surveyor surveyed the terrestrial habitat and the other surveyed the aquatic habitat. The terrestrial surveyor examined the area between the shoreline and 5 m from shore. Cover objects were turned (logs and rocks greater than 5 cm in diameter), wetted graminoids and soil along the shoreline patted, and cracks examined with headlamps. The aquatic surveyor used a combination of snorkelling and wading to examine an area up to two meters depth. The aquatic surveyor continuously visually examined the water column and substrate in front of his/her path prior to disturbing and potentially stirring up the substrate. They also examined cracks and lifted rocks. The number of individuals per 50-meter transect searched was documented and summarised by age class (egg-masses, larvae, and adults) and habitat characteristics recorded. For each individual encountered, photographs were taken, the total length was estimated, and age class and habitat characteristics (depth, position, substrate) were recorded. Salamander larvae and adults were only handled after the receipt of the Provincial general wildlife live capture and release permit and then only to provide a reference for the estimation of sizes without capture (*Wildlife Act* Permit #SU15-174420). Any handling of amphibians followed provincial standards (RIC 1998b), including the Interim Standard Operating Procedure for Hygiene Protocol for Amphibian Field Staff and Researchers (MOE 2008), and federal animal care standards (CCAC 2004). No egg masses were disturbed.

Habitat and survey parameters that were recorded for each transect included search time, time of day, weather, water temperature, shade, and dominant aquatic habitat type. Additional notes on habitat characteristics were recorded both in association with each transect and in the habitat mapping portion of the study (Section 4.1.1 and 4.2.1).

Table 3. Locations of aquatic breeding salamander survey transects for systematic surveys conducted in 2015 in Ramona Lake and adjacent small lakes.

Waterbody	Transect	UTM (Zone 10U)		Elevation (m)	Aspect	Date
		Easting	Northing			
Ramona Lake	RAM-PBA01	451597	5514633	1363	NW	10-Jun-2015
	RAM-PBA02	451434	5514583	1363	E	10-Jun-2015 23-Jul-2015
	RAM-PBA03	451502	5514574	1363	E	10-Jun-2015
	RAM-PBA04	451586	5514505	1363	All	11-Jun-2015
	RAM-PBA05	451506	5514484	1363	NE	09-Jun-2015
	RAM-PBA06	451636	5514318	1363	NE	09-Jun-2015
	RAM-PBA07	451822	5514288	1363	N	09-Jun-2015
	RAM-PBA08	452003	5514223	1363	NE	09-Jun-2015
	RAM-PBA09	452173	5514096	1363	NW	09-Jun-2015
	RAM-PBA10	452381	5513958	1363	NE	09-Jun-2015
	RAM-PBA11	452541	5513843	1363	NW	09-Jun-2015
	RAM-PBA12	452689	5513978	1363	W	11-Jun-2015
	RAM-PBA13	452549	5514147	1363	SW	11-Jun-2015
	RAM-PBA14	452399	5514307	1363	NW	11-Jun-2015
	RAM-PBA15	452327	5514497	1363	SW	11-Jun-2015
	RAM-PBA16	452318	5514620	1363	SW	11-Jun-2015
	RAM-PBA17	452166	5514816	1363	SE	10-Jun-2015
	RAM-PBA18	452069	5514981	1363	SW	10-Jun-2015
	RAM-PBA19	451832	5514895	1363	SW	10-Jun-2015
	RAM-PBA20	451639	5514911	1363	SW	10-Jun-2015 23-Jul-2015
	RAM-PBA21	451478	5514880	1363	SE	10-Jun-2015
Ramona 1	RAM-PBA22	451712	5515108	1376	W	10-Jun-2015
Ramona 2	RAM-PBA23	451920	5515519	1387	N	10-Jun-2015

Survey Effort

The proportion of dominant habitat types and quality ranks that were searched during surveys was estimated relative to shoreline (proportion of linear shoreline searched relative to total lake shore circumference). However, the shoreline mapped from orthophotos in the office was slightly more detailed than that measured on the ground (see also Density and Relative Abundance below). Thus, because the proportion of habitat types surveyed was based on search distances measured on the ground relative to overall shoreline distances mapped from orthophotos, the estimation of the proportion of shoreline searched is biased low.

Density and Relative Abundance

Densities of detected individuals (egg-masses, larvae, and adults) were calculated for each habitat quality rank in order to estimate the relative abundance of salamander egg-masses and other life stages in the study area; and thereby allowing comparison among habitat types and time periods. Densities were calculated by multiplying the number of observations along the 50 m transect by the proportion of mapped habitat quality in the transect, summing the proportions allotted to each habitat quality rank for each transect, and dividing that number by the total amount of habitat of each quality rank. Thus, density measures are linear and represent the density of detections along a linear stretch of shoreline (number of detections per meter) (RIC 1998a).

Density calculations are considered rough estimates for the following reasons:

1) Due to imperfect detectability, and because occupancy modelling was not conducted to estimate and correct for detectability, detection numbers are expected to be lower than the actual number of salamanders present.

2) It was the initial intention that the proportion of the lake perimeter sampled by transects would represent 30% of the length of total available shoreline, and this was supported by pre-field plot placement and ground measurements. However, lengths calculated from desk-top shoreline mapping indicated that approximately 15% of the shoreline was surveyed. This discrepancy was due to slightly more detailed mapping from orthophotos in the office relative to ground measurements in the field, and meant that density estimates for all salamander life stages, which were based on numbers detected in the field relative to shoreline measurements made on orthophoto maps, is biased high. However, because this bias likely affects all locations and habitat types equally, comparisons among habitat types are not biased.

3) Additional breeding was observed on the north side of the lake after the first round of systematic surveys had been completed and where transects were not repeated. Thus, because these breeding events would not have been detected, egg and adult densities were biased low.

4) Transects sometimes crossed habitat polygon boundaries and it was not possible while doing field surveys to accurately identify these boundaries. Detections were therefore summarized for each transect and assigned to habitat quality ranks in proportion to the amount of habitat for each quality rank sampled by the transect. This generally resulted in detections being associated with the appropriate habitat quality rank; however, in some cases detections may have been assigned to habitat quality polygons other than those from where they were recorded. For example, in rare cases where a transect sampled a high proportion of low quality habitat in which there were no or few detections, and only a small amount of high

quality habitat in which there were many detections, some of the detections from the high quality habitat could have been assigned to low quality habitat.

4.1.3. Environmental Conditions During the Breeding Period

Ramona Lake water temperature data were collected by data loggers along a depth profile by Aquarius Research and Development (ARD). Measurements were taken at 0.2, 2, and 6 m depth for 2012-2015 and are summarized in West *et al.* 2016. Air temperature and relative humidity measurements were collected by Ecofish at the Lower Ramona Creek intake (station RAM-LUSAT), the closest weather station to Ramona Lake, at an elevation of 465 m, which is 898 m lower than Ramona Lake and has more of a marine and forest canopy influence, then an alpine influence.

4.2. Results and Discussion

4.2.1. Habitat Mapping

4.2.1.1. Aquatic Habitat

The ranking scheme that was developed and field verified to rank aquatic habitat quality is presented in Table 4. This ranking scheme considered habitat data collected at the transect and detection scales and integrated all recorded aquatic habitat attributes, except for emergent vegetation and aspect. Emergent vegetation was excluded from consideration for aquatic habitat quality because the lakes were void of emergent vegetation except for graminoids bordering the delta of Ramona Lake and the edges of the other lakes and small pools with a soil substrate. No salamander eggs were found on or near these graminoids. Aspect was also excluded because eggs were laid in full or partial sun on all aspects, and aquatic bottom aspect did not appear to predict egg presence. Lastly, proximity of inflows and outflows were identified as potentially important in the classification of habitat quality but were only considered when a direct influence was noted.

Assigned ranks were verified with results from systematic inventory surveys: egg-masses were most common in polygons ranked as high quality habitat (Section 4.2.2.2), thereby providing confidence in the defined quality categories.

Table 4. Aquatic breeding habitat quality ranks and associated attributes.

Quality Rank	Attributes
High	High quality aquatic breeding habitats were considered those that had abundant to moderate CWD with fine branches and were relatively shallow located in small bays or associated with small talus. Small bays at the base of draws consisted of the highest quality habitats. Often microhabitat features in these small bays included balds and coarse fragments. High quality habitat generally had little sediment and was adjacent to a partially or fully vegetated shoreline. High quality habitat did not occur in flowing or sluggish water or near relatively moderate to large glacial inflows.
Moderate	Moderate quality aquatic breeding habitats had moderate amounts of CWD with fine branches and were relatively shallow. They were often small bays, balds, and small talus macrohabitats with cracks and coarse fragments that could be used as cover, and were adjacent to a partially to fully vegetated shoreline.
Low	Low quality aquatic breeding habitats had little to no CWD, and were often associated with large talus slopes that extended into the lake, or were in large silty deltas (bays) or near relatively moderate to large sized inflows and outflows. Low quality habitats included deeper balds with little cover.
Nil	Nil quality aquatic habitat were steep bedrock bald cliffs that held no structure to support eggs. Creeks and small shallow pools with sestin bottoms were also asslociated with nil quality.

The quantity of aquatic habitat of each quality rank in each waterbody is presented in Table 5 and depicted in Map 3 and Map 4. Ramona Lake contained 70% of the total aquatic habitat area available within the Ramona Lake basin (Table 5). Most of the high quality habitat in the basin was located in Ramona Lake (96%) and a small amount was located in Ramona 2 (4%). High quality habitat comprised 15.5% of the Ramona Lake shore (Figure 1). Moderate and low quality habitat was present in Ramona Lake and the two upper lakes (Figure 2, Figure 3). Approximately half of the total habitat in the basin and within Ramona Lake was classified as low quality habitat. The small pools, located between Ramona 1 and 2, contained only nil quality habitat (Figure 4).

High quality aquatic habitat in Ramona Lake was identified only in small bays and small talus, with the majority in small bays (Table 6, Figure 1, Figure 2). The small talus dominated habitats ranked as high quality, in areas adjacent to terrestrial habitat with some soil development and vegetation and where the base of the slope had relatively high terrain stability (Map 3). Moderate quality habitat was more widely distributed among habitat types; however, the majority was associated with small bays. Balds and small talus habitat types contained a similar portion of moderate quality habitat and large bays had the lowest proportion. Low quality habitats were typically found on balds, large talus, and large bays with cold inflows (Figure 3). Nil habitat was found on steep balds and in moving water (Table 6), as well as in small pools.

Habitat quality was associated with water depth and the amount of CWD. High quality habitat had abundant to moderate amounts of CWD and the average depth one meter from shore was 40.8 cm (Table 7). In contrast, moderate and low quality habitats had deeper water and less CWD.

The quantity of each habitat type in each waterbody is presented in Table 8. Ramona Lake had a greater variety of habitat types than the upper lakes. The small pools did not have any of the identified dominant habitat types. Ramona Lake was the only waterbody with small talus habitat type, and most of the small bay habitat type, which were both linked to high habitat quality. Ramona 2 also had some small bays but Ramona 1 did not.

Table 5. Quantity of aquatic breeding habitat of high, moderate, low, and nil quality available to Long-toed Salamanders in Ramona Lake, the two upper lakes (Ramona 1 and 2), and surrounding small pools.

Habitat Quality Rank	Total Area (ha)	% of Total Area (ha)	Ramona Lake		Ramona 1		Ramona 2		Small Pools	
			Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
High	0.75	11.3%	0.72	15.5%	0.00	0.0%	0.03	5.4%	0.00	0.0%
Moderate	2.33	35.0%	1.36	29.4%	0.45	33.7%	0.52	86.0%	0.00	0.0%
Low	3.40	51.2%	2.46	53.3%	0.89	66.3%	0.05	8.6%	0.00	0.0%
Nil	0.17	2.5%	0.08	1.8%	0.00	0.0%	0.00	0.0%	0.08	100.0%
Total	**6.65**	**100.0%**	**4.62**	**100.0%**	**1.34**	**100.0%**	**0.60**	**100.0%**	**0.08**	**100.0%**

Table 6. Quantity of aquatic breeding habitat of high, moderate, low, and nil quality available to Long-toed Salamanders in Ramona Lake by dominant habitat type.

Habitat Quality Rank	Total Area (ha)	Bald		Small Talus[1]		Large Talus		Small Bay		Large Bay		Creek	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
High	0.72			0.17	23.6%			0.55	76.4%				
Moderate	1.36	0.26	19.5%	0.25	18.3%	0.05	4.0%	0.63	46.1%	0.16	12.0%		
Low	2.46	0.49	19.8%	0.34	14.0%	0.76	30.8%	0.03	1.1%	0.85	34.4%		
Nil	0.08	0.04	51.6%									0.04	48.4%
Total	**4.62**	**0.80**		**0.76**		**0.81**		**1.20**		**1.01**		**0.04**	

[1] All high ranked small talus habitat is from one polygon with consolidated talus over bedrock. The slope is relatively stable as indicated by adjacent mature terrestrial vegetation communities.

Table 7. Average water depth and relative amount of CWD by aquatic habitat quality rank in Ramona Lake.

Habitat Quality Rank	Average Depth 1 m from Shore (cm)	Amount of Coarse Woody Debris			
		Abundant[1]	Moderate	Few	Nil
High	40.8	56.0%	43.5%	0.6%	
Moderate	77.5		59.5%	40.5%	
Low	85.5	0.8%	5.3%	88.8%	5.1%
Nil	330.0	48.4%			51.6%

[1] High abundance of coarse woody debris recorded in Nil habitat is entirely due to wood in inflows and outflows.

Table 8. Quantity of each dominant aquatic habitat type in each waterbody in the Ramona Lake basin.

Dominant Habitat Type	Total Area (ha)	% of Total Area (ha)	Ramona Lake		Ramona 1		Ramona 2		Small Pools	
			Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Bald	0.81	12.2%	0.80	17.2%			0.02	2.6%		
Small Talus	0.76	11.5%	0.76	16.5%						
Large Talus	0.81	12.2%	0.81	17.6%						
Small Bay	1.26	19.0%	1.20	26.0%			0.06	10.2%		
Large Bay	2.62	39.4%	1.01	21.8%	1.11	82.5%	0.50	83.7%		
Creek	0.04	0.6%	0.04	0.9%						
Inflow	0.04	0.6%			0.04	3.2%				
Outflow	0.21	3.2%			0.19	14.3%	0.02	3.5%		
Small Pool[1]	0.08	1.3%							0.08	100.0%
Total	**6.65**	**100.0%**	**4.62**	**100.0%**	**1.34**	**100.0%**	**0.60**	**100.0%**	**0.08**	**100.0%**

[1]Only small pools had a dominant habitat type of small pool.

Figure 1. Example of high quality aquatic and terrestrial habitat along Ramona Lake, on May 28, 2015. Image shows a small bay with coarse fragments and woody debris and a moist gully that is treed beyond photo.

Figure 2. Example of moderate quality aquatic and terrestrial habitat along Ramona Lake on May 28, 2015. Image shows a bald aquatic habitat type and pocket meadow to parkland terrestrial habitat type. Low quality terrestrial large talus and high quality treed habitat can be seen on opposite shore.

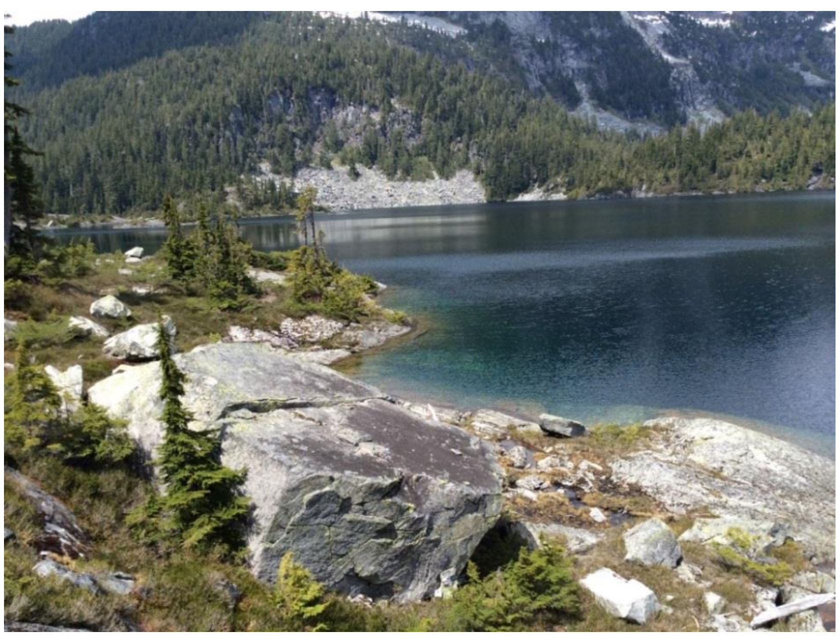


Figure 3. Example of low quality large talus aquatic and terrestrial habitat along Ramona Lake on May 28, 2015.

Figure 4. Example of a small pool that was classified as nil habitat and within which no salamanders were detected, on May 28, 2015.

4.2.1.2. Terrestrial Breeding Habitat

The ranking scheme that was developed and field verified to rank terrestrial breeding habitat quality is presented in Table 9.

The quantity of terrestrial breeding habitat of each quality rank within 5 meters of the shoreline of Ramona Lake and the upper lakes (Ramona 1 and 2) is presented in Table 10 and depicted in Map 3 and Map 4. A total of 0.38 ha of high quality terrestrial breeding habitat was mapped surrounding Ramona Lake, accounting for 13.6% of the lakeshore, and 1.02 ha of moderate quality habitat was mapped, accounting for 36.5% of the lakeshore. The upper lakes were also surrounded by high quality terrestrial habitats accounting for 81.7% of the shoreline of Ramona 1 and 24.4% of Ramona 2. Nevertheless, the majority of the terrestrial habitat in the Ramona Lake basin was classified as low quality.

The majority of high quality terrestrial breeding habitats surrounding Ramona Lake were forested and parkland areas (Table 11, Figure 1). The majority of moderate quality habitats were parkland and pocket meadows (on bald or talus habitats) (Figure 2) and those of low quality habitats were mostly talus (Figure 3). All three lakes had similar proportions of forested habitats but the proportions of other habitat types differed (Table 12). Only Ramona Lake had the small talus habitat type. The most common habitat type in Ramona 1 was bald-parkland, and that for Ramona 2 was pocket meadow.

Trees were the dominant structural stage in high quality habitats surrounding Ramona Lake (Table 13), as documented by the relationship between habitat quality and forested habitat type in Table 11. Shrubs were the only other structural stage in high quality habitats. Tree and shrub structural stages were similar in proportion for moderate quality habitats. Herbs and rock were also present in small proportions. Low quality habitats had a high proportion of rock and nil quality habitat contained entirely rock. Treed and other vegetated habitats retain more moisture and have more moderated climates than exposed rocky habitats (i.e., talus or unvegetated balds). They also have more soil, litter, and root associated tunnels for burrowing, and typically support a higher diversity of cover including CWD. Thus, tree and shrub structural stages, as well as forested habitat types, are associated with higher habitat quality.

No relationship between habitat quality and aspect was identified (Table 14). Although more polygons had northerly and southerly aspects than easterly and westerly given the orientation of Ramona Lake and the two upper lakes, high quality habitat polygons were relatively evenly distributed among aspects of the lake shore along Ramona Lake (Map 3, Map 4).

Table 9. Terrestrial breeding habitat quality ranks and associated attributes.

Quality Rank	Attributes
High	High quality terrestrial breeding habitats were those that were forested or parkland and that had a treed structural stage. They were often associated with moist drainages and had several types of cover including CWD, vegetation, soil, cracks, and rocks.
Moderate	Moderate quality terrestrial breeding habitat supported vegetated elements such as pocket meadows on balds, shrubs, and forested areas. Bedrock areas had abundant cracks that could be used as movement corridors. Cover was abundant and included long cracks in bedrock, soil, and vegetation.
Low	Low quality terrestrial breeding habitats typically included talus slopes or balds with large expanses of rock without vegetation or soil pockets to retain moisture and provide cover. Small islands with little vegetation were considered low quality.
Nil	Nil quality terrestrial breeding habitat consisted of large balds with few to no cracks, that had little to no cover or moisture retention capability.

Table 10. Quantity of terrestrial breeding habitat of high, moderate, low, and nil quality available to Long-toed Salamanders in the Ramona Lake basin.

Habitat Quality Rank	Total Area (ha)	% of Total Area (ha)	Ramona Lake		Ramona 1		Ramona 2	
			Area (ha)	%	Area (ha)	%	Area (ha)	%
High	0.91	24.2%	0.38	13.6%	0.42	81.7%	0.11	24.4%
Moderate	1.14	30.3%	1.02	36.5%	0.04	8.0%	0.08	17.4%
Low	1.70	45.0%	1.38	49.3%	0.05	10.2%	0.26	58.2%
Nil	0.02	0.5%	0.02	0.6%		0.0%	0.00	0.0%
Total	**3.77**	**100.0%**	**2.80**	**100.0%**	**0.51**	**18.3%**	**0.45**	**100.0%**

Table 11. Quantity of terrestrial breeding habitat of high, moderate, low, and nil quality by dominant habitat type in Ramona Lake.

Habitat Quality Rank	Total Area (ha)	Forested		Bald - Parkland		Bald - Many Cracks		Bald - Few Cracks		Pocket Meadow		Large Talus		Small Talus	
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
High	0.38	0.27	70.7%	0.11	29.3%										
Moderate	1.02	0.13	12.4%	0.42	41.2%	0.09	8.4%			0.39	38.0%				
Low	1.38			0.14	9.8%	0.14	10.4%	0.02	1.6%	0.29	21.3%	0.51	36.9%	0.28	20.1%
Nil	0.02							0.02	100.0%						
Total	**2.80**	**0.40**		**0.67**		**0.23**		**0.04**		**0.68**		**0.51**		**0.28**	

Table 12. Quantity of each terrestrial habitat type surrounding Ramona Lake and the upper two lakes.

Dominant habitat type	Total Area (ha)	% of Total Area (ha)	Ramona Lake		Ramona 1		Ramona 2	
			Area (ha)	%	Area (ha)	%	Area (ha)	%
Forested	0.58	15.5%	0.40	14.1%	0.08	15.7%	0.11	24.4%
Bald - Parkland	1.01	26.8%	0.67	23.9%	0.26	51.5%	0.08	17.4%
Bald - Many Cracks	0.23	6.1%	0.23	8.2%				
Bald - Few Cracks	0.06	1.7%	0.04	1.4%			0.02	5.3%
Pocket Meadow	1.01	26.9%	0.68	24.3%	0.12	23.2%	0.21	46.5%
Large Talus	0.59	15.7%	0.51	18.2%	0.05	10.2%	0.03	6.4%
Small Talus	0.28	7.4%	0.28	9.9%				
Total	**3.77**	**100.0%**	**2.80**	**100.0%**	**0.51**	**100.0%**	**0.45**	**100.0%**

Table 13. Dominant structural stage of each terrestrial habitat quality rank surrounding Ramona Lake.

Habitat Quality Rank	Structural Stage			
	Tree	Shrub	Herb	Rock
High	80.0%	20.0%		
Moderate	46.2%	38.4%	11.5%	3.87%
Low	9.8%	2.0%	21.9%	66.3%
Nil				100.0%

Table 14. Number of habitat polygons for terrestrial breeding habitat of high, moderate, low, and nil quality for each aspect in the Ramona Lake basin.

Habitat Quality Rank	Aspect				Total
	Northerly (316° - 45°)	Easterly (46° - 135°)	Southerly (136° - 225°)	Westerly (226° - 315°)	
High	4	5	6	2	**17**
Moderate	18	2	2		**22**
Low	15	4	9	3	**31**
Nil	1		1		**2**
Total	**38**	**11**	**18**	**5**	**72**

Figure 5. Example of high quality terrestrial habitat along Ramona Lake on June 10, 2015. Image shows forested and parkland terrestrial habitat type.

Figure 6. Example of low quality terrestrial habitat along Ramona Lake on June 10, 2015. Image shows talus slope terrestrial habitat type.

4.2.2.Salamander Reconnaissance and Systematic Surveys

Aquatic and terrestrial Long-toed Salamander breeding habitats were searched for 103:43 person hours (hours:minutes) in the Ramona Lake basin over the survey period (Table 15). This included 68:03 hours of reconnaissance survey time and 35:41 hours of systematic survey time. By lake, the time spent on reconnaissance and systematic surveys was 80:25 hours on Ramona Lake, 10:29 hours on Ramona 1, and 12:49 hours on Ramona 2.

Table 15. Time spent searching each lake during reconnaissance and systematic surveys during the 2015 Long-toed Salamander breeding period.

Waterbody	Date	Daily Survey Times per Crew (h:m)			Systematic Survey Time (h:m)		Approximate Reconnaissance Survey Time (h:m)		Total Survey Time per Person (h:m)
		Start	End	Total	Total	Person	Total	Person	
Ramona Lake	28-May-15	8:30	16:30	8:00	-		8:00	16:00	16:00
	09-Jun-15	8:00	18:30	10:30	6:01	12:03	7:29	12:29	24:32
	10-Jun-15	9:15	18:30	9:15	4:24	8:48	4:50	9:41	18:30
	11-Jun-15	8:30	16:30	8:00	3:23	6:46	4:36	18:27	24:13
	23-Jul-15	10:30	14:20	3:50	2:29	4:59	1:20	2:40	7:40
		17:00	17:30	0:30			0:30	1:00	1:00
Total					*16:18*	*32:37*	*26:46*	*47:48*	*80:25*
Ramona 1	10-Jun-15	9:30	12:00	2:30	0:49	1:39	1:40	3:20	5:00
		17:40	18:30	0:50			0:50	1:40	1:40
	23-Jul-15	14:20	15:45	1:25			1:25	2:50	2:50
		16:30	17:00	0:30			0:30	1:00	1:00
Total					*0:49*	*1:39*	*4:25*	*8:50*	*10:29*
Ramona 2	10-Jun-15	12:00	17:40	5:40	0:42	1:24	4:57	9:55	11:20
	23-Jul-15	15:45	16:30	0:45			0:45	1:30	1:30
Total					*0:42*	*1:24*	*5:42*	*11:25*	*12:49*
Total					**17:51**	**35:41**	**36:53**	**68:03**	**103:43**

*Survey person time is based on a crew of two except for on July 9 when two crews of two conducted surveys on Ramona Lake and July 11 when one crew conducted surveys and one crew was mapping habitat of which the time is included in reconaissance surveys.

4.2.2.1. Reconnaissance Survey

During reconnaissance surveys, egg-masses, larvae, and adults were observed in May. Egg-masses and larvae were observed in June and larvae and adults were observed in July (Table 16 Map 5). Evidence of breeding was detected in each of the three lakes but was not detected in any of the small pools. Microhabitat characteristics for eggs, larvae, and adults detected during reconnaissance surveys are summarized in Table 17. Egg-masses were detected at an average depth of 15.8 cm, with an average water temperature of 10.4°C, on woody debris in small bays and balds, and in large bays in the upper two lakes (Table 17). Larvae were detected at depths similar to egg-masses, in similar to much warmer water, in a variety of positions and mostly in small bays in Ramona Lake and in large bays in the upper two lakes. Adults were detected in cooler water when breeding but remained in moist habitats along the shoreline, as the water warmed later in the summer. They were mostly detected swimming in the water column early in the season and under rocks (or coarse wood) on land later in the summer. In aquatic habitats, adults were detected in small bays and balds. On land, they were located in moist habitats beside inflows and large bays in the upper lakes (Table 17). Salamander and habitat observations from each of the three reconnaissance survey periods are described below.

Table 16. Total number of Long-toed Salamanders detected during reconnaissance surveys conducted between May and July 2015.

Waterbody	Date	Long-toed Salamander Detections		
		Egg-masses	Larvae	Adults
Ramona Lake	28-May-15	6	3	6
	09-Jun-15	0	3	0
	23-Jul-15	0	6	0
	Subtotal	*6*	*12*	*6*
Ramona 1[1]	10-Jun-15	0	0	0
	23-Jul-15	0	3	8
	Subtotal	*0*	*3*	*8*
Ramona 2[1]	10-Jun-15	2	3	0
	23-Jul-15	0	0	0
	Subtotal	*2*	*3*	*0*
Small Pools[2]	28-May-15	0	0	0
	10-Jun-15	0	0	0
	Subtotal	*0*	*0*	*0*
Total		**8**	**18**	**14**

[1] The Upper Lakes were not accessible during the first reconnaissance survey.

[2] Small pools were not assessed during the third reconnaissance survey as no salamanders were detected during the previous two surveys.

Table 17. Microhabitat characteristics of Long-toed Salamanders observed during reconnaissance surveys in the Ramona Lake basin.

Age Class	*n*	Depth (cm)			Water Temp. (ºC)			Position					Habitat Type					
		Avg.[1]	Min.	Max.	Avg.	Min.	Max.	On Woody Debris	On Rock	On Bottom	Water Column	Under Rock	Small Bay	Bald	Small Talus	Large Talus	Large Bay[2]	Inflow
Egg-masses	*8*	15.8	6	30	10.4	9	11.8	87.5%	12.5%				50.0%	25.0%			25.0%	
Larvae	*8-18*	16.7	5	30	18.2	8	24	8.3%	33.3%	25.0%		33.3%	62.5%		12.5%		25.0%	
Adults	*6-14*	-	5	100	12.2	8	17.5				28.6%	71.4%	28.6%	14.3%	7.1%		42.9%	7.1%

[1] No average depth because a portion of adults were on land

[2] All observations in Large Bay habitat were in the upper two lakes

May 28, 2015

The first reconnaissance survey was conducted on May 28th a week after the ice had thawed over Ramona Lake. The purpose of the first survey was to capture the beginning of the egg laying period. Approximately 2,000 m of the southwestern shoreline, equaling a third of the total lake shore, was searched ranging from the middle of the large talus slope at the western end of the lake, halfway to the southeast end of the lake (Map 5). The survey included a diversity of habitats covering all of the terrestrial and aquatic habitat types along Ramona Lake. Several small sestin-bottomed pools (small pools) and wetted draws were also searched. Ramona 1 and 2 were not searched on this field trip.

Breeding was earliest on the western side of Ramona Lake. The likely reason for this was that the southwest facing marine influenced slope, which slopes away from Ramona Lake and towards Narrows Inlet, likely warmed prior to habitats within the Ramona Lake basin which would be cooled by the cooling effects of adjacent residual snow and glaciers and the sinking effects of cool air. Thus salamanders that overwinter southwest of Ramona Lake in warmer local conditions appear to migrate and arrive at Ramona Lake before salamanders that breed in other parts of the lake.

Recently laid Long-toed Salamanders egg-masses and breeding adults were observed in two locations, north and south of RAM-PBA06, along the western shore of Ramona Lake indicating the beginning of the breeding period (Table 16, Map 5). It was estimated by visual inspection of the eggs and by the presence of adults near egg masses that eggs were at most a few days old, and lay date was estimated at May 25 (note that embryos become visible to the naked eye as they grow; see photos in Section 4.2.2.2). All observed egg masses were on the topside of fine coarse woody debris (except for one mass which was found between rocks), at 6-30 cm depth, with a water temperature of approximately 9ºC. Each egg mass was composed of 1–25 individual eggs. Adults were detected actively swimming in the water column or being sedentary under rocks in moist habitats within a meter of the shoreline. A few individuals had swollen cloacae or abdomens. Adults and egg masses were located in small to medium sized bays near to moist vegetated draws. Substrates were fractured bedrock with abundant coarse fragments and moderate amounts of coarse woody debris.

Two size classes of larvae were detected at several locations along the shoreline (approximately 35 cm and 65 cm snout to tail length). Larvae were detected on exposed rock, under rocks, and in cracks in the bedrock.

Water temperatures ranged from approximately 4ºC in the morning in deeper shaded areas to 12ºC in the afternoon on the southeast facing talus. Little water level fluctuation was apparent as the shoreline vegetation was scoured five centimeters above the current water level which was continuous with an algae line on the rocks. The bedrock was severely cracked in a 20 cm band at the current water level, presumably from freeze/thaw associated weathering. As noted above, several larvae were observed in these cracks.

No signs of breeding were detected in the small sestin-bottom pools searched.

June 9-11, 2015

The second set of reconnaissance surveys were conducted between June 9 to 11 in conjunction with the systematic surveys and habitat mapping. These surveys included some areas between systematic survey locations around Ramona Lake and the entire shoreline of the two small lakes, some key habitats on these lakes, and numerous small pools in the vicinity of the lakes. Specifically, extra search effort was applied to the delta at the east end of Ramona Lake because this habitat type was not covered by any systematic survey transects, contained emergent grasses and sedges, and had warm backchannels. High search efforts were applied to the entirety of the two small lakes in an attempt to determine if they could provide alternate breeding habitat for the Long-toed Salamander population occupying Ramona Lake.

Egg-masses that had been detected in Ramona Lake on the May 28 field visit had not yet hatched. Given estimated lay date of May 25, these were approximately 17 days old. No Long-toed Salamander eggs or adults were detected in the shallow delta of Ramona Lake associated with warm watered backchannels (24-30ºC) with emergent vegetation, along the south and eastern margin of the upper lakes, or in the small pools in the vicinity of the lakes. Delta habitats away from the warm channels and pools were quickly cooled from the glacial inflow and had water temperatures of approximately 5.5ºC. Only Long-toed Salamander larvae and breeding Pacific Chorus Frogs (*Pseudacris regilla*) were observed in warmer shallow channels associated with terrestrial meadow habitats. However, two salamander egg-masses were detected in Ramona 2 in the shallow delta at the east end of the lake (Map 5). One mass consisting of 22 eggs was laid on the fine branches of a cedar tree at 7 cm depth, with a water temperature of 15°C. The second mass was nearby attached to the underside of a log at 6 cm depth where the water temperature was 11.8°C. A few larvae were detected in each of the two lakes concentrated in relatively warm and shallow habitats with a west aspect (Table 17).

July 23, 2015

The third reconnaissance survey was scheduled to occur two weeks after the second survey and was intended to capture the end of the breeding period. During this last trip, systematic surveys in key locations were to be repeated, including those locations where adults were detected but no eggs observed. However, due to local wildfires the field crew could not safely access the site until the end of July. Two systematic surveys were conducted on this single day trip in areas where Long-toed Salamander adults had previously been observed in seemingly high quality habitat. In addition, a few other locations on Ramona Lake were checked for egg masses. The perimeter of the two upper lakes was also searched. During this visit, more adults were detected under cover objects adjacent to the lake than in previous visits. Three age classes of larvae were detected but egg masses were not. The water had warmed and the water level of Ramona Lake had dropped approximately 60 cm. Eight adults were detected adjacent to Ramona 1 in a moist draw under rocks in a small meadow surrounded by treed habitats. Three larvae were also detected in Ramona 1: two were in their second summer and one in its third summer and had almost metamorphosed into a terrestrial juvenile. Six larvae, consisting of individuals in their first, second, and third summers, were incidentally observed in Ramona Lake. No salamanders were detected in Ramona 2.

4.2.2.2. Systematic Survey

Field Inventory Survey

Twenty-three systematic transects were surveyed in June to determine the relative abundance and distribution of salamanders (Table 18, Figure 7, Map 5). Two of these transects were repeated in July (RAM-PBA20 and RAM-PBA02) to improve knowledge on the specific changes in local abundance and age class distribution (Table 19).

Long-toed Salamanders were detected at all 23 transects (Table 18, Table 19). Larvae were the most abundant life stage and were detected in all except one transect during both survey periods. Egg-masses were detected only in June and were detected at five of the 23 transects. Adults were detected at six of the 23 transects in June. Larvae were detected in all three lakes but eggs and larvae were only detected in Ramona Lake. However, during reconnaissance surveys, eggs were detected in Ramona 2 and adults near Ramona 1 (Table 16 and Table 17 in Section 4.2.2.1).

Although the last set of surveys was delayed due to wildfires, two important observations were made during this survey period (Table 19). Firstly, a large number of adults were observed in transect RAM-PBA20 where previously few adults had been detected (beside the cold inflow). Secondly, a third newly hatched age class of larvae (22-25 mm) was found at locations of both transects surveyed where no egg-masses had been previously observed (Table 18, Table 19). This indicates that successful breeding had occurred following the June surveys when only adults (at RAM-PBA02) or larvae (at RAM-PBA20) had been found in these locations within Ramona Lake. Given this observation, along with the detection of recently-laid egg masses on May 28 (estimated lay date of May 25; see Section 4.2.2.1), egg-laying in Ramona Lake was estimated to occur between May 25 and June 15. Further, the embryonic period was estimated to be about one month long at the beginning of the season, judging by the partly developed eggs seen on June 9 to 11 that were about 17 days old, but was likely reduced in duration due to water temperature increases as the season progressed, when it was estimated to be approximately 25 days in duration. Thus, the egg residency period was therefore estimated to occur in Ramona Lake in 2015 from approximately May 25 to July 10.

Long-toed Salamander breeding habitat suitability is best determined by egg-mass presence. Microhabitat characteristics for eggs, larvae, and adults detected during systematic surveys and combined reconnaissance and systematic surveys are summarized in Table 20 and Table 21, respectively. During systematic surveys in the Ramona Lake basin, egg-masses were detected at depths of 4-160 cm (average 61.1 cm), resided in water temperatures of 12-17°C (average 15.1°C), were most often laid on fine coarse woody debris (79.4%), and commonly detected in small bays (52.9%) and on balds (35.3%) (Table 20, Figure 9, Figure 10, Figure 11). Egg-masses contained 1-25 eggs with an average of 10 eggs (*n=23,* reconnaissance and systematic data combined).

In Ramona Lake, larvae were typically detected at depths of 2-96 cm, temperatures of 9-19.5°C, and were most often detected under, between, or on cobble sized rocks in small bays, on balds, and among large and small talus. In the upper lakes, they were detected on the sediment bottom or else on or under rocks in warm coves in the larger bays (Table 20, Table 21). Adults were detected along the shoreline under rocks (Figure 8) and swimming in the water column at depths up to approximately one meter. Surface water temperatures at or adjacent to detection locations in Ramona Lake ranged from 14-17°C (Table 20).

Table 18. Long-toed Salamanders detected during systematic surveys on June 9-11, 2015.

Waterbody	Transect	Systematic Survey Time (h:m:s)		Long-toed Salamander Detections June 9-11, 2015			
		Total	Person	Egg-masses	Larvae	Adults	Unknown[1]
Ramona Lake	RAM-PBA01	0:44:46	1:29:32		22		
	RAM-PBA02	0:31:57	1:03:54			3	
	RAM-PBA03	0:36:08	1:12:16		8		
	RAM-PBA04	0:45:54	1:31:48		44		
	RAM-PBA05	0:40:54	1:21:48	2	4		
	RAM-PBA06	1:12:33	2:25:06	15	20	2	
	RAM-PBA07	1:01:11	2:02:22	7	1		
	RAM-PBA08	0:36:57	1:13:54	1	11	3	
	RAM-PBA09	0:36:59	1:13:58		4		
	RAM-PBA10	0:58:30	1:57:00		17		
	RAM-PBA11	0:54:30	1:49:00		11		
	RAM-PBA12	0:23:07	0:46:14		14		
	RAM-PBA13	0:59:00	1:58:00		8	6	
	RAM-PBA14	0:24:49	0:49:38		1	2	
	RAM-PBA15	0:24:39	0:49:18		5	3	
	RAM-PBA16	0:25:39	0:51:18		3		
	RAM-PBA17	0:18:37	0:37:14		2		
	RAM-PBA18	0:38:17	1:16:34	1	7		
	RAM-PBA19	0:24:53	0:49:46		3		
	RAM-PBA20	0:38:11	1:16:22		20		
	RAM-PBA21	0:31:30	1:03:00		2		
	Subtotal	*13:49:01*	*27:38:02*	*26*	*207*	*19*	*0*
Ramona 1	RAM-PBA22	0:49:59	1:39:58		8		
Ramona 2	RAM-PBA23	0:42:17	1:24:34		5		
Total		**15:21:17**	**30:42:34**	**26**	**220**	**19**	

Table 19. Long-toed Salamanders detected during systematic surveys on July 23, 2015.

Waterbody	Transect	Systematic Survey Time (h:m:s)		July Long-toed Salamander Detections			
		Total	Person	Egg-masses	Larvae[1]	Adults	Unknown[2]
Ramona Lake	RAM-PBA02	0:32:40	1:05:20		6	3	
	RAM-PBA20	1:57:16	3:54:32		17	17	1
Total		2:29:56	4:59:52	0	23	20	1

[1] Some larvae dectected at each of PBA02 and PBA20 were recently hatched, indicating breeding happened at these sites following the June egg-mass surveys.

[2] This was an aquatic individual that was likely almost fully morphed into a terrestrial juvenile (considered a year 3 juvenile for the purpose of this study).

Table 20. Microhabitat characteristics of Long-toed Salamanders observed during systematic surveys in the Ramona Lake basin.

Age Class	*n*	Number of Eggs			Depth (cm)			Water Temp. (ºC)			Position					Habitat Type					
		Avg.	Min.	Max.	Avg.[1]	Min.	Max.	Avg.	Min.	Max.	On Woody Debris	On Rock	On Bottom	Water Column[2]	Under Rock	Small Bay	Bald	Small Talus	Large Talus	Large Bay[3]	Inflow
Egg-masses	*24-26*	9.4	1	26	61.1	4	160	15.1	12	17	76.9%	7.7%	7.7%	3.8%	3.8%	53.8%	38.5%	3.8%	3.8%		
Larvae	*220*				49.1	2	96	13.4	9	19.5	5.5%	20.3%	1.4%	6.0%	67.3%	30.4%	29.0%	13.4%	27.7%	0.5%	
Adults	*16-19*				-	0	90	14.8	14	17			10.5%		89.5%	10.5%	52.6%	15.8%	21.1%		

[1]No average depth was calculated for adults because a portion of adults were on land.

[2]The larvae observed in the water column were likely disturbed and fleeing.

[3]All observations in Large Bay habitat were in the upper two lakes.

Table 21. Microhabitat characteristics of all Long-toed Salamanders observed during reconnaissance and systematic surveys combined in the Ramona Lake basin.

Age Class	*n*	Depth (cm)			Water Temp. (ºC)			Position					Habitat Type					
		Avg.[1]	Min.	Max.	Avg.	Min.	Max.	On Woody Debris	On Rock	On Bottom	Water Column[2]	Under Rock	Small Bay	Bald	Small Talus	Large Talus	Large Bay[3]	Inflow
Egg-masses	*32-34*	52.6	4	160	13.1	9	17	79.4%	8.8%	5.9%	2.9%	2.9%	52.9%	35.3%	2.9%	2.9%	5.9%	
Larvae	*227-238*	32.4	1	96	13.7	8	24	5.7%	21.0%	2.6%	5.7%	66.4%	31.6%	28.0%	13.3%	26.8%	1.3%	
Adults	*25-33*	-	0	100	13.78	8	17.5			6.1%	12.1%	81.8%	18.2%	36.4%	12.1%	12.1%	18.2%	3.0%

[1]No average depth because a portion of adults were on land

[2]These larvae were likely disturbed and fleeing

[3]All observations in Large Bay habitat were in the upper two lakes

Figure 7. Surveyor conducting a systematic survey of aquatic habitat at site RAM-PBA06 on June 9, 2015.

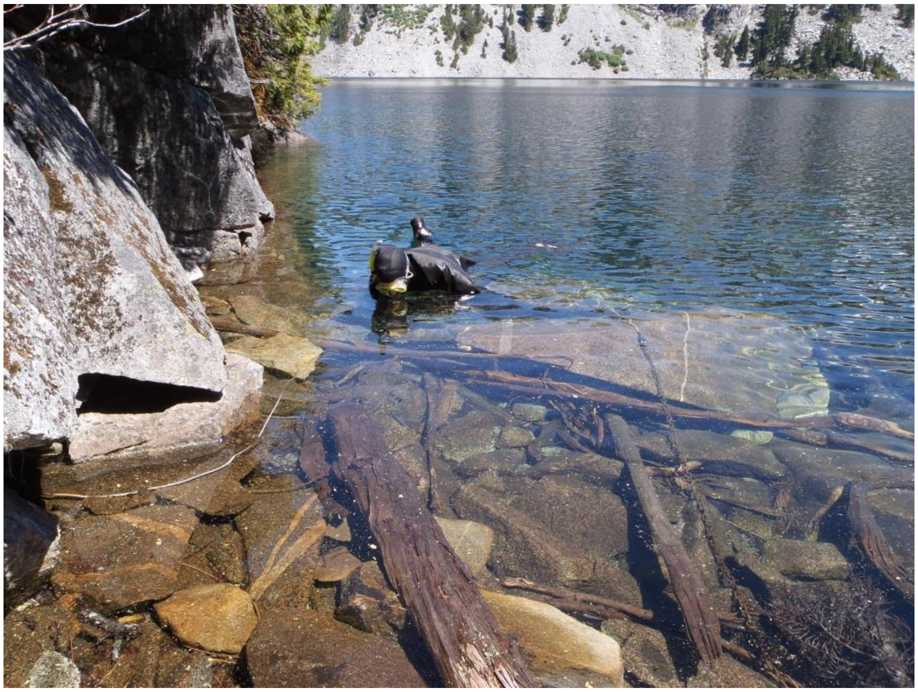


Figure 8. Seven adult Long-toed Salamanders detected under a rock at RAM-PBA20 on July 23, 2015.

Figure 9. Long-toed Salamander egg-mass consisting of seven eggs with round embryos attached to coarse woody debris at RAM-PBA06 on June 9, 2015.

Figure 10. Relatively deep egg mass laid 160 cm deep on coarse woody debris at RAM-PBA06 observed on June 9, 2015.

Figure 11. Crescent shaped embryo demonstrating development progress observed at RAM-PBA06 on June 9, 2015. Note that this egg was likely laid in the end of May at the time of the first reconnaissance survey.

Survey Effort

The proportion of low, moderate, and high quality habitats searched during systematic surveys ranged from 10% to 17% (Table 22). Most of the nil quality habitat was in small pools which were only searched during reconnaissance surveys. A total of 15-24% of the most common aquatic habitat types were systematically searched, except for large bays (Table 23). Most large bays were in the upper lakes and a low proportion of these were searched. As described in Section 4.1.2.2, the proportions of each habitat quality rank and habitat type searched are likely an underestimate because the shoreline was mapped in greater detail in the office than in the field. Thus, search effort was high and well distributed among habitat quality ranks and dominant habitat types and conclusions are considered representative of habitat available in Ramona Lake. However, because only one transect was surveyed in each of Ramona 1 and 2, these small lakes are not well represented by systematic survey results.

Table 22. Proportion of each aquatic breeding habitat quality searched during systematic surveys at all lakes.

Habitat Quality Rank	Distance Searched (m)	Distance Available (m)	Percent of Total Available Habitat (%)	Percent of Habitat Searched (%)
High	122	1,160	14.4%	**10.5%**
Moderate	394	3,050	37.8%	**12.9%**
Low	627	3,695	45.8%	**17.0%**
Nil	7	155	1.9%	**4.8%**
Total	**1,150**	**8,060**	**100.0%**	**14.3%**

Table 23. Proportion of each aquatic habitat type searched during systematic surveys at all lakes as determined from shoreline mapping.

Aquatic Habitat Type	Distance Searched (m)	Distance Available (m)	Percent of Total Available Habitat (%)	Percent of Habitat Searched (%)
Bald	396	2,017	25.0%	**19.6%**
Small Bay	256	1,778	22.1%	**14.4%**
Large Talus	200	843	10.5%	**23.7%**
Small Talus	193	1,060	13.2%	**18.2%**
Large Bay	68	2,015	25.0%	**3.4%**
Other	37	347	4.3%	**10.6%**
Total	**1,150**	**8,060**	**100.0%**	**14.3%**

Density and Relative Abundance

Average density of salamander egg-masses, larvae, and adults estimated from results of systematic surveys in June were 0.02, 0.19, and 0.02 detections per meter, respectively, for all habitat qualities and lakes combined (Table 24). As described in Section 4.1.2.2 (Density and Relative Abundance), biases in density estimates were identified some of which would cause underestimation and others overestimation of density. However, these estimates provide useful indicators of relative abundance because biases are expected to be similar across habitat quality ranks and sampling periods. Thus, these estimates are considered unbiased for comparative purposes.

Egg-masses were detected twice as frequently in high quality habitat as in moderate and low quality habitats in both June and July (Table 25, Table 26). No egg masses were observed in nil quality Habitat. Although egg-mass density was highest in the high quality habitat, the majority of egg-masses were observed in low and moderate quality habitats because these habitats represented more of the lakeshore. Because habitat qualities were assessed and boundaries identified before systematic inventory survey results were compiled (Section 4.1.1), the association between egg-mass density and habitat quality, as previously defined, verified that our habitat quality classification captured the important large-scale habitat features selected by salamanders for egg laying.

Adult density was also twice that in high quality habitat as in the other habitat quality ranks in June (Table 25), but in July density was highest in low quality habitat (Table 26). The abundance of adults detected in low quality habitat in July was related to the method by which detections were assigned proportionately to the habitat quality ranks when transects intersect multiple habitat quality polygons (Section 4.1.2.2). In this case, the adults that had been assigned to a low habitat quality rank in July had been found in a moderate quality habitat section of a transect that ran mostly through low quality habitat. This anomaly was particularly evident in the July surveys because only two transects were surveyed in July.

Larvae density was less closely associated with habitat quality rank than egg-masses and adults, which reflects the fact that habitat quality was categorized specifically for breeding (egg-mass) attributes and not for larvae.

Relative abundance estimated for all life stages by waterbody in the Ramona Lake basin is presented in Table 24. Only larvae were detected in Ramona 1 and Ramona 2; hence, the density of only this life stage can be compared. Density of larvae was highest in Ramona Lake and was higher in Ramona 1 than in Ramona 2; however, sample size in Ramona 1 and 2 was small.

The relative density of larvae in each waterbody can indicate multi-annual breeding success in each lake, and can be used as an indicator of breeding success in the absence of egg-masses or adults which are more challenging to detect and occupy the breeding habitat for a short portion of the year. Larvae age classes can be distinguished by size which allows evaluation of an index of breeding effort by year. Two age classes of larvae were observed during the June systematic surveys and three age classes during the truncated July survey (Figure 12, Figure 13, Figure 14). This indicates that an additional age class has appeared owing to the hatch of eggs of the current breeding season.

Table 24. Relative abundance of Long-toed Salamander egg-masses, larvae, and adults estimated for each waterbody during June systematic surveys.

Waterbody	Egg-masses		Larvae		Adults	
	#	#/m	#	#/m	#	#/m
Ramona Lake	26	0.02	207	0.20	19	0.02
Ramona 1			8	0.16		
Ramona 2			5	0.10		
Total Upper Lakes	*0*	*0.00*	*13*	*0.13*	*0*	*0.00*
Total	**26**	**0.02**	**220**	**0.19**	**19**	**0.02**

Table 25. Total number[1], density, and percent of individual egg-masses, larvae and adults detected in all lakes in the Ramona Lake basin by aquatic habitat quality rank during June 9 to 11 survey period.

Habitat Quality Rank	Egg-masses		Larvae		Adults	
	#	#/m	#	#/m	#	#/m
High	5.3	0.04	24.6	0.20	5.0	0.04
Moderate	9.4	0.02	38.4	0.10	8.6	0.02
Low	11.3	0.02	156.8	0.25	5.4	0.01
Nil	0.0	0.00	0.1	0.02	0.0	0.00
Total	**26.0**	**0.02**	**220.0**	**0.19**	**19.0**	**0.02**

[1] Numbers of individuals detected along transects were assigned to habitat quality ranks in proportion to the amount of habitat quality sampled by each transect (see Section 4.1.2.2.); hence,they are not whole numbers.

Table 26. Total number, density, and percent of individual egg-masses, larvae, and adults detected in all lakes in the Ramona Lake basin by aquatic habitat rank during July 23 survey period.

Habitat Quality Rank	Egg-masses		Larvae		Adults[2]	
	#	#/m	#	#/m	#	#/m
High	0.0	0.00	10.8	0.27	10.1	0.26
Moderate	0.0	0.00	4.8	0.12	2.5	0.07
Low	0.0	0.00	7.4	0.34	7.4	0.34
Nil	0.0	0.00	0.0	0.02	0.0	0.00
Total	**0.0**	**0.00**	**23.0**	**0.23**	**20.0**	**0.2**

[1] Numbers of individuals detected along transects were assigned to habitat quality ranks in proportion to the amount of habitat quality sampled by each transect (see Section 4.1.2.2.); hence,they are not whole numbers.

[2] The high density of salamanders that appear to be in low quality habitat were detected in a moderate quality habitat area along a transect with mostly low habitat.

Figure 12. Larva in its second summer under a rock at RAM-PBA23 on June 10, 2015.

Figure 13. Two recently hatched larvae detected at RAM-PBA02 on July 23, 2015.

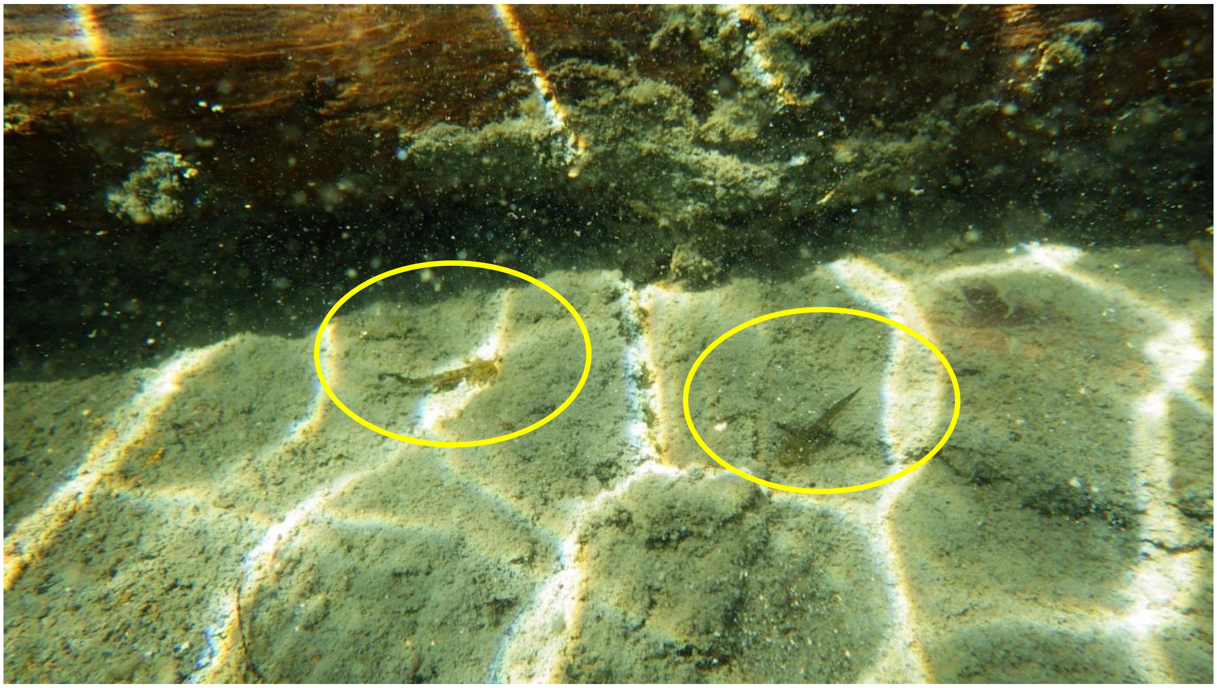


Figure 14. Long-toed Salamander larva in its third summer metamorphosing into a terrestrial juvenile observed at RAM-PBA20 on July 23, 2015.

4.2.3. Environmental Conditions During the Breeding Period

Environmental conditions in the vicinity of Ramona Lake in the winter of 2015, similar to the rest of the South Coast, were warmer than normal and the snow pack was extremely low (13% of normal for April 1st) (FLNR 2015), thus the lakes were likely snow free earlier than is typical. Similarly, summer temperatures were high with low precipitation (Environment Canada 2016a, Environment Canada 2016b), likely lending to lower and faster dropping water levels than normal and accelerated salamander egg development.

Ramona Lake was mostly void of ice on May 22 in 2015, eight days prior to the first survey in which eggs were detected. Water temperatures varied little by depth during the immigration and first egg laying period; however, egg laying depths became much warmer throughout the egg residency period, especially near the water surface (Table 27).

Air temperatures at the Lower Ramona intake in late May (May 27-31) when breeding was first observed ranged from 11.8 – 20.6ºC, and relative humidity ranged from 50.8 - 97.0%. Over the duration of the expected egg residency period temperatures averaged 15.6 ºC and ranged from 8.6 to 27.5 ºC and relative humidity averaged 78.3% and ranged from 40.6 to 100%. For comparison, Environment Canada climate normals for June from Gibsons, BC, between 1981 and 2010 were 15.7ºC with 66.8 mm of precipitation, while in 2015 average temperatures were 18.2ºC with 13 mm of rain (Environment Canada 2016a, Environment Canada 2016b).

Table 27. Water temperatures along a depth profile in Ramona Lake during the 2015 breeding period.

Period	Date	Depth (m)	Water Temp. (ºC)		
			Avg.	Min.	Max.
Immigration and first egg laying	May 22-28	0.2	4.7	3.8	7.3
		2	4.2	3.3	5.6
		6	4.0	3.6	4.3
Egg residency period	May 28-July 3	0.2	16.0	9.4	22.6
		2	12.6	6.8	18.7
		6	5.4	4.0	7.2

4.3. Summary of Baseline Conditions

The Ramona Lake basin supports a high elevation population of Long-toed Salamanders. Reconnaissance and systematic inventory surveys for aquatic breeding salamanders in the Ramona Lake basin, following modified Provincial standards (RIC 1998a), indicate that Long-toed Salamanders are the only species of salamander that breed and occupy the area. Ramona Lake is the primary breeding pond for the population, although this is supplemented to some extent by breeding in the upper two lakes in the basin (Ramona 1 and 2). Although, salamanders are known to use small temporal pools and slower backwaters of streams for breeding (DeLisle and Grayston 2011), no evidence of breeding was found in any such habitats in the waterbodies surveyed. Thus, the small pools near Ramona Lake are unlikely to provide viable breeding habitat. Similarly, only a single larva was detected in the slow moving water between lakes and near outlets.

Long-toed Salamanders start laying eggs on the western side of Ramona Lake immediately after break-up and continue to arrive and lay eggs at other parts of the shoreline and the upper lakes over the following several weeks. Low night time temperatures within the Ramona Lake basin, influenced by the alpine environment, likely delay salamander migration and breeding in the upper lakes and the northwestern shoreline of Ramona Lake (Beneski *et al.* 1986). In contrast, salamanders arriving earlier likely migrate from the more marine influenced southwestern side of the lake. After hatching, the larvae spend the next two years as aquatic juveniles, and they metamorphose into terrestrial juveniles in their third summer. Long-toed Salamanders are highly philopatric to breeding sites (Funk and Dunlap 1999), and Ramona Lake and the upper two lakes likely provide the only breeding habitat for the population, although occasional migration over alpine passes to nearby lakes (over 1,500 m away) or small low elevation pools may occur.

Combined data from reconnaissance and systematic surveys in 2015 indicate that Long-toed Salamander egg-masses in the Ramona Lake watershed were composed of 1 -25 eggs (average of 10) and were laid in 4 to 160 cm of water (average depth of 52.6 cm) in sunny locations in water temperatures ranging from 9 to 17ºC (average 13.1ºC). Eggs were most frequently laid on fine woody debris in small bays adjacent to moist drainages. Adults were found in terrestrial shoreline habitats in close proximity to egg laying locations or in locations expected to support high quality egg-mass habitat. Adults were also found in aquatic habitat early in the season while breeding and many remained within a meter of the shoreline, on moist soil under rocks or coarse wood, or in cracks in the bedrock, throughout the spring and summer. Larvae were detected in all habitat types around Ramona Lake but were most frequently observed in warm bays and on balds in shallow water and under water, between or on angular cobbles. In the upper two lakes, larvae were concentrated in warm shallow bays on the sediment and around rocks.

During the 2015 breeding season, it was estimated that the embryonic period was approximately 30 days long early in the season and was somewhat reduced in duration later in the season due to warming water temperatures (estimated at approximately 25 days). Based on observations of recently laid eggs on May 28 and recently hatched larvae on July 23, the egg laying period was estimated as May 25 to June 15 and the egg-mass residency period from May 25 to July 10 (i.e., approximately 45 days). However, environmental conditions around Ramona Lake in 2015, similar to the rest of the South Coast, were warmer than normal. The snow pack was low, thus the lakes were likely snow free earlier than normal, and summer temperatures were high with low precipitation, likely leading to lower water levels that dropped faster than normal and accelerated salamander egg development (FLNR 2015, Environment Canada 2016a, Environment Canada 2016b). Thus, it is likely that in typical years timing of breeding would be later and that the egg residency period may be extended. Consideration of climate change, however, suggests that normal conditions may soon need to be redefined.

Aquatic and terrestrial habitat mapping was used to delineate polygons of similar habitat quality (high, moderate, low, and nil quality) and identify broad scale dominant habitat types correlated with important aquatic habitat characteristics such as substrate and cover with regards to egg-masses. Egg masses were observed in higher density in polygons previously identified as high quality habitat than in those with other habitat quality ranks, thereby verifying that habitat quality rank assignments were generally associated with habitat selection by salamanders for egg laying. Aquatic habitat quality was associated with small bays and small talus habitat types and with shallow water depth and abundant CWD. However, habitat quality was also affected by microhabitat characteristics such as cracks in in smaller scale balds that could provide cover and egg-mass attachment sites. Most of the aquatic habitat within the Ramona Lake basin (70%), and the great majority of high quality habitat (96%), was found in Ramona Lake. High quality terrestrial habitat was associated with forested and parkland habitat types and tree and shrub structural stages, given that treed and other vegetated habitats retain more moisture, provide more cover, and have more moderated climates than exposed rocky habitats. High quality terrestrial habitat was distributed throughout the Ramona Lake basin and represented about a quarter of the terrestrial habitat classified.

5. EFFECTS ASSESSMENT

The Upper Ramona Component of the Narrows Inlet Hydro Project is a storage lake design with Ramona Lake as its water storage source. Long-toed Salamanders breed in Ramona Lake (Section 4), thus eggs are laid in the lake, larvae mature in the lake, and adults use the terrestrial habitat surrounding the lake during summer and aquatic habitat during the courtship and egg laying period. Project construction and operations therefore have the potential to affect all Long-toed Salamander life stages. Aquatic Breeding Salamanders were therefore identified as a key indicator of the Amphibian & Reptile valued Component (VC) in the original environmental assessment application (EA) for an EAC (Robertson 2012b), which identified habitat loss, habitat change, and increased mortality as potential Project adverse effects.

An updated effects assessment for the Aquatic Breeding Salamanders key indicator is required for two reasons. First, data gaps were identified in the original EA and thus Condition #2 of the EAC requires that additional information on breeding habitat be provided and that the potential Project effects be re-evaluated in light of this new information. Second, modifications in Project design that have been proposed since the original EA have the potential to change the evaluation of Project effects on Aquatic Breeding Salamanders; hence, potential Project effects need to be re-evaluated in light of the proposed design changes.

5.1. Objectives

This updated EA for Aquatic Breeding Salamanders in Ramona Lake has two high level objectives. First, Condition #2 of the EAC specifies that additional assessments must be made with regard to habitat availability and loss, and egg mortality risk (Section 2). It also requires that population-level risk be evaluated. These TOC requirements necessitated additional inventory studies and an updated EA based on the new biological information collected and obtained (Section 4).

The second high level objective of this updated EA is to assess whether Project effects on Aquatic Breeding Salamanders will change given that the design of the Upper Ramona intake has been modified since the original EA was conducted. During the EA process, potential adverse effects were identified for Aquatic Breeding Salamanders and evaluated to assess potential effects from all phases of Project development and mitigation measures were prescribed to avoid or minimize such adverse effects. Thus, because the schedules of the current EAC reflect the conclusions of the Project's EAC Application, and because any changes to these schedules have the potential to modify such conclusions, the potential consequences of the proposed changes on the conclusions of the original EA must be evaluated. The assessment presented in this updated EA will ultimately determine whether the proposed changes will affect the conclusions of the EAC Application, on which the Ministers made their decision to grant Project approval.

In summary, the objectives of this assessment were therefore to:

1. Evaluate the potential adverse effects of Project construction and operations on Aquatic Breeding Salamanders based on the newly acquired baseline inventory data (and considering

the most recent Project design), in accordance with requirements of Condition #2 of the EAC. This includes evaluation of the effectiveness of prescribed mitigations measures, identifying any additional mitigation that may be required, identifying and characterizing residual effects, and determination of significance for any identified adverse residual effects; and

2. Evaluate the potential adverse effects of the proposed design changes on Aquatic Breeding Salamanders during construction and operations relative to the design that was originally proposed and on which the original EA was based. This includes a comparison of adverse effects, mitigation effectiveness, characterization of residual effects, and determination of significance for any identified adverse residual effects.

5.2. Modifications to Upper Ramona Intake and Operating Regime

In order to evaluate effects of the Upper Ramona Component on Aquatic Breeding Salamanders, it is important to clarify the current proposed Project infrastructure, design, and operating regime that may interact with salamanders breeding in Ramona Lake. It is also important to consider the difference in the original design and the modified design and the implications of these differences on Project effects on salamanders. A summary of the comparison of the two designs is provided in Table 28.

The intake design that was proposed for the Upper Ramona Component at the time of the Application was a pumped intake mounted on a floating pontoon on the northwest portion of Ramona Lake. A 3 m high dam was proposed at the natural lake outlet that would capture flash precipitation and seasonal freshet snowmelt for the purpose of flow regulation. The Upper Ramona Component would generate electricity from the water stored by this dam along with that made available when drawing the lake level down by 45 m (Figure 15). It was expected that this dam would cause the lake water level to rise up to 3 m and flood up to 3.7 ha of riparian/terrestrial habitat (Robertson 2012c). In addition to the dam, other infrastructure would have been required near the intake to accommodate pumps, water tank, fuel supplies, and related equipment.

In 2014, site investigations revealed the presence of difficult terrain within the penstock alignment and changes to the water conveyance system were proposed such that a tunnel replaced a surface mounted penstock design. Changes to the intake were therefore required to conform to the revised water conveyance system design (CanMine 2016). The updated intake design is now proposed to be a lake tap which will involve extending the tunnel towards Ramona Lake (CanMine 2016). A short rock plug would initially be left on the lake side at a depth of 26 m below the natural lake surface elevation, near the tap exit (at 1,337 meters above sea level (masl)) which will then be removed through blasting. This blast (breakthrough blast) will pierce the lake bed and allow water to enter the tunnel through gravity. The technology required to create this lake tap is well-established, and several hundred lake taps have been constructed worldwide (CanMine 2016). An example of such an intake is at the nearby Tyson Creek Hydroelectric Project. No lake drawdown would be required to construct this type of intake.

The steep upper portion of the tunnel (~629 m), also referred to as the Alimak shaft, will be constructed using an Alimak raise climber. The Alimak shaft will daylight near Ramona Lake, more than 10 m away, and an Alimak building (7 m x 7 m) will be constructed over the shaft to allow valve control (CanMine 2016, Meier 2016, pers. comm.).

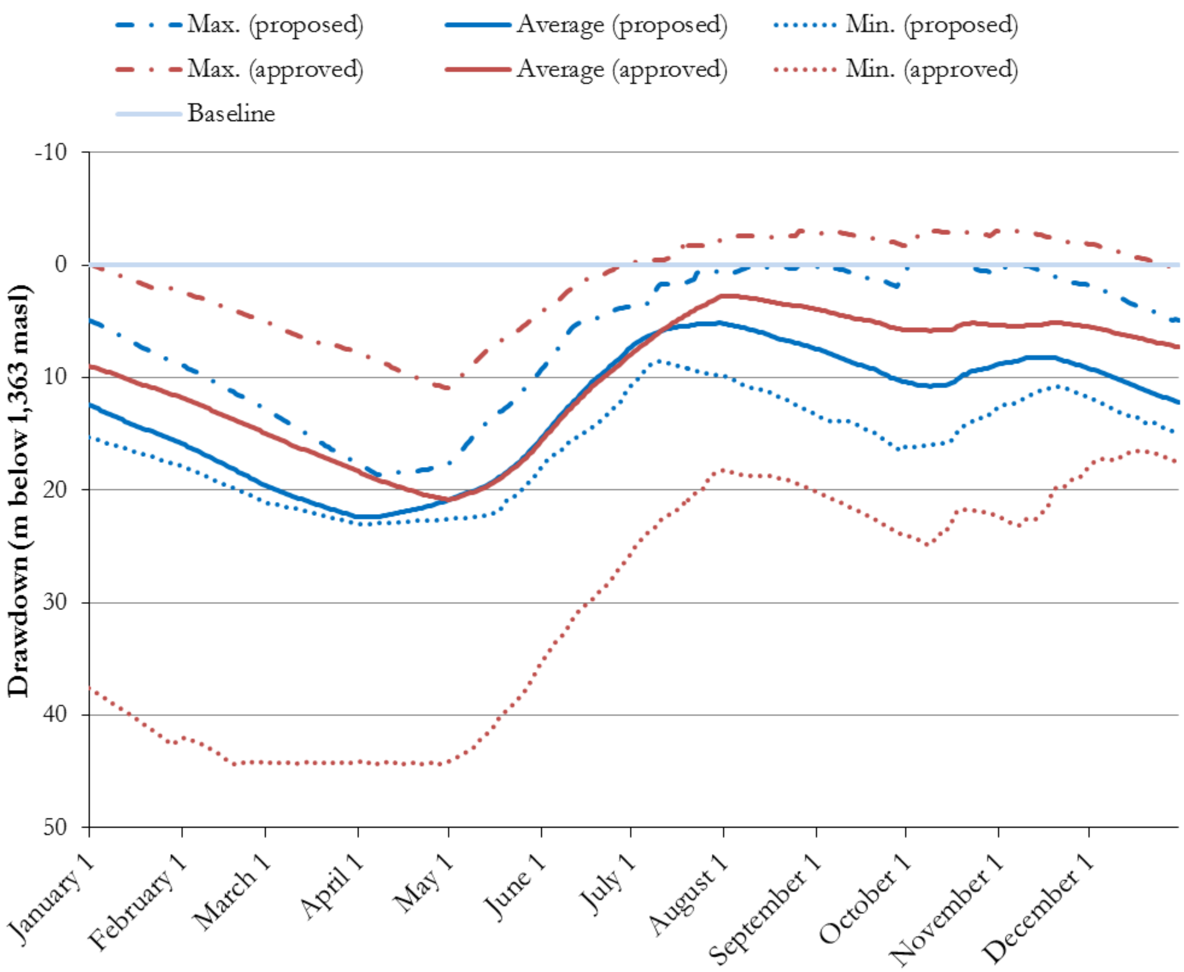
The new intake design also led to changes in operating drawdown regime in Ramona Lake. In contrast to the originally proposed maximum 45 m lake drawdown, power and energy modelling based on the modified intake design indicate that a drawdown of 23 m would be sufficient to meet the seasonal energy targets of the Project's Energy Purchase Agreement (EPA). Lake level modelling using data from the 15 year period of 1995-2009 was used to predict seasonal effects to Ramona Lake water levels for the new design and to compare water level fluctuations between designs (Figure 15). Both the original and the new design have similar seasonal water level patterns. For both designs, water in Ramona Lake was predicted to be drawn down to its lowest levels early in the spring, prior to freshet, rise rapidly between May and July, drop off gradually in late summer and fall, and drop relatively rapidly in late winter. Further, both designs have almost identical average drawdown values (just over 20 m). However, for the original design, water level was predicted to exceed its natural level in late summer and fall in some years, flooding up to 3.7 ha of riparian/terrestrial habitat, as previously noted, and would have dropped to much lower levels in extreme years, potentially as far as 45 m, as approved under Condition #14 of TOC (EAO 2016). In contrast, there is little difference in maximum and average drawdown values in the new design, indicating little inter-year variation in maximum drawdown level.

Although the new intake design is primarily required to conform to changes in the water conveyance system, there are also a number of design and safety advantages over the originally proposed pumped intake. Advantages include reduced operational and maintenance requirements (including no fuel transport requirements to power a pump), reduced rock fall hazard for the intake and construction workers given that the submerged intake is located away from an identified potential rock fall zone, no intake stability issues such as were previously required for a floating intake, and net energy production gain given that gravity will replace pump power requirements (CPL 2015). Two disadvantages in design were also identified: increased complexity of maintenance and the potential for sediments to enter the intake. There are two key ecological advantages of the reduced drawdown in the new design. First, no flooding of riparian/terrestrial habitat will occur because a submerged intake will not require a dam near the lake outlet. Second, less attenuation of natural peak flow events will occur in Ramona Creek because less flow will be stored in Ramona Lake than in the original design; thus the flow regime in Ramona Creek will be a bit closer to natural.

Table 28. Infrastructure modifications proposed for the Upper Ramona Component of the Project that are relevant to potential effects on Aquatic Breeding Salamanders.

Type of Change	Design Component	2012 EAC Application	2016 Proposed Design	Rationale for Change
Infrastructure Design	Intake Design	Pumped intake mounted on a floating pontoon in the northwest rim of the lake. Water is taken from the lake surface. Requires construction of a small (3 m-high) dam at the natural lake outlet to capture flash precipitation and seasonal freshet snowmelt for the purpose of flow regulation.	A lake tap intake that involves running a tunnel towards the Ramona Lake bed. Water is taken from the lake bed. Valves are accessed from the surface adjacent to Ramona Lake. Does not require a dam at the natural lake outlet, but requires a small footprint for an Alimak building to control intake valves.	Required to be compatible with revised water conveyance system. Design and safety advantages include reduced operational and maintenance requirements, reduced rock fall hazard, no intake stability issues, and net energy production gain because gravity replaces pump power. Ecological advantages include no flooding of terrestrial habitat and more normal flow in Ramona Creek.
Operational Regime	Lake Drawdown	Water is drawn down over the winter months from November through April and refills from April through August during freshet. Water elevation will decrease through the end of summer and slightly recharge during fall storms, before lowering throughout the winter. Maximum drawdown is 45 m but average drawdown is just over 20 m. Water levels increase above the natural lake elevation in some years.	Water is drawn down over the winter months from November through April and refills from April through August during freshet. Water elevation will decrease through the end of summer and slightly recharge during fall storms, before lowering throughout the winter. Maximum drawdown is 23 m and differs little from average drawdown. Water levels never increase above the natural lake elevation.	The EAC allows for a maximum lake drawdown during operation of 45 m (Condition #14); however, power and energy modelling indicates that a drawdown of only 23 m is sufficient to meet the seasonal energy targets of the EPA based on the new intake design.

Figure 15. Maximum, average, and minimum drawdown depths that correspond to projected post-Project daily mean Ramona Lake elevations for the 15-year period of 1995-2009. Estimates are shown for the original (proposed in Application) and updated (current) management schedules.



5.3. <u>Overview of Potential Effects on Salamanders due to Water Level Fluctuations</u>

Development and management of water impoundments can affect amphibians through changes to their habitat and through direct impacts to population parameters such as survival and recruitment (Lind *et al.* 1996, Brandao and Araujo 2008, Maxell *et al.* 2009, Eskew *et al.* 2012, Hawkes and Wood 2014, Swan *et al.* 2015). Few studies have investigated impacts of water impoundment projects on amphibian populations; however, Brandao and Arujo (2008) documented rapid amphibian declines following hydroelectric dam flooding in central Brazil, and Eskew *et al.* (2012) reported that damming in South Carolina had a strong negative effect on multiple anuran species across large spatial extents. Flooding and desiccation of habitat through water level fluctuations can reduce habitat suitability by altering critical habitat features (e.g., water depth, quality, and temperature, the

2013) and it is therefore difficult to make presence and abundance of vegetation) (Hawkes and Tuttle 2008, Maxell *et al.* 2009, Hawkes and Wood 2014, Swan *et al.* 2015). In addition to inundation or desiccation, decreases in water surface temperature may result from inundation which may decrease larval growth rates and immune response (Hawkes and Tuttle 2008, Maxell *et al.* 2009). Water level fluctuations can also cause direct mortality of eggs and larvae through stranding or inundation (Lind *et al.* 1996, Hawkes and Tuttle 2008, Maxell *et al.* 2009, Hawkes and Wood 2014). Effects related to water level fluctuations may also be complicated through interactions with environmental factors such as climate change, predation risk, and changes in species composition owing to changes in the environment (Maxell *et al.* 2009, Hawkes and Wood 2014).

Although negative effects of reservoir creation on amphibian occupancy and abundance have been demonstrated in a few studies (e.g., Eskew *et al.* 2012), and relationships between abundance and site-specific characteristics that influence inundation timing and extent have been documented (Swan *et al.* 2015), assessment of direct effects of reservoir operations on amphibian populations can be difficult. In BC, studies of the effects of large hydro projects on amphibians exist (Hawkes and Tuttle 2008, Hawkes and Wood 2014, Swan *et al.* 2015); however, these hydro projects are already in operations, thus pre-construction baseline information is not available for comparison which reduces the ability to evaluate effects. These studies also tend to have insufficient data to generate specific relationships between amphibian populations and hydro development (Hawkes and Tuttle detailed predictions and develop thresholds (e.g., relationship between inundation depth and egg mortality). Further, due to the variability in operating regimes and site-specific habitat features (e.g., timing of water level changes, frequency of inundation and desiccation, habitat availability at different water levels due to topographic characteristics, temperature changes), effects resulting from water level fluctuations are likely to vary substantially among projects. In some cases, a window of time may be available that allows successful amphibian breeding in some locations in some years (e.g., Columbia Spotted Frogs (*Rana luteiventris*) and Western Toads (*Anaxyrus boreas*) in the Valemount Peatland in Kinbasket Reservoir) (Hawkes and Wood 2014, Swan *et al.* 2015). However, the ability of amphibian populations to persist in reservoirs with fluctuating water levels will depend on their life-history parameters, site-specific environmental characteristics, and specific operating regime.

Little research has been conducted on Long-toed Salamanders in BC, especially in relation to effects of reservoirs. There is some suggestion that Long-toed Salamanders may be more sensitive to water level fluctuations than some other amphibian species. In BC Hydro's monitoring study of ponds and lakeshores in the drawdown zone of the Kinbasket and Arrow Reservoirs, Long-toed Salamanders were observed at 2 of 100 ponds surveyed, and occupied 2-43% of available habitats in these ponds (Hawkes and Tuttle 2008). In contrast, Western Toads were observed at all sites and Columbia Spotted Frog were observed at most. A Long-toed Salamander habitat suitability model created for reservoir drawdown zones applied to the Valemount Peatlands in the Kinbasket Reservoir determined the best habitat for the species in the drawdown zone to be in the upper elevation bands which are relatively close to the forest and therefore minimize the distance between suitable terrestrial habitat and aquatic breeding areas (Hawkes and Tuttle 2008). Thus upper elevation portions of drawdown zones that retain proximity to suitable terrestrial habitat may have highest probability of supporting Long-toed Salamanders, provided that aquatic habitat requirements are met.

5.4. Scope of Assessment

This updated environmental assessment generally followed the approach and scope of the original EA (Robertson 2012b, c). The same adverse effects on Aquatic Breeding Salamanders were generally considered and the criteria and values used to characterize residual Project effects and to determine their significance was based on the same methodological approach (Table 29, Table 30), which included determining the probability of significance (Robertson 2012b). However, in some cases adverse effects, not previously identified in the original EA, were identified or effects were categorized differently. Where our approach deviated from the original EA, the rationale for this is provided.

In order to meet the first objective of this updated EA, Project effects (given the most recently proposed design) on habitat, egg survival, and the salamander population in the Ramona Lake basin, were assessed by comparison to baseline. The second objective required comparison of Project effects between the new design and the original design considered in the EAC Application.

Table 29. Criteria and values used to characterize residual effects in the original EA (Robertson 2012b).

Criteria	Definition	Values
Direction	The long-term trend of the effect.	**Positive** – effect will benefit the VC **Neutral** – no effect on the VC **Negative** – effect will be detrimental to the VC
Geographic Extent	The area within which an effect of a defined magnitude occurs.	**Project Development Area** – Project footprint only **Local Assessment Area** – local assessment area as specified for the VC **Regional Assessment Area** – regional assessment area as specified for the VC
Magnitude	The amount of change in a measurable parameter or variable relative to baseline conditions. As this is unique for each VC, definitions of magnitude will vary.	**Negligible** – no measurable change over the baseline condition **Low** – effect is expected above baseline, but within generally accepted standards (regulations or guidelines) **Moderate** – effect is expected to be considerably above baseline (within or above accepted standards), or could cause a change in ecological, social or other parameters **High** – effect is expected to exceed accepted standards and to cause a measurable change well beyond the natural variability
Duration	The period of time required for a VC to return to its baseline condition, or for the effect to no longer be measurable or otherwise perceived. As this is unique to each VC, definitions of duration vary, but are typically defined as those noted.	**Short** – intermittently during construction (<1 year) **Medium** – continuous during construction or intermittently operations (1 – 5 years) **Long** – continuous during construction and operations (>5 years)
Frequency	The number of times during a Project or a specific Project phase that an effect might occur.	**Once** **Rarely** – at sporadic intervals **Regular** – occurs on a regular basis and at regular intervals **Continuous**
Reversibility	The likelihood that a measurable parameter will recover from an effect.	**Reversible** **Irreversible**
Context	The general characteristics of the area in which the Project is located.	**Undisturbed** **Disturbed** **Urban Setting**

Table 30. Criteria used to classify the significance of a residual effect in the original EA (Robertson 2012b).

Criteria	Definition	Values
Likelihood	Probability of occurrence in combination with level of scientific uncertainty	Low Moderate High
Level of Confidence	Confidence in the information used to characterize the residual effect.	Low Moderate High

5.5. Assessment of Potential Effects

Three potential Project effects on Aquatic Breeding Salamanders were identified: (1) habitat loss and change; (2) change in behaviour; and (3) increased mortality. Identification and evaluation of these effects followed the approach of the original EA with two exceptions. First, habitat loss and habitat change are interrelated and the distinction between these two effects is not always clear. For example, scouring of the shoreline due to fluctuating water levels can result in either habitat loss or change depending on the degree to which important habitat characteristics are affected. Thus, in contrast to the original EA that attempted to separate these effects and considered loss of habitat attributes that affect habitat quality under both loss and change, this updated EA evaluated habitat loss and habitat change under a single effect. Secondly, although change in behaviour was identified for some Amphibian & Reptiles key indicators, it was not identified as a potential effect for Aquatic Breeding Salamanders in the original EA although some disturbance to breeding salamanders at Ramona Lake would likely have occurred with the original design (i.e., similar to that assessed for Coastal Tailed Frogs due to instream and riparian disturbance in Ramona Creek). In this updated EA, change in behaviour was identified and assessed as a potential adverse effect. Most other effects described in the sections below were also identified in the original EA. A summary of potential effects identified for the new design and a comparison to the original EA is presented in Table 31.

Table 31. Potential adverse effects identified for the new design in comparison to the original EA.

Project Effect		Phase	Potential Effect Mechanism	Change from Original EA
Habitat Loss and Change	Aquatic Habitat	Construction	• direct water quality reduction (sedimentation and water chemistry) due to	• new effect: construction with original design did not directly affect water quality
		Operations	• inundation (least 5 m) can result in the loss of viable egg-laying habitat	• no change in effect. Original design would have resulted in larger inundation
			• loss of habitat for larvae with lake drawdown due to lake topography	• effect not evaluated in original EA; effect similar between designs but slightly less severe with new design due to reduced maximum drawdown
			• reduced habitat quality for larvae within the lake drawdown zone due to scouring and loss of microhabitat features	• little change in effect; effect similar between designs but slightly less severe with new design due to reduced maximum drawdown
			• water quality reduction due to scouring and erosion	• reduced potential for erosion and sedimentation with the new design relative to the original because flooding of riparian habitat will not occur
	Terrestrial Breeding Habitat	Construction	• permanent and temporary footprint for Alimak shaft and building (225 m^2)	• new footprint smaller than original; if footprint is farther from Ramona Lake than 5 m, no effect on terrestrial breeding habitat with new design
		Operations	• loss of habitat for adults with lake drawdown due to lake topography	• effect not evaluated in original EA; little change in effect by design
			• reduced habitat quality for adults within the lake drawdown zone due to scouring and loss of microhabitat features	• effect less severe with new design because riparian/terrestrial habitat will not be flooded
Change in Behaviour		Construction	• construction of Alimak building near Ramona Lake	• less potential for disturbance given smaller new footprint; if footprint is farther from Ramona Lake than 5 m, no effect on terrestrial breeding habitat with new design
			• single disturbance event during breakthrough blast	• new effect: original design did not require a breakthrough blast
		Operations	• forced relocation due to constantly changing water levels	• effect not evaluated in original EA; effect similar but slightly less severe with new design due to reduced maximum drawdown
			• concentration of individuals into smaller areas wdue to drawdown	• effect not evaluated in original EA; effect similar but slightly less severe with new design due to reduced loss of habitat at maximum drawdown

Table 31. Potential adverse effects identified for the new design in comparison to the original EA (Continued).

Project Effect	Phase	Potential Effect Mechanism	Change from Original EA
Increased Mortality	Construction	• vibrations associated with the breakthrough blast	• new effect: original design did not require a breakthrough blast; however, potential mortality associated with construction in aquatic and terrestrial habitat was not considered in the original EA
	Operations	• inundation of egg-laying habitat by at least 5 m of water causes egg mortality	• no change in effect. Original design would have resulted in larger inundation
		• mortality of overwintering larvae due to water level drop during winter	• no change in effect. Original design would have resulted in larger inundation
		• potential mortality of adults due to stranding and drowning in some locations	• no change in effect. Original design would have resulted in larger inundation
		• entrainment in the intake of adults and larvae	• negligible effect for both designs

5.5.1. Habitat Loss and Change

5.5.1.1. Aquatic Habitat

Aquatic habitat exists in Ramona Lake for all three Long-toed Salamander life stages: eggs, larvae, and adults (Section 4.2.1.1). Aquatic habitat loss and change may occur for all life stages during Project construction due to footprint effects and during operations due to the drawdown regime in Ramona Lake.

Construction

No aquatic habitat will be lost due to footprint effects during construction of the intake and associated infrastructure because the new intake is submerged below the aquatic habitat of eggs, larvae, and adults. At maximum lake drawdown, the submerged intake is expected to be 3 m below the water level, and eggs, larvae, and adults were not detected below depths of 160 cm below the water surface (Section 4.2.2.2). Thus, water below 160 cm depth, which is at least 140 cm above the level of the intake at all times, is not likely to represent aquatic habitat for any life stage. In the original EA when impacts from a floating intake and dam were assessed, some aquatic footprint losses would have existed; however, this was not considered in the original EA; likely because the contribution of this aquatic footprint to habitat loss would have been negligible.

Habitat change for aquatic habitat may also result from sedimentation and introduction of contaminants that may alter water quality when the rock plug at the lake tap exit is removed through blasting. Total suspended solids (TSS) in Ramona Lake is expected to temporarily increase following the final breakthrough blast, when the rock mass between the lake tap tunnel and the lake is removed using explosives. Concentrations of TSS will increase due to mobilization of lake bed sediments in the vicinity of the blast area, in addition to the generation of fine sediment due to pulverization of rock during the blast. The spatial extent of this impact will be limited because the area of the lake bed that will be directly affected by the blast is relatively small (the entrance to the lake tap on the bed of the lake will have a diameter of 2.4 m (CanMine 2016)). Therefore, the effect is expected to be localized to the vicinity of the lake tap, although some dispersion of elevated TSS conditions could occur depending on ambient conditions (principally wind) that influence horizontal transport mechanisms (e.g., internal waves) at the time. The results of sediment settling modelling undertaken by Hughes-Adams (2012) (in relation to erosion following rainstorms) indicates that the majority of existing lake bed sediments mobilized during the final blast are likely to settle after < 10 days, although the finest sediments (clay-sized particles) may remain suspended for longer. The additional potential extent of fine sediment generated by rock pulverization is uncertain, although the mass of any fine sediments generated is expected to be small relative to the volume of the lake, based on the relatively small blasting area.

There is also potential for the breakthrough blast to alter the water chemistry on Ramona Lake. These include increased nutrient concentrations associated with elevated TSS, reductions in dissolved oxygen (DO) concentration associated with elevated TSS, and the introduction of contaminants associated with cement products (e.g. shotcrete) and hydrocarbons (e.g., associated with oils) and blasting residues. In particular, explosives can contain significant quantities of inorganic nitrogen, predominantly ammonium nitrate (Forsyth *et al.* 1995). Inorganic forms of nitrogen (nitrate, nitrate and ammonia) can be toxic to aquatic life at high concentrations, while nitrogen addition can also cause eutrophication (Meays 2009). Significant lake-wide increases in inorganic nitrogen concentrations are not predicted to occur because the blasting area will be small relative to the size of the lake, and only a single blasting operation (the final blast) has potential to introduce blasting residues directly into the lake. However, localized and biologically significant increases in inorganic nitrogen concentrations could temporarily occur in the vicinity of the lake tap. The magnitude of these increases will depend on the quantity and composition of the explosives. Nitrogen solubility (and thus risks to aquatic life) is highest with the use ammonium nitrate fuel oils and lowest with the use of gels/slurries or emulsions (Forsyth *et al.* 1995). Depending on the composition of the bedrock, there may also be potential for some acid generation if rock spoil that is high in sulphide bearing minerals is exposed to oxic waters in Ramona Lake. However, the potential risk is expected to be low due to the relatively small blasting area and the absence of contact with air.

Habitat change was not identified as a potential effect for Aquatic Breeding Salamanders in the original EA for the construction phase because affects to water quality were not an expected or considered to result from intake construction with the original design. However, increased sedimentation during Project operations associated with lake drawdown was deemed to have the potential to affect egg and larval development and to impact survival of larvae and their prey organisms, with potential causes of reduced survival identified as the clogging of gills, smothering of eggs, and impacts to digestion and nutrient uptake of larvae (Robertson 2012c, Section 14.3.4.2.3). Given that the proposed changes to the intake design are anticipated to result in changes in sedimentation and other water quality attributes in Ramona Lake during intake construction, this potential effect must now also be evaluated for habitat loss and change for the construction phase.

Operations

Aquatic habitat loss and change during Project operations is anticipated for four reasons. First, the topography of the lake basin indicates that the band of useable habitat during lake drawdown will be shrink in size (become smaller in surface area and therefore also in volume) for all three aquatic life stages. Second, rising water levels during the egg residency period are predicted to cause loss of egg-laying habitat because any habitat available when eggs are laid will become inundated prior to hatching. Third, the scouring action of water and ice during water level rise and fall will impact the organic layer and reduce habitat suitability by removing or altering habitat attributes that impact habitat quality (e.g., soil, vegetation, CWD abundance) along the lake sides. Fourth, water level fluctuations may impact water quality which may in turn affect habitat suitability. The extent to which these factors affect habitat loss and change depends on season and associated changes in water levels. Habitat loss and change for eggs, larvae, and adults are therefore assessed separately wherever effects differ by life stage.

Egg-laying habitat

Although some egg-laying habitat will be lost in Ramona Lake from the shrinkage of area when water levels are low due to lake topography, and habitat quality will be altered because scouring of the shoreline during water level fluctuation causes loss of microhabitat features such as attachment sites and availability of CWD, rising water levels during the egg residency period are anticipated to have a much larger impact on egg-laying habitat than will other causes of habitat loss and change. Current predictions of seasonal lake level patterns during Project operations in relation to timing of breeding (Figure 16) indicate that the egg-laying habitat of early breeding salamanders (estimated lay date approximately May 25) will be flooded with 10 additional meters of water during the embryonic period, while the habitat of late breeders (estimated lay date approximately June 15) will be flooded by a 5 m water level rise.

Long-toed Salamanders select specific depths in which to lay eggs that are relatively near to the water surface (egg masses were observed in Ramona Lake between 4 cm and 160 cm) (Table 20). As water depth increases, important habitat characteristics, such oxygen levels, light levels, and temperature, will also change which in turn will affect the quality and viability of egg-laying habitat. Reservoir operations have been shown to affect the availability and suitability of aquatic habitats in the drawdown zone (Hawkes and Wood 2014). Further, a relationship between habitat use and timing of inundation was demonstrated for Columbia Spotted Frogs and Western Toads in the drawdown zone of the Kinbasket Reservoir, where egg masses were found to be more abundant in higher elevation ponds that were last to be inundated each summer (Swan *et al.* 2015). These results suggest that timing of inundation affects habitat quality and that flooding of breeding habitat by large amounts of water (i.e., as would occur for low elevation habitats inundated early in the breeding season) causes these habitats to become unviable. Given that the egg-laying habitat of all breeding salamanders in Ramona Lake is anticipated to be impacted by flooding of at least 5 m in depth, and that egg masses in Ramona Lake were observed at maximum depths of 160 cm below the water surface, water level rises during the egg residency period are anticipated to have substantial effects to all egg-laying habitat in all operating years. It is unlikely that any egg-laying habitat would remain viable through the embryonic stage.

Given that all egg-laying habitat flooded by at least 5 m of water is predicted to become unviable, all of the low, moderate, and high quality habitat identified for egg-laying in Ramona Lake (Section 4.2.1.1) is anticipated to be lost during Project operations. Thus, a total of 4.54 ha of aquatic habitat (0.72, 1.36, and 2.46, ha of high, moderate, and low quality habitat, respectively) will be lost within Ramona Lake due to the operational drawdown regime (Table 5, Section 4.2.1.1). The assumption that all egg-laying habitat within Ramona Lake will be lost in all years is reasonable because even if extreme late breeders in years with a delayed breeding season laid eggs near the peak of water level rise and avoided some of the effects of inundation during the rising water level phase, water level would then rapidly drop again causing desiccation any eggs that had survived inundation (Figure 16). Ramona Lake represents 70% of the available habitat in the Ramona Lake basin and 96% of the high quality habitat, all of which is anticipated to be lost each year (Table 32).

The similarity in the pattern of seasonal water level rise in the original and new Project design (Figure 16) indicates that predictions of habitat loss due to flooding has not changed in light of design modifications. Although predictions for the original design indicate that egg masses could have been flooded to substantially greater extents in extreme years than they could be with the new design (Figure 16), flooding of egg-laying habitat by at least 5 m of water would be anticipated during all years with both designs.

Habitat quality for egg-laying may also be reduced within the drawdown zone during Project operations because the scouring of the lake sides by water and ice caused by water level fluctuations will impact the microhabitat features used by salamanders for egg attachment sites (see Table 4, Section 4.2.1.1) and may increase sedimentation. Further, given that water temperatures in Ramona Lake become stratified during summer (Lewis *et al*. 2016), decreases in water temperature of egg-laying habitat may impact the rate of egg development. However, given that all egg-laying habitat is anticipated to become unviable due to flooding, no other causes of habitat loss or change were assessed further.

Figure 16. **Egg laying and residency period overlaid onto the Upper Ramona operational regime. Maximum, average, and minimum drawdown depths that correspond to projected post-Project daily mean Ramona Lake elevations for the 15-year period of 1995-2009. Estimates are shown for the original (proposed in Application) and updated (current) management schedules.**

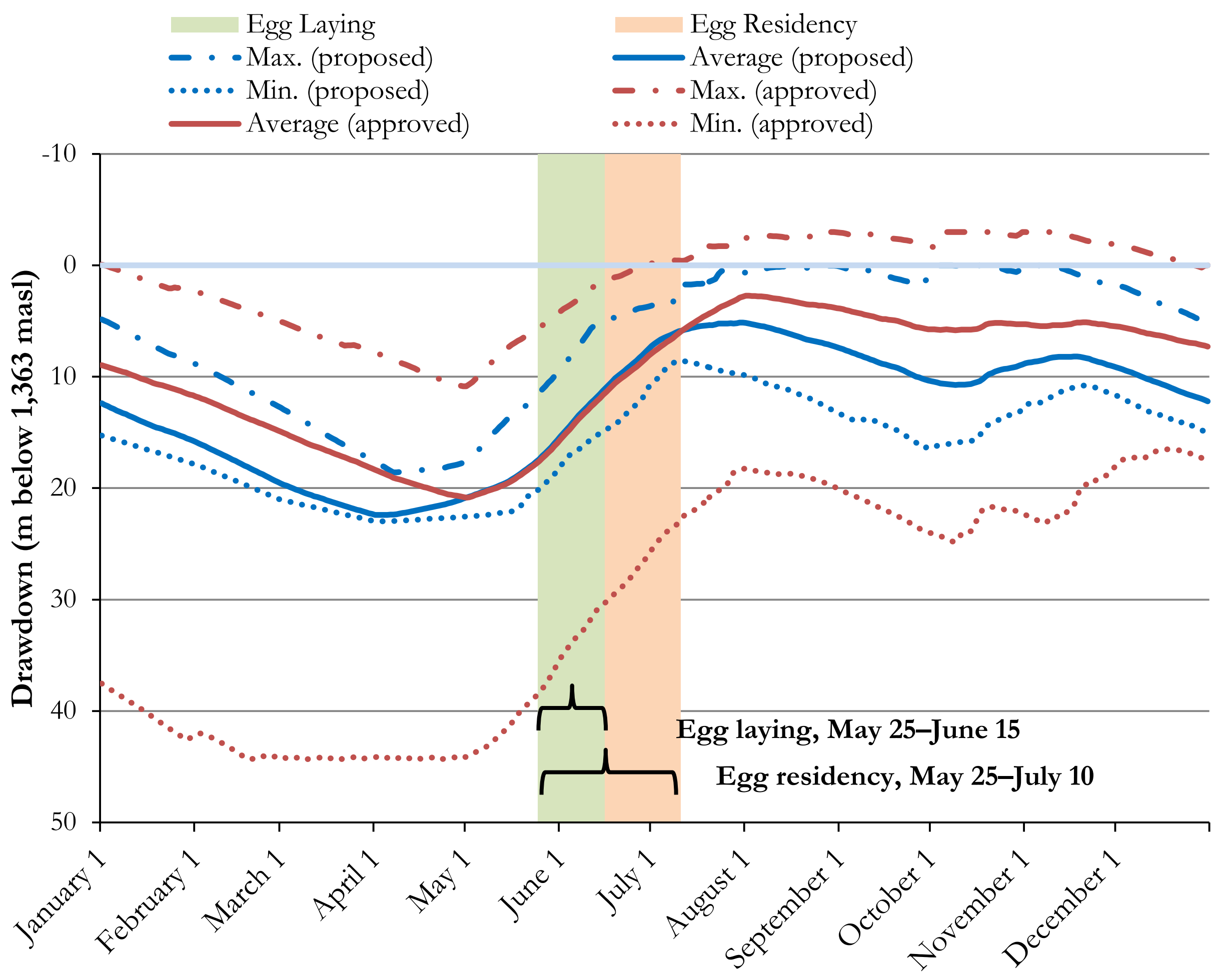


Table 32. Total amount of egg-laying habitat lost due to inundation during the egg residency period in Ramona Lake and in the Ramona Lake basin.

Aquatic Habitat Quality	Habitat Available in Ramona Lake Basin (ha)[1]	Habitat Loss in Ramona Lake (ha)	% Habitat Loss in the Ramona Lake Basin
High	0.75	0.72	96.0
Moderate	2.33	1.36	58.4
Low	3.40	2.46	72.4
Total	6.48	4.54	70.1

Larvae habitat

Habitat for larvae growth and maturation that will be lost or altered is not related to flooding or stranding because, unlike egg masses, larvae are mobile and can adjust their position within the water column to optimize depth. However, little information exists on the effects of reservoir operations on larvae behaviour and habitat selection, thus estimates of loss and alterations of larvae habitat entail greater uncertainty than those for egg masses.

Assuming that larvae can adjust their position within the water column, the area lost due to lake topography would be the limiting factor for larvae habitat loss. However, this loss of habitat with lake drawdown will change with water levels throughout the year. Based conservatively on the lowest annual water levels and on the assumptions and calculations of aquatic habitat available to larvae under baseline conditions (Section 4.2.1.1), the aquatic habitat available in Ramona Lake in a 1.75 m depth band at the natural lake elevation considering all habitat quality ranks is 4.62 ha (Table 5) and that available when water levels are at their lowest levels (i.e., at 23 m drawdown) is 1.14 ha (Table 33, Map 6). Thus, a maximum of approximately 3.48 ha (75.3%) of aquatic habitat will be lost to larvae when the lake is fully drawn down in late winter. For comparison, 1.75 ha will be available when the lake is drawn down by 12 m which translates to a 2.87 ha (62.1%) habitat loss. These losses represent 43.2% and 52.3% of the habitat available in the Ramona Lake basin when the lake is drawn down to 12 m and 23 m, respectively (Table 33).

Although the loss of 75.3% of aquatic habitat for larvae represents the maximum loss that will occur in Ramona Lake when water levels are lowest and less habitat will be lost when water levels are higher, effects of habitat change are anticipated for most remaining habitat. Any habitat available within the drawdown zone will be altered due to the loss of microhabitat features through scouring of the lake sides by water and ice. Habitat quality ranking during inventory studies was focused primarily on egg-laying habitat because larvae have less specific requirements. However, habitat attributes, such as prey availability and the presence of cover objects, are also important for larvae and these microhabitat features will be impacted by the scouring effects of water level fluctuations. Habitat alteration due to scouring would extend to the lowest drawdown level and be most severe in the higher portions of the lake impacted by water level fluctuations in all or most years. Thus, of the habitat that remains after seasonal changes in area due to lake topography are taken into consideration, all moderate and high quality habitat is anticipated to be reduced to low quality. For example, when the lake is drawn down to 12 m below its natural surface level, the remaining 1.75 ha of habitat would likely be entirely of low quality.

Effects of habitat loss and change will be slightly less severe with the new design than they would have been with the original design. Because the lake would have been drawn down to deeper depths in extreme years with the original design (Figure 16), more aquatic habitat would have been lost due to lake topography in such years and the lake sides would have been scoured to deeper depths. Thus, for the original design, during all except extreme drawdown years where water levels drop to 45 m, all aquatic habitat would have been altered by scouring and all moderate and high quality habitat would have also been reduced to low quality. In contrast, the difference between the minimum and average low water levels is less for the new design (Figure 16). This indicates that there is little inter-year variation in maximum drawdown level with the new design, and because habitat will be relatively unaltered when water levels are at their lowest (at maximum drawdown no scouring of the lake has occurred below the water level), more years are predicted for the new design in which the band of aquatic habitat will be relatively unaltered. However, all habitat above the lowest water level would be scoured by either design and in many years there would therefore be no difference between designs in the alteration of aquatic habitat due to scouring.

Table 33. Total amount of aquatic habitat for larvae lost due to loss of area from operation drawdown of Ramona Lake and in the Ramona Lake basin.

Location	Scenario	Habitat Available (ha)[1]	Habitat Loss (ha)	% Habitat Loss in Ramona Lake	% Habitat Loss in Ramona Lake Basin
Ramona Lake basin	at baseline	6.65	-	-	-
Ramona Lake	at baseline	4.62	-	-	-
	at 12 m drawdown	1.75	2.87	62.1	43.2
	at 23 m drawdown	1.14	3.48	75.3	52.3

[1] All habitat quality ranks are included for comparison, including nil quality habitat (0.08 ha in Ramona Lake and 0.17 ha in the Ramona Lake basin) because it was not possible to rank habitat quality at drawdown depths.

Adult habitat

Adult salamanders use aquatic habitat during the courtship and egg laying periods. However, because their aquatic habitat use is closely linked to egg laying, habitat loss and change for adults was considered to be equivalent to that of eggs.

All aquatic habitat

Aquatic habitat for all life stages may also be changed through water quality effects during operations because the process of lake drawdown is anticipated to cause sedimentation due to erosion of the shoreline. Sediment in the water has the potential to impact vital functions and survival of salamander eggs and larvae (discussed under Construction above). However, the proposed reduction in maximum drawdown range with the new design and because flooding of riparian and terrestrial habitat will no longer occur, this will reduce the potential for erosion and sedimentation relative to the original design.

5.5.1.2. Terrestrial Breeding Habitat

Terrestrial habitat exists around the shoreline in Ramona Lake and is used by Long-toed Salamander adults. Terrestrial breeding habitat has been defined as the 5 m band of habitat surrounding the lake shore used by adults during the breeding season (as described in Section 4.1.1.2). Terrestrial breeding habitat loss and change may occur during Project construction due to footprint effects and during operations due to the drawdown regime in Ramona Lake.

Construction

Terrestrial breeding habitat will be lost or altered during construction where permanent infrastructure footprints and temporary construction footprints overlap with the area surrounding Ramona Lake extending 5 m from the lake shore. The new intake design will have a small permanent footprint associated with the Alimak tunnel shaft access and Alimak building, but this will be small and require minimal clearing. This footprint is estimated at 225 m^2, which includes both the permanent building footprint (49 m^2) and the temporary clearing footprint. If the entire footprint is placed greater than 5 m from the shore of Ramona Lake, this will not result in the loss of any terrestrial breeding habitat and an insignificant amount of terrestrial overwintering habitat and habitat used during migration.

The original design required the construction of permanent infrastructure in the vicinity of Ramona Lake, including the dam, infrastructure to accommodate pumps, water tank, fuel supplies, and related ancillary equipment, as well as a temporary footprint for infrastructure which would have resulted in some loss of forest cover and terrestrial habitat. The new design will therefore result in less terrestrial breeding habitat loss than the original design.

Operations

Potential effects of terrestrial breeding habitat loss and change during operations for the new design are related to the shrinkage of area with drawdown due to lake topography and the scouring of the lake shoreline by water and ice during water level fluctuations. Adult salamanders reside within a narrow band adjacent to the lake shoreline during the breeding season and are dependent on this narrow riparian zone for moisture and other important habitat features. As the lake level drops, the 5 m band adjacent to the lake shore will become reduced in area due to lake topography. Specifically, the current area of 2.80 ha (Table 10, Section 4.2.1.2) will be reduced to 2.03 ha when water levels are 12 m below the natural water level (Table 34), which is predicted to occur in the middle of June when the majority of egg-laying is expected to have taken place (Figure 16). These losses represent 20.4% of the habitat available in the Ramona Lake basin when the lake is drawn down to 12 m (Table 34).

A reduction in habitat quality within the 5 m band of terrestrial habitat adjacent to the lake is also anticipated to result from water level fluctuations. This narrow band of terrestrial breeding habitat is defined by its proximity to the water and suitable habitat will therefore migrate as water levels drop. As discussed in the original EA (Robertson 2012c), the scouring effects of water and ice will remove organics and the fine scale habitat features in shallow shoreline habitats which are important to salamanders.

Potential effects of water level fluctuations are also anticipated to impact salamander prey species because microhabitat features affected by scouring will likely affect the zooplankton and aquatic invertebrates that represent an important food source for salamanders. However, as discussed in the EA (Robertson 2012c, Section 14.3.4.2.3), there is uncertainty regarding the long-term effect of repeated drawdowns on the local invertebrate community that salamanders prey on. Surveys at nearby Tyson Lake that had experienced its first winter drawdown did not indicate a negative effect of drawdown in terms of macroinvertebrate occurrence and relative abundance for the three main groups captured, and capture rates were higher in the post-drawdown survey year than in the pre-drawdown year (Wind 2010, 2015, pers. comm.). However, effects of repeated drawdowns at Tyson Lake in the long-term are unknown and differences between the two systems make it difficult to predict the extent of change to the invertebrate populations under many years of Project operations in Ramona Lake.

The loss of microhabitat features are therefore predicted to reduce suitability of terrestrial breeding habitat for activities and movement for a variety of reasons including increased predation risk, decreased cover for thermal and moisture regulation, and potentially decreased abundance of prey species. Habitat change due to the loss of important microhabitat features that will occur from shoreline scouring of water and ice will impact all terrestrial breeding habitat lower in elevation than the 5 m band available during baseline conditions and will extend to the lowest drawdown level. Habitat change will be most severe in the higher portions of the lake impacted by water level fluctuations in every year. However, given that the highest water level is predicted to only be achieved in some years and only in late summer (maximum levels in Figure 16), terrestrial breeding habitat is anticipated to be in an altered state during the time of adult use in all years. As a consequence, all habitat that is not lost due to lake topography as water levels drop will be reduced in quality. Thus, of the habitat that remains after drawdown, all moderate and high quality habitats are anticipated to be reduced to low or nil quality because these habitats will no longer have vegetation or cover objects and may have little moisture retention ability (Table 9). Thus, all high and moderate quality habitats of the 2.03 ha remaining when water levels are 12 m below the natural water level are predicted to become reduced to low or nil quality.

Habitat loss and change for terrestrial breeding habitat will be less severe with the new design than it would have been with the original design. In the original design, up to 3.7 ha of riparian/terrestrial habitat was expected to be flooded in some years. Given that the 5 m strip of terrestrial breeding habitat around Ramona Lake was calculated to be 2.80 ha, this flooding would have inundated this entire habitat band adjacent to Ramona Lake in some years. This would have caused erosion and loss of important habitat features, such as vegetation and cover objects. No flooding of terrestrial breeding habitat will occur with the new design. Secondly, in the original design, the lake would have been drawn down to deeper depths in extreme years (minimum original levels in Figure 15); thus more terrestrial habitat would have been lost due to lake topography in such years and the shoreline would have been scoured to deeper depths generating a wider band of altered habitat, because terrestrial breeding habitat is defined as the 5 m band adjacent to the water, and because the reservoir is anticipated to be full only in some years and only in late summer with the new design, all terrestrial breeding habitat available during the egg-laying period would be scoured by either design.

Table 34. Total amount of terrestrial breeding habitat (5 m from lake shore) for adults lost due to loss of area with lake drawdown in Ramona Lake and in the Ramona Lake basin.

Location	Scenario	Habitat Available (ha)[1]	Habitat Loss (ha)	% Habitat Loss in Ramona Lake	% Habitat Loss in Ramona Lake Basin
Ramona Lake basin	at baseline	3.77	-	-	-
Ramona Lake	at baseline	2.80	-	-	-
	at 12 m drawdown	2.03	0.77	27.5	20.4

[1] All habitat quality ranks are included for comparison, including nil quality habitat (0.02 ha in Ramona Lake and in the Ramona Lake basin) because it was not possible to rank habitat quality at drawdown depths.

5.5.2. Change in Behaviour

5.5.2.1. Construction

Change in behavior was not identified as an adverse effect for Aquatic Breeding Salamanders in the original EA. However, some disturbance would have been anticipated during intake construction with the original design similar to that assessed for the Coastal Tailed Frog key indicator due to disturbances at breeding streams (Robertson 2012c, Section 14.3.4.4.3). Salamander adults and larvae occupying terrestrial and aquatic habitats have the potential to be affected by construction activities and this could cause changes in their time and energy budgets. For example, disturbed individuals may take cover or move rather than spending time feeding. Some change in the activity and use of cover objects of Long-toed Salamanders has been reported in response to the presence of predators (unpublished data cited in Pilliod and Fronzuto 2005); thus, similar changes may occur if they are disturbed by humans or machines.

The potential for change in behavior due to disturbance would be reduced with the new design relative to the original because there will be no footprint in aquatic habitat (Section 5.5.1.1) (in contrast to the original design) and because the footprint in terrestrial habitat in the vicinity of Ramona Lake is small (225 m^2; Section 5.5.1.2). However, the infrastructure will be located adjacent to productive high and moderate quality aquatic and terrestrial breeding habitat (Map 3, Map 5). If the entire terrestrial footprint is placed greater than 5 m from the shoreline of Ramona Lake, the potential for disturbance of salamanders occupying either aquatic or terrestrial breeding habitats due to construction footprints with the new design will be greatly reduced. The breakthrough blast that will occur during intake construction with the new design has the potential to cause some disturbance to salamanders in and adjacent to Ramona Lake due to surface vibrations; however, the brevity of this single event suggests that any potential effect would be negligible.

5.5.2.2. Operations

Although also not considered in the original EA, disturbances to larvae and adults are anticipated to result from fluctuating water levels. Because lake water levels will be constantly changing during the breeding period, larvae and adults will be constantly forced to relocate to new surroundings. Adults will need to move in order to remain proximate to the water and larvae will need to adjust their positions to remain within the water and at an appropriate distance from the surface. Familiarity with local surroundings and microhabitat features entail benefits and forced relocation is therefore likely to entail costs. Long-toed Salamanders are highly site faithful and have been reported to have relatively small home ranges, estimated at 115.6 m^2 and 167.5 m^2 for females and males, respectively (Sheppard 1977 cited in Pilliod and Fronzuto 2005), and the homing behavior of individuals traveling to and from breeding ponds has been well established (Beneski *et al.* 1986). Thus, individuals likely reuse suitable cover objects and movement routes and become familiar with suitable foraging locations. Forced relocation would impact factors such as predation risk and time and energy budgets for both larvae and adults and is therefore likely to affect population parameters such as survival rates and reproductive success.

In addition to potential effects of forced relocation, reduced habitat available for both terrestrial and aquatic habitat during lake drawdown due to lake topography (Sections 5.5.1.1 and 5.5.1.2) is anticipated to lead to concentration of individuals into smaller areas and therefore could result in density dependent adverse effects such as competition for prey or cannibalism. Larvae are not known to be territorial but both juveniles and adults can be aggressive in competition for food and cannibalism is known to occur (Anderson 1967, Pilliod and Fronzuto 2005). Although non-breeding adults may be social rather than territorial (Verrell and Davis 2003), competition over resources may lead to the spacing of individuals in breeding areas (Anderson 1967).

Operational effects on change in behavior would have been predicted for both the new and the original design. Effects would have been similar but slightly reduced in severity for the new design relative to the original because more aquatic and terrestrial habitat would be lost with the original design due to lake topography and because the water level fluctuations would have been more extreme in some years leading to potentially greater impacts related to relocation and density dependent factors. Given the lack of available information of direct effects of water level changes on salamander behaviour, it is difficult to predict the results of the operational regime on the salamander population due to continuous forced relocation and density dependent factors.

5.5.3. Increased Mortality

5.5.3.1. Construction

Increased mortality may result during construction of the intake with the new design because the breakthrough blast is anticipated to affect water quality and chemistry in Ramona Lake through sedimentation and introduction of contaminants when the rock plug at the lake tap exit is removed. Potential effects of increased mortality were identified for the operations phase only with the original design. However, intake construction for the original design would also have increased mortality risk of larvae and adults through construction activities associated with footprints in aquatic and terrestrial habitats. Increased mortality and habitat change effects interact because alteration of habitat quality through factors such as sedimentation (as described under Construction of Section 5.5.1.1) impact larvae and egg survival. In order to remain consistent with the approach taken in the original EA, effects of sedimentation during construction were therefore considered a habitat change effect and not an increased mortality effect. However, vibrations associated with the breakthrough blast required for intake construction for the new design have the potential to impact mortality risk.

Vibrations from the breakthrough blast have the potential to affect any aquatic life stage present in Ramona Lake at the time of the blast. Hence, increased mortality effects during the construction period due to the breakthrough blast are anticipated that were not an issue with the original intake design. Eggs are likely to be particularly vulnerable to vibrations from the blast if it occurs during the egg residency period because egg masses could be disturbed and dislodged from the substrate which is likely to result in mortality of embryos. Adults and larvae may also be impacted by the vibrations, and mortality could occur through impact if objects (e.g., rocks, CWD) are dislodged and cause crushing or injury.

5.5.3.2. Operations

Mortality risk is anticipated to increase during operations relative to baseline for all life stages. Increased mortality risks due to operations, and in comparison to the original design, are discussed in detail for eggs, larvae, and adults, in the sections below.

Eggs

As discussed in the original EA and under habitat loss and change in Section 5.5.1.1 above, the greatest mortality risk for Ramona Lake salamanders during Project operations is the mortality risk associated with flooding of egg masses during the egg residency period. Although assessing the direct effects of reservoir operations on amphibian populations is difficult (Hawkes and Tuttle 2013), indirect evidence from studies of amphibians in reservoir systems suggests that water level rises can impact egg survival. There is evidence that increasing water level and timing of inundation affects breeding success and abundance of amphibians in the Kinbasket drawdown zone because low elevation habitats inundated early in the breeding season had lower occupancy than higher elevation ponds that were flooded later (Hawkes and Tuttle 2012, Swan *et al.* 2015). Egg mortality due to flooding or high flow rates have also been reported for the Foothill Yellow-legged Frog (*Rana boylii*) downstream of a dam in Northwester California (Lind *et al.* 1996).

Long-toed Salamanders select specific depths in which to lay eggs that are relatively near to the water surface (egg masses were only observed in Ramona Lake between 4 cm and 160 cm; Table 20). Based on this depth in relation to predicted water level rises during the egg residency period, egg masses from early breeding salamanders (estimated lay date approximately May 25) will be flooded with 10 additional meters of water during the embryonic period, while the egg masses of late breeders (estimated lay date approximately June 15) will be flooded by a 5 m water level rise (Figure 16). As water depth increases, important habitat characteristics, such oxygen levels, light levels, and temperature, will also change which will also affect egg viability. Given this degree of inundation, it is unlikely that any eggs would survive through the embryonic stage.

Given the magnitude of flooding anticipated during the egg residency period, mortality of all eggs (100%) is anticipated within Ramona Lake each year. Although 2015 was considered to be a particularly warm year in which breeding was likely earlier than normal (Sections 4.2.3 and 4.3), as discussed in Section 5.5.1.1, the assumption that all eggs will die in Ramona Lake in all years is reasonable because even if extreme late breeders in years with a delayed breeding season (i.e., cooler spring) laid eggs near the peak of water level rise and avoided some of the effects of inundation during the rising water level phase, water level would then rapidly drop again causing desiccation of any eggs that had survived inundation (Figure 16).

Estimating the proportion of eggs that will be lost within the Ramona Lake basin is best done through comparison of aquatic habitat availability and quality rank because this was evaluated fully for all waterbodies in the basin and thus is unbiased. Further, the density of egg masses was shown to be correlated with pre-assigned habitat quality ranks (Table 25, Section 4.2.2.2) indicating that aquatic habitat quality classification was generally associated with habitat selection by salamanders for egg laying. Because Ramona Lake represents the majority (70%) of egg-laying habitat in the Ramona Lake basin, a minimum of 70% of all egg masses laid in the Ramona Lake basin are predicted to be lost each year (Table 32). Ramona Lake also supports almost the entire high quality aquatic habitat in the Ramona Lake basin (96%) (Table 32) which supports approximately twice as many eggs as low and moderate quality habitat (Table 19, Section 4.2.2.2). Further, the high breeding site fidelity of Long-toed Salamanders suggests that individuals are unlikely to move to more suitable locations but will continue to attempt breeding in Ramona Lake, in which case Ramona Lake may act as an ecological trap (Battin 2004). The increased mortality risk for eggs relative to baseline would not differ between the original and the new design because for both designs, water levels are predicted to rise rapidly during the egg residency period (Figure 15) and would therefore cause mortality of all egg masses.

Increased mortality risk to eggs may also be caused by increased sedimentation through erosion of the lake shore during water level changes. Changes to water quality and potential impacts of such changes on aquatic life stages were assessed under habitat change in Section 5.5.1.1.

Larvae and Adults

Mortality risk of larvae and adult life stages will also be increased during Project operations due to seasonal water level changes. Water levels are predicted to begin to decline in the fall and continue to decline through winter (Figure 16). Thus, larvae overwintering in Ramona Lake will be subject to continued water level declines.

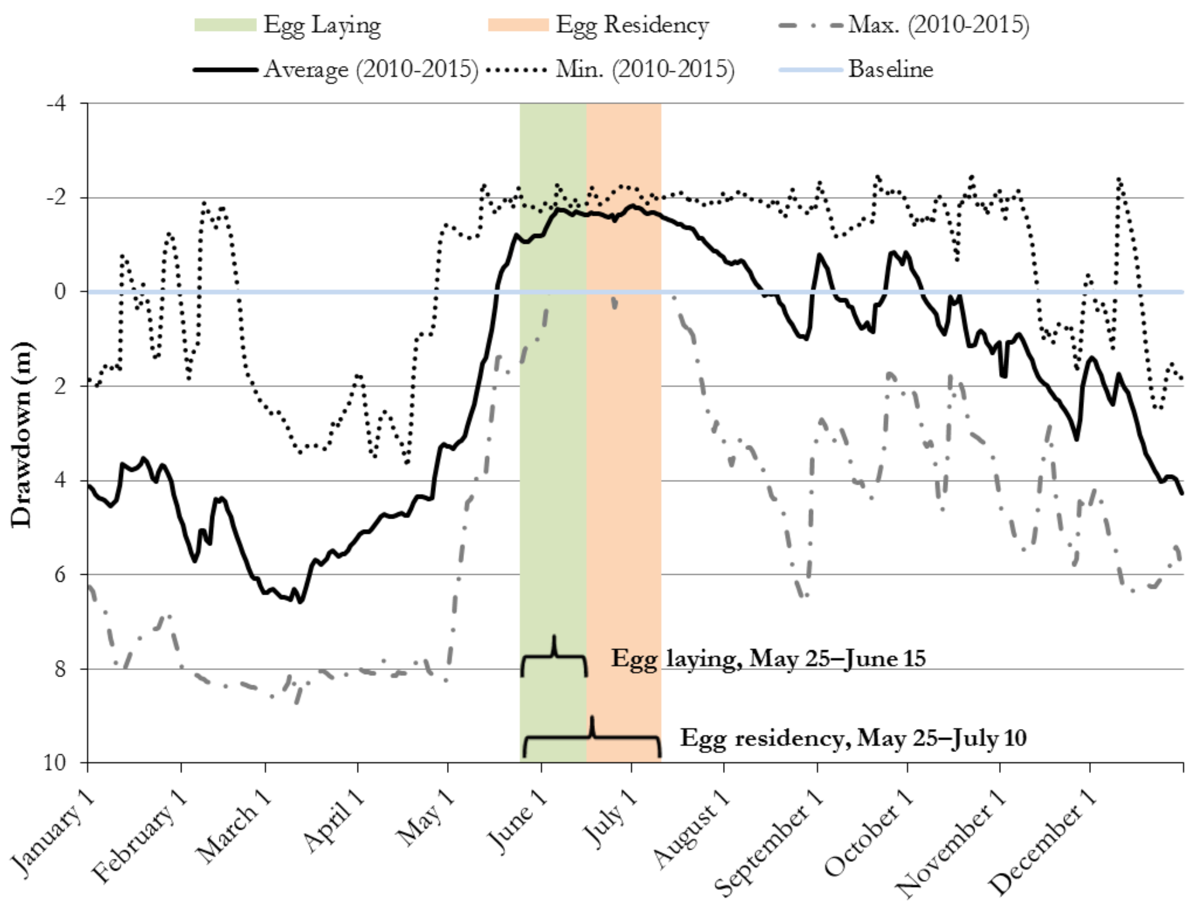
As stated in the original EA (Robertson 2012c, Section 14.3.4.5.3), little is known of the habitat requirements and behaviour of overwintering Long-toed Salamanders. It is reported that over-wintering larvae become less active and retreat under cover objects when water temperatures drop and surface ice forms (Anderson 1967). Further, in high elevation ponds and ephemeral pools that freeze solid during winter, Long-toed Salamander larvae have been observed to move from shallow pools to subsurface springs (Pilliod and Fronzuto 2005). However, their ability to respond to lowering water levels during winter is unknown. Overwintering larvae concealed in crevices or under rocks on the sides of Ramona Lake may be unable to relocate with dropping water levels, and the microhabitat attributes that were selected for overwintering (e.g., temperature, oxygen levels) are likely to change with changing water level. Further, larvae may become exposed to freezing temperatures and dry conditions as the water level drops below their overwintering location. Although surveys at a nearby high elevation lake (Tyson Lake) indicate that the salamander larvae survived after the first winter lake drawdown (Wind 2010, 2015, pers. comm.), the magnitude of drawdowns at this reservoir are substantially less than those expected for Ramona Lake (Figure 17) and the long-term effects of repeated winter drawdowns at Tyson Lake are unknown. Potential mortality effects to breeding adults due to water level changes are also unknown. It is possible that some risk of stranding and drowning may exist in some locations. In light of the scarcity of information regarding larvae behaviour and response ability during winter, and given that larvae are more mobile than eggs, there is greater uncertainly in the assessment of mortality risks for larvae than for eggs; nevertheless, it is likely that mortality risks will be elevated above baseline levels.

The predictions of reduced larvae survival would not differ between Project designs. Although the magnitude of water level fluctuations were predicted to be substantially greater for the original design in extreme years, both designs will have sufficient water level fluctuations that all aquatic habitat available in the fall is likely to become dewatered during late winter.

Mortality risk may also increase because a submerged intake in Ramona Lake may cause entrainment of larvae or adults, and entrainment into the intake pipe of the proposed floating intake pump was also identified as a potential Project effect for the original floating intake design. Although, entrainment into the intake, which may be only 3 m below the water level during full drawdown, is a possible mortality risk for salamander larvae and adults, this risk is low. Salamander larvae were detected at depths between 2 and 96 cm, and therefore would be located above the level of the intake by at least 2 m, during full drawdown. Eggs were located at greatest depth (up to 160 cm below the water surface), thus breeding adults laying eggs may have the highest risk of entrainment. However, given these results, all aquatic habitat would still remain well above the level of the intake. Thus, any potential increases in mortality risk that may be due to intake location are negligible relative to potential mortality risk associated with lake drawdown. Mortality risks associated with entrainment in the originally proposed floating intake would also have been low given that the design included a protective cover (screen) over the intake pipe.

Other mortality risks for larvae and adults include increased predation risk due to changes in microhabitat features and density dependent effects due to shrinkage of habitat area. These effects were assessed under habitat change and change in behavior above.

Figure 17. Egg laying and residency period overlaid onto the Upper Ramona operational regime. Maximum, average, and minimum drawdown depths for the Tyson Lake operating regime for the 5-year period of 2010-2015.



5.6. Mitigation Measures

5.6.1. Habitat Loss and Change

Mitigation prescribed in the original EA to minimize effects of habitat loss and change included implementation of the Surface Water Quality Protection Plan during construction, implementation of measures to minimize sediment loads in the lake during operations (e.g., reduce drawdown rates or depths during storm events) which were later captured in Condition #14 and #15 of the TOC (Table 35), and, where possible, implementation of methods to maintain and facilitate emergent and submerged vegetative growth in Ramona Lake. The first two mitigation measures remain relevant for the protection of water from sedimentation. However, we additionally recommend that a Care of Water Plan, as a component of the Construction Environmental Management Plan (CEMP) (Robert *et al.* 2016), is prepared that will specifically outline measures to mitigate potential water quality impacts during the breakthrough blast, that sedimentation anticipated as a result of the breakthrough blast is contained with a silt curtain, and that risks associated with inorganic nitrogen leaching during blasting are mitigated by using only packaged emulsion or bulk emulsion products (low solubility) and by minimizing the use of ammonium nitrate fuel oil during tunnel and shaft blasting operations but avoiding their use for the breakthrough blast (CanMine 2016).

The effects of aquatic and terrestrial habitat loss and change during operations due to flooding of egg-laying habitat, loss of habitat for larvae with water level decreases resulting from lake topography, and loss of habitat quality due to shoreline scouring cannot be mitigated because these are unavoidable impacts of drawdown. The previously prescribed mitigation to maintain and facilitate vegetation growth in the drawdown zone of Ramona Lake and thereby mitigate the effects of scouring is unlikely to be feasible; thus, it is not anticipated to help minimize effects of habitat loss and change for adults and larvae caused by shoreline scouring.

In summary, the following mitigation, additional to those from the original EA, is prescribed to minimize impacts to water quality and footprint effects:

- A Care of Water Plan will be prepared and implemented that will specifically outline measures to mitigate potential water quality impacts during the final blast, as is required by the CEMP (Robert *et al.* 2016);
- Only packaged emulsion or bulk emulsion products (low solubility) will be used during blasting and the use of ammonium nitrate fuel oil during tunnel and shaft blasting operations will be avoided, consistent with the CEMP (Robert *et al.* 2016), which requires the contractor to prepare an Excavation, Borrowing, Blasting and Metal Leaching/ARD Environmental Protection Plan;
- The implementation of the ML/ARD Management Plan (Lorax 2016);
- A silt curtain will be installed surrounding the approximate location of the breakthrough plume during intake construction (as determined by the Independent Environmental Monitor (IEM)) to contain sediment from the blast and facilitate more rapid settlement;
- The IEM review and oversee all works associated with the breakthrough blast; and
- The permanent and temporary footprint associated with the Alimak building near Ramona Lake will be located greater than 5 m from the natural lake shore of Ramona Lake.

Table 35. Conditions related to drawdown of Ramona Lake specified in Schedule B of the EAC for the Upper Ramona Component (EAO 2016).

<table>
<tr><th>Condition #</th><th>Condition</th></tr>
<tr><td>14</td><td>The Holder may only draw down Ramona Lake in accordance with the following conditions:
(a) the maximum daily drawdown is less than or equal to 1 m/day;
(b) subject to paragraph (c), lake drawdown must be conducted in order to allow lake levels to be at the following levels during the listed year of operations:
<table>
<tr><th>Year</th><th>Drawdown Level</th></tr>
<tr><td>1</td><td>(i) above 1361 m above sea level (masl) on October 1st; and
(ii) not less than 1353 masl for the remainder of that year.</td></tr>
<tr><td>2</td><td>A maximum lake drawdown of 16 m from the natural lake level (1,363 masl) which is to be determined in year 1.</td></tr>
</table>
(c) in years 3 and following, no incremental lake drawdown may be conducted unless approved by FLNR and the maximum drawdown for Ramona Lake must not exceed 45 m; and
(d) the Holder must not draw down Ramona Lake if at any time the total suspended solids (TSS) values measured at the outlet monitoring points specified below in Condition 15 exceed site specific water quality guidelines for freshwater aquatic life (BC Water Quality Guidelines).</td></tr>
<tr><td>15</td><td>The Holder must develop and implement a water quality and lake level monitoring program at Ramona Lake to the satisfaction of FLNR. All monitoring instrumentation associated with this program must be installed and be operational prior to the start of operations. The water quality parameters must include temperature, TSS and nutrients. The monitoring program must include the following:
• at least one water quality monitoring station at the Upper Ramona tailrace, and one station at the Ramona Lake outlet;
• the frequency and location of temperature and nutrient monitoring must be determined by a QP;
• at least one lake level monitoring station in Ramona Lake at the Lake pump/intake structure;
• a minimum turbidity monitoring frequency of every 30 minutes;
• a minimum lake level monitoring frequency of every 1 hour; and
• turbidity trigger levels at which operational responses (to be specified by FLNR) and supplemental TSS sampling are carried out.</td></tr>
</table>

5.6.2. Change in Behaviour

Change in behavior was not identified as an adverse effect for Aquatic Breeding Salamanders in the original EA thus no mitigation was previously prescribed. Change in behavior is nevertheless anticipated to result primarily from forced relocation and density dependent factors due to constantly changing water levels in Ramona Lake during operations and would have also resulted from the original design. However, these effects cannot be mitigated because changes in the location of the shoreline and the shrinkage of area when water levels drop are unavoidable impacts of drawdown. Effects on behavior due to disturbance during construction of the Alimak shaft and building can be mitigated by keeping all construction boundaries further than 5 m from the lake shore.

In summary, the following mitigation is prescribed to avoid disturbance impacts during construction:

- The permanent and temporary footprint associated with the Alimak building near Ramona Lake will be placed greater than 5 m from the natural lake shore of Ramona Lake.

5.6.3. Increased Mortality

Mitigation prescribed in the original EA to minimize effects of increased mortality included implementation of methods to maintain and facilitate emergent and submerged vegetative growth in Ramona Lake and gradual intake start-up to avoid sudden suction. As stated in Section 5.6.1 above, the first mitigation is unlikely to be feasible. The second mitigation is less relevant than with the previous design because the intake is no longer surface mounted but is submerged below the habitat zones of all life stages.

Mortality risk associated with flooding of eggs and stranding of overwintering larvae during operations cannot be mitigated because seasonal changes in water levels are unavoidable impacts of the operational regime. However, mitigation measures are recommended to minimize potential mortality effects resulting from sedimentation and vibrations associated with the breakthrough blast during intake construction. The following mitigation measures are prescribed to protect eggs and larvae during intake construction:

- The breakthrough blast will not occur between May 25 and July 10 when egg masses may be present in Ramona Lake, unless otherwise approved by a QP. Timing will be based on timing of breeding information collected for the current salamander breeding season;
- A silt curtain will be installed surrounding the approximate location of the breakthrough plume (as determined by the IEM) to contain sediment from the blast and facilitate more rapid settlement;
- Salvage of salamander larvae will be conducted within the silt curtain immediately prior to the breakthrough blast to minimize potential effects of water quality reductions and vibrations on larvae; and

- Salvage of salamander adults will be conducted prior to the daylighting of the Alimak shaft and within the clearing boundary of the Alimak building prior to associated works proceeding.

5.7. Residual Effects and Determination of Significance

Given the prescribed mitigation, residual effects were assessed for each potential adverse effect and compared to conclusions from the original EA (Robertson 2012c). Residual effects are summarized in Table 36.

Table 36. Residual adverse Project effects evaluated and characterized for the original and updated EA. Changes in conclusions are highlighted in grey.

Project Effect	Phase	Original or Updated EA	Residual Effects	Extent	Magnitude	Duration	Frequency	Reversibility	Ecological Context	Significance	Likelihood	Confidence
Habitat Loss and Change[1]	Construction	Original	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Updated	Yes	Ramona Lake	Low	Short	Once	Reversible	Undisturbed	n/a	n/a	n/a
	Operation	Original	Yes	Ramona Lake	Moderate	Long	Regular	Reversible	Undisturbed	Not Significant	n/a	n/a
		Updated	Yes	Ramona Lake	High	Long	Regular	Reversible	Undisturbed	Significant	Moderate	Moderate
Change in Behaviour	Construction	Original	*Not identified as an adverse effect.*									
		Updated	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operation	Original	*Not identified as an adverse effect.*									
		Updated	Yes	Ramona Lake	Moderate	Long	Regular	Reversible	Undisturbed	Not Significant	n/a	n/a
Increased Mortality	Construction	Original	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Updated	Yes	Ramona Lake	Low	Short	Once	Reversible	Undisturbed	n/a	n/a	n/a
	Operation	Original	Yes	Ramona Lake	Moderate	Long	Regular	Reversible	Undisturbed	Not Significant	n/a	n/a
		Updated	Yes	Ramona Lake	High	Long	Regular	Irreversible	Undisturbed	Significant	High	Moderate

[1] Habitat loss and change were considered separate effects in the original EA and combined into a single effect in the updated EA. There was no difference in the characterization of residual effects between habitat loss and habitat change in the original EA.

5.7.1. Habitat Loss and Change

In the original EA, no residual effects were anticipated for habitat loss and change during Project construction. This was based on minimal construction in salamander habitat and on the implementation of the CEMP Surface Water Quality Protection Plan. With the new intake design, no footprint effects are anticipated within aquatic or terrestrial breeding habitat given mitigation to locate the Alimak building footprint greater than 5 m from the natural lake shore of Ramona Lake. However, sedimentation and the potential introduction of contaminants into Ramona Lake are nevertheless anticipated to result from the breakthrough blast causing a change in habitat quality. Proposed mitigation for implementation of a silt curtain will minimize effects of sedimentation within Ramona Lake and increase the speed of sediment settling, and mitigation is also prescribed to minimize the potential for contamination. However, although these mitigation measures will reduce impacts to habitat quality, the effects cannot be entirely mitigated. Thus, non-significant residual effects are characterized to be low in magnitude, within the Ramona Lake basin, short-term in duration, acting once, reversible, and acting in an undisturbed ecological context. These conclusions differ from those of the original EA because construction with the original design was not anticipated to affect water quality.

For Project operations, residual effects for habitat loss and change were anticipated in the original EA due to water level fluctuations and the resultant scouring that will impact valuable habitat features along the lake shore. Residual effects of both habitat loss and change were originally characterized to be moderate in magnitude assuming additional habitat availability in the LAA (including Ramona 1 and Ramona 2 that are not impacted by the Project). However, habitat mapping in 2015 has indicated that Ramona Lake represents the majority of the habitat available in the Ramona Lake basin (70%) and the great majority of high quality habitat (96%). Thus, the magnitude of the residual effect of habitat loss and change is now evaluated to be high because the effect is expected to exceed accepted standards and to cause a measurable change well beyond natural variability. The other characteristics of the residual effects, with the exception of significance, remain unchanged from those assessed in the original EA. The geographic extent is within the Ramona Lake basin, the duration is long-term, frequency is on a regular basis, the effect is reversible if the Project is decommissioned, and the ecological context is undisturbed.

Residual effects for habitat loss and change during operations were originally classified as non-significant. This evaluation was based on evidence from Tyson Lake that some salamanders and aquatic macroinvertebrates had survived their first winter of drawdown, that major declines of the species were not expected within the Ramona watershed or the Tzoonie watershed, and that the species is relatively common and robust in lake and wetland systems in coastal BC. However, following habitat mapping within the Ramona Lake basin, the residual effects of habitat loss and change are now re-evaluated as significant. This evaluation is based on: 1) Ramona Lake supports 70% of the total aquatic habitat within the Ramona Lake basin and 96% of the high quality habitat (the original EA assumed that surrounding systems provided more suitable habitat and use); 2) Tyson Lake water level fluctuations are smaller in magnitude and relatively stable during the egg residency period (Figure 17) compared to Ramona Lake (Figure 16), and the Tyson Lake salamander population may therefore be more able to withstand its effects; 3) mitigation to maintain and facilitate emergent and submerged vegetative growth which the original EA assumed is not feasible; 4) a substantial impact to the population of Long-toed Salamanders in the Ramona Lake basin is anticipated based on the high proportion of habitat affected; and 5) population size and degree of isolation, which are associated with population viability and genetic diversity, may impart particular risk and value to small and isolated populations.

This evaluation of significance was made with moderate likelihood and confidence because although little direct and quantitative information exists on the effects of reservoirs on salamander habitat, the scouring and flooding effects of reservoirs and habitat preferences of salamanders are well documented. The evaluation of significance applies only to the isolated Ramona Lake basin Long-toed Salamander population. Populations in broader spatial context will not be put at risk by Project development, for example within the Tzoonie River watershed. However, small isolated populations tend to diverge genetically from populations with higher connectivity and therefore have particular genetic diversity value (Section 3.2.2). The contribution of genetic diversity to the species by the isolated Ramona Lake population is unknown.

5.7.2. Change in Behaviour

Change in behavior was not identified as an adverse effect for Aquatic Breeding Salamanders in the original EA. Thus, residual effects were not evaluated for either construction or operations although the effects identified in this updated EA would have equally applied to the original design.

No residual effects are anticipated for change in behavior during construction. Since there will be no footprint in aquatic habitat, and given mitigation that the footprint in terrestrial habitat in the vicinity of Ramona Lake will not fall within 5 m of the natural lake shore, there will no potential for disturbance of salamanders occupying aquatic and terrestrial breeding habitats due to construction footprints with the new design. Further, any potential disturbance that the breakthrough blast may cause is anticipated to be negligible.

Given that mitigation for change in behavior resulting from forced relocation and density dependent factors due to constantly changing water levels in Ramona Lake during Project operations is not possible, residual effects for change in behavior are anticipated during operations. These are anticipated to be moderate in magnitude, within the Ramona Lake basin, long-term in duration, on a regular basis, reversible if the Project is decommissioned, and acting in an undisturbed ecological context. The magnitude was evaluated to be moderate because changing water levels and forced movement of adults and larvae is likely to cause a measurable change considerably above baseline and above accepted standards. The residual effect is evaluated to be non-significant.

5.7.3. Increased Mortality

No residual effects were anticipated for increased mortality during Project construction in the original EA. With the new design, and given prescribed mitigation, no infrastructure footprint exists within aquatic or terrestrial breeding habitat thus there is little potential for morality from construction activity. However, the breakthrough blast has the potential to cause mortality to eggs and larvae through vibrations because eggs may be disturbed and become dislodged from their substrates and larvae may be crushed or injured if objects are dislodged. Prescribed mitigation measures include conducting the blasting event outside of the sensitive egg residency period, unless approved by a QP, and salvaging larvae within the silt curtain immediately prior to the blast. However, although these mitigation measures will reduce the potential for increased mortality, the effects cannot be entirely mitigated. Salvage of larvae is unlikely to be exhaustive and although salvage within the silt curtain will target those individuals at greatest risk, effects of the vibrations will extend beyond the silt curtain within which the salvage will be conducted. Thus, non-significant residual effects are anticipated that are low in magnitude, within the Ramona Lake basin, short-term in duration, acting once, reversible, and acting in an undisturbed ecological context. These conclusions differ from those of the original EA because a breakthrough blast was not required for the original design.

Residual effects for increased mortality were anticipated in the original EA for Project operations due to the potential for water level fluctuations to affect survival probability of eggs and overwintering larvae. Residual effects of increased mortality were originally characterized to be moderate in magnitude because some salamanders were thought to be able to survive in Ramona Lake and it was believed that the local population may be sustained through breeding and overwintering at adjacent small lakes. However, habitat mapping in 2015 has indicated that Ramona Lake represents the majority of the habitat available in the Ramona Lake basin for eggs and larvae and that a minimum of 70% of all eggs in the Ramona Lake basin will likely not survive each year. Further, the magnitude and timing of water level rises predicted during the egg residency period indicates that all eggs laid in Ramona Lake will die in most years. Thus, the magnitude of the residual effect of increased mortality is now evaluated to be high because the effect is expected to exceed accepted standards and to cause a measurable change well beyond natural variability. Further, the effect is now considered to be irreversible because the population is not expected to persist given the magnitude of these mortality impacts (see Section 7.4.1). The other characteristics of the residual effects, with the exception of significance, remain unchanged from those assessed in the original EA. The geographic extent is with the Ramona Lake basin, the duration is long-term, frequency is on a regular basis, and the ecological context is undisturbed.

Residual effects for increased mortality were originally classified as non-significant. This evaluation was based on evidence from Tyson Lake that some salamanders had survived their first winter of drawdown, that major declines of the species were not expected within the Ramona watershed or the Tzoonie watershed, and that the species is relatively common and robust in lake and wetland systems in coastal BC. However, following habitat mapping within the Ramona Lake basin, and in consideration of the magnitude of the predicted flooding of eggs throughout the egg residency period, with all egg masses anticipated to be flooded by at least 5 m of water, the residual effects of habitat loss and change are now re-evaluated as significant. Comparisons to the Tyson Lake seasonal water level changes (Figure 17) indicated that, and assuming similar timing of breeding at Tyson

Lake as at Ramona Lake, water levels during the peak egg residency period (month of June) are stable; hence, little egg mortality due to water level fluctuations would be predicted.

The evaluation of significance for the effect of increased mortality is based on: 1) Ramona Lake supports 70% of the total aquatic habitat within the Ramona Lake basin and 96% of the high quality habitat (the latter of which supports twice the density of egg masses as other habitat ranks); thus it is predicted that at least 70% of all egg masses from the population will die each year (the original EA assumed that surrounding systems provided more suitable habitat and use); 2) Tyson Lake water levels are stable during the peak egg residency period (month of June; Figure 17); thus, this system is not comparable to Ramona Lake with regards to egg mortality risk; 3) water level fluctuations in Tyson Lake are smaller in magnitude than those predicted for Ramona Lake (Figure 17 compared to Figure 16) and overwintering larvae may therefore be more able to withstand its effects; 4) given the high predicted mortality of egg masses for the population, Ramona Lake may act as an ecological trap because eggs may be laid in a location where they cannot survive; 5) a substantial impact to the population of Long-toed Salamanders in the Ramona Lake basin is anticipated based on the high proportion of eggs that will be affected; and 6) population size and degree of isolation, which are associated with population viability and genetic diversity, may impart particular risk and biodiversity value to this population. This evaluation of significance was made with high likelihood and moderate confidence because although little direct and quantitative information exists on the effects of reservoirs on the survival of the salamander life stages, the flooding effects of reservoirs and habitat preferences of salamanders are well documented. The evaluation of significance applies only to the isolated Ramona Lake basin Long-toed Salamander population, and populations in broader spatial context, such as the Tzoonie River watershed, will not be put at risk by Project development. However, small isolated populations tend to diverge genetically from populations with higher connectivity and therefore have particular genetic diversity value (Section 3.2.2). The contribution of genetic diversity to the species by the isolated Ramona Lake population is unknown.

6. OFFSETTING

A compensation/offsetting plan will be developed and implemented to provide compensation for the loss of high quality habitat and for impacts from egg-mass mortality. This plan will be developed at a later date, to the satisfaction of FLNR.

7. STATUS OF CONDITION #2 OF THE TOC

Of the five parts in Condition #2 of the TOC, requirements specified in the first four (2a through 2d) have now been met. The fifth requirement (2e) is outstanding. These conditions, their status, and how their requirements have been met, are described in the sections below.

7.1. Habitat Availability (Condition 2a)

Condition #2a in the TOC states that the Holder must "*Determine the habitat for aquatic breeding salamanders using a QP.*" Habitat mapping for Long-toed Salamanders was conducted in 2015 by a QP using a combination of desk-top mapping and field verification. Aquatic habitat used by larvae, eggs, and adults during courtship and egg laying, and terrestrial breeding habitat, defined as terrestrial habitat within 5 m of the lake shore, were identified and quantified for the Ramona Lake basin and habitat was ranked for quality. Occupancy of salamanders in waterbodies in the Ramona Lake basin (Ramona Lake, Ramona 1, Ramona 2, small pools in the vicinity of the lakes) was determined by reconnaissance and systematic inventory surveys. Systematic surveys were also used to evaluate relative abundance of eggs, larvae, and adults and to determine whether habitat quality ranks were associated with measures of productivity. These inventory studies (methods and results presented in Sections 4.1 and 4.2, respectively) therefore determined habitat for Aquatic Breeding Salamanders in the Ramona Lake basin and the requirements of Condition #2a have thereby been met.

7.2. Risk of Egg-mass Stranding (Condition 2b)

Condition #2b in the TOC states that the Holder must "*Evaluate the risk of egg mass stranding resulting from lake drawdown during the period from egg-laying to hatching for that area using a QP.*" The risk of egg mass stranding (or flooding) was evaluated by determining the breeding period of Long-toed Salamanders in the Ramona Lake basin and relating this to the predicted pattern of water level changes during Project operations. Field reconnaissance and systematic surveys, conducted by a QP during the 2015 breeding season, determined that the egg laying period (period in which adults are laying eggs) extended from May 25 to June 15, and that the egg residency period (period during which eggs are developing) extended from May 25 to July 10 (Section 4.2.2.2). Comparison of these breeding periods with predicted operational water level fluctuations indicated that eggs would be flooded by at least a 5 m water level rise regardless of when during the egg laying period they were laid (Figure 16). Further, given that 2015 was an unusually warm year, egg mass mortality was also evaluated if breeding occurred later. Even if extreme late breeders in years with a delayed breeding season (i.e., cooler spring) laid eggs near the peak of water level rise and avoided some of the effects of inundation during the rising water level phase, water level would then rapidly drop again causing desiccation of any eggs that had survived inundation. Thus, it was determined that flooding (or rarely desiccation) would impact 100% of Long-toed Salamander eggs in Ramona Lake, and at least 70% of the eggs in the Ramona Lake basin, given that some breeding was observed in Ramona 1 and 2. Based on the magnitude of water level fluctuations, it was predicted that no eggs in Ramona Lake would survive in any year. These results therefore evaluated the mortality risk of eggs in

Ramona Lake due to Project operations and the requirements of Condition #2b have thereby been met.

7.3. Habitat Quantity and Quality and Potential Loss (Condition 2c)

Condition #2c in the TOC states that the Holder must "*Submit a report to FLNR documenting habitat quantity and quality for salamanders, and potential habitat loss resulting from lake drawdown and lake surcharge.*" This report documents the methods and results of baseline inventory studies conducted in 2015 and also provides an updated effects assessment given the results of these studies. Habitat quantity and quality has been evaluated (as described in Section 4.2.1) and the effects of habitat loss and change were assessed for Project construction and operations for both aquatic and terrestrial habitat (Sections 5.5.1 and 5.7.1). This report therefore meets the requirements of Condition #2c.

7.4. Egg-mass Mortality and Population-level Impacts (Condition 2d)

Condition #2d in the TOC states that the Holder must "*Submit a report to FLNR documenting risk of egg mass mortality and related population-level impacts from project operations.*" This report evaluates the risk of egg mass mortality (as described in Section 7.2). Population-level impacts from Project operations have been evaluated in the section below. This report therefore meets the requirements of Condition #2d.

7.4.1. Population-level Impacts of Project Operations

Following habitat mapping within the Ramona Lake basin, and in consideration of the magnitude of water level increases throughout the egg residency period, significant, irreversible residual effects of high magnitude have been assessed for increased mortality during Project operations (Section 5.7.3). Significant effects of high magnitude have also been identified for aquatic habitat loss and change due to substantial flooding of egg-laying habitat through the breeding period (Section 5.7.1). Other identified effects during Project operations such as habitat loss and change for both aquatic and terrestrial habitat due to a shrinkage in available area with decreasing water level, scouring of the lake sides by water and ice, and water quality reductions, as well as mortality of overwintering larvae due to water level decreases in winter, were also identified that may contribute to population-level impacts. However, the greatest impact on the population is the predicted loss of 100% of eggs in Ramona Lake every year due to water level changes during the egg residency period. Because water level changes are unavoidable for the hydroelectric reservoir, mitigation is not possible. In contrast, fewer potential adverse effects were identified for Project construction and these were more amenable to mitigation.

The mortality of all eggs in Ramona Lake during each breeding season, in combination with the risk that Ramona Lake may become an ecological trap (Battin 2004), suggests that population effects will be substantial. Results from habitat mapping in combination with the timing of predicted water level change indicate that Ramona Lake supports 70% of the aquatic breeding habitat in the Ramona Lake basin. Thus, at least 70% of egg masses from the Ramona Lake basin Long-toed Salamander population will be lost in all years. Further, 96% of all high quality habitat in the Ramona Lake basin occurs in Ramona Lake, which supports twice the density of egg masses as other habitat ranks (Section 4.2.2.2). This suggests that within one generation, approximately 70% of the population will be lost. In addition to these losses, Ramona Lake may become an ecological trap because if eggs are laid in Ramona Lake they will not survive. Thus, any dispersing individuals from the nearby Ramona 1 and 2 (e.g., newly metamorphed individuals; Pilliod and Fronzuto 2005) will also fail if they attempt to breed in Ramona Lake. It is also possible that, given the reduction in terrestrial breeding habitat quality for adult salamanders due to the scouring effects of water level changes (Section 5.5.1.2), salamanders will not attempt to breed in Ramona Lake and some will move to Ramona 1 or Ramona 2. However, the high breeding site fidelity of Long-toed Salamanders (Funk and Dunlap 1999) suggests that current Ramona Lake breeders are unlikely to attempt to move to more suitable locations but will instead continue to attempt breeding in Ramona Lake where they will experience complete reproductive failure.

It is anticipated that the population of Long-toed Salamanders will not persist in the Ramona Lake basin (i.e., Ramona Lake, Ramona 1, and Ramona 2) after the Project becomes operational given that at least 70% of individuals are expected to be lost and that little high quality habitat (4%) was identified in the Ramona Lake basin outside of Ramona Lake. However, it is not possible to predict the probability of persistence or minimal viable population size for this population because this would require a good understanding of many complex population and environmental factors (Soulé and Simberloff 1986). Nevertheless, it is assumed that the Ramona Lake population is particularly vulnerable due to its small size and isolation. Small isolated populations are especially vulnerable to extinction owing to demographic and environmental stochasticity and genetic factors (Lande 1988, 1993, 1994, Soulé and Simberloff 1986, Lynch *et al.* 1995). Because Long-toed Salamander females typically lay eggs in multiple clutches (Pilliod and Fronzuto 2005, Matsuda *et al.* 2006), a crude estimation of the population size is best made by a count of adults. Systematic surveys detected 20 adults while surveying approximately 15-30% of available breeding habitat. Thus, although limitations of the study (see Section 4.1.2.2) indicate that substantial uncertainty exists, and assuming imperfect detectability, the baseline number of adults is estimated roughly on the order of 100 to 200 individuals. Thus, the breeding population of the Ramona Lake basin is already of a vulnerable size without Project effects (Lande 1988, Lynch *et al.* 1995) and it is not expected to persist following a 70% reduction in size, even if assuming substantial uncertainty in our estimates.

The Ramona Lake basin Long-toed Salamander population will therefore be put at high risk by Project operations. This risk applies only to this isolated population and populations in broader spatial context will not be put at risk by Project development. Long-toed Salamanders populations are provincially secure (Yellow-listed) (CDC 2015) and occupy a wide range of habitats. The species has been demonstrated to preferential use forested habitats with high canopy cover and abundant wood-based cover and litter (DeMaynadier and Hunter 1998). However, it is unknown how the loss of this small isolated population may affect population genetics in a broader context.

7.5. Compensation Plan (Condition 2e)

Condition #2e in the TOC states that the Holder must "*Develop and implement a compensation plan for the loss of high quality habitat for aquatic breeding salamanders, and for impact from egg mass mortality. The plan, including any proposed changes, must be prepared and implemented to the satisfaction of FLNR.*" Development of the compensation plan was not an objective of this report and will be completed in collaboration with Ministry of Forests, Lands and Natural Resource Operations (FLNR). Thus, the requirements specified in Condition #2e are outstanding.

8. CONCLUSION

The aquatic and terrestrial habitat for Long-toed Salamanders in the Ramona Lake basin was evaluated and quantified through habitat mapping, and targeted reconnaissance and systematic inventory surveys were conducted for all three life stages: adults, eggs, and larvae. These inventory studies were required by Condition #2 of the TOC, which specifies that additional assessments must be made with regard to habitat availability and loss, egg mortality risk, population-level risk, and compensation requirements. In addition, Project effects needed to be re-assessed in light of design modifications that have the potential to modify conclusions from the original EA. Accordingly, the objectives of this report were to present baseline inventory results and provide an updated assessment of Project effects on Long-toed Salamanders in light of additional biological information and in comparison to the EA conducted for the original design. Long-toed Salamanders represent the Aquatic Breeding Salamander key indicator of the Amphibians & Reptiles VC identified in the original EA (Robertson 2012c).

Inventory studies determined that Ramona Lake is the primary breeding pond for Long-toed Salamanders in the Ramona Lake basin. It was calculated that Ramona Lake supports 70% of all aquatic breeding habitat in the basin and 96% of the high quality habitat, which has twice the density of egg masses as other quality ranks. Two small upper lakes, Ramona 1 and Ramona 2, also support some salamander breeding, but the small pools in the vicinity of the lakes do not.

The Project is expected to have adverse effects on Long-toed Salamanders through habitat loss and change, change in behaviour, and increased mortality. Among these, operational effects on aquatic habitat and egg-mass mortality are anticipated to be most severe, resulting in the loss of 70% of all aquatic habitat, and 96% of all high quality habitat, available in the Ramona Lake basin due to water level rises during the egg residency period. Water level rises during the breeding period are also anticipated to result in the mortality of at least 70% of all the eggs in the Ramona Lake basin every year. Given that effects resulting from operational fluctuations in water level cannot be mitigated and based on the likely consequence of such effects to the population, these predictions resulted in the identification of significant residual effects that are high in magnitude for both habitat loss and change and increased mortality, and that are irreversible for increased mortality because the population is not expected to persist under the proposed operating regime. These conclusions differed from those of the original EA where residual effects were considered non-significant, moderate in magnitude and reversible because the value of Ramona Lake to the population had not been quantified through habitat mapping and systematic surveys.

Other effects of habitat loss and change and increased mortality were also identified for Project operations. The loss of aquatic habitat for larvae with lake drawdown due to lake topography, reduced habitat quality for larvae within the lake drawdown zone due to scouring and loss of microhabitat features, and water quality reduction due to scouring and erosion also contribute to effects of habitat loss and change; however, flooding of egg-laying habitat was assessed as the most severe impact. Similarly, although egg mortality due to rising water levels during the breeding season is the most severe cause of increased mortality, water level changes are also anticipated to increase mortality risk to overwintering larvae, which may become exposed to freezing temperatures, and adults, that may become stranded.

During construction, water quality reductions owing to the effects of the breakthrough blast are anticipated that will change habitat quality, and vibrations have the potential to increase mortality risk. Non-significant residual effects of low magnitude were anticipated for habitat loss and change and for increased mortality risk for construction, which differed from conclusions of the original EA due to the change in construction activities associated with the new design.

Change in behavior due to disturbance was not identified as an adverse effect for Aquatic Breeding Salamanders in the original EA although the potential for disturbance exists for both designs. The updated EA concluded that change in behavior may occur during construction due to construction of the Alimak building and potentially from vibrations from the breakthrough blast, although residual effects were not anticipated given mitigation that the Alimak building footprint is located more than 5 m from the shore of Ramona Lake. Change in behavior is anticipated during operations because constantly shifting water levels will to force adults and larvae out of established home ranges, potentially affecting survival rates and reproductive success, and concentrating individuals into smaller areas, potentially resulting in competition for resources. Given that mitigation for constantly changing water levels is not possible, non-significant residual effects for change in behavior are anticipated during operations that are moderate in magnitude, within the Ramona Lake basin, long-term in duration, on a regular basis, reversible if the Project is decommissioned, and acting in an undisturbed ecological context.

Population-level effects of Project operations were evaluated in light of residual effects identified in the updated EA and in accordance with requirements of Condition #2 of the TOC. Based on the magnitude of predicted egg-mass mortality, the inability to mitigate Project effects, and the current size and isolation of the population of Long-toed Salamanders in the Ramona Lake basin, the population is not expected to persist after the Project becomes operational. A crude estimate of population size based on systematic surveys in an estimated proportion of breeding habitat, and assuming imperfect detectability, was that the population contains roughly on the order of 100 to 200 individuals. Complete reproductive failure by 70% of the population each year in Ramona Lake, in combination with the risk that Ramona Lake may become an ecological trap, suggests that the population will not persist, even if assuming substantial uncertainty in our estimates. This prediction refers only to the Ramona Lake basin population, and populations in broader spatial context will not be put at risk by Project development (i.e., populations within the Tzoonie River watershed). However, because small isolated populations tend to diverge genetically, the contribution of genetic diversity by the isolated Ramona Lake population is unknown.

The status of the requirements of Condition #2 of the TOC was evaluated. Of the five requirements, the first four (2a through 2d) have now been met. These require the determination of habitat quality and quantity for Aquatic Breeding Salamanders, assessing the risk of egg mortality, evaluation of population-level impacts, and submitting a report to FLNR to document these effects. The fifth requirement (2e), which requires that a compensation plan be developed and implemented, will be presented in a stand-alone report following discussions with FLNR.

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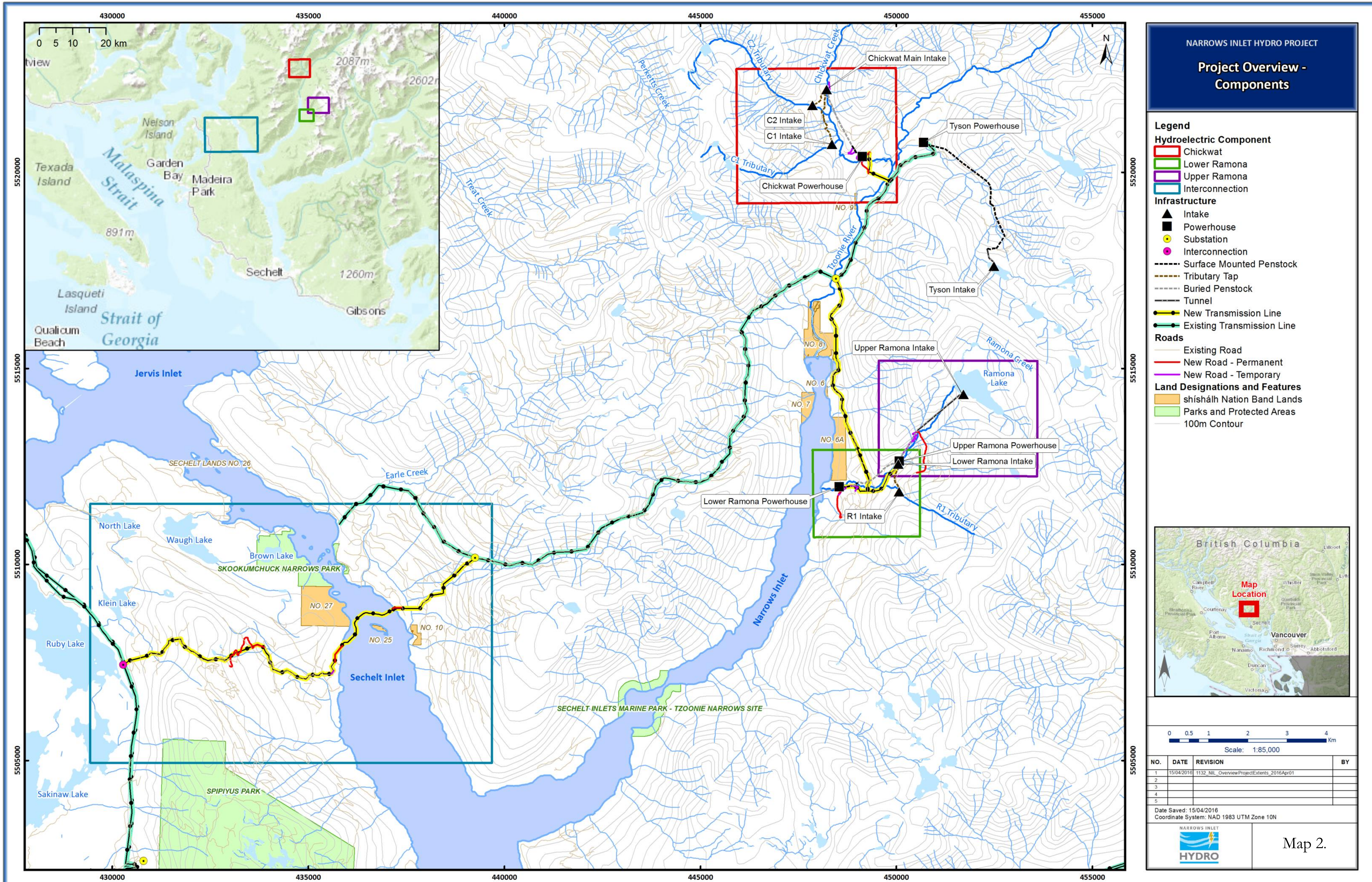
PROJECT MAPS



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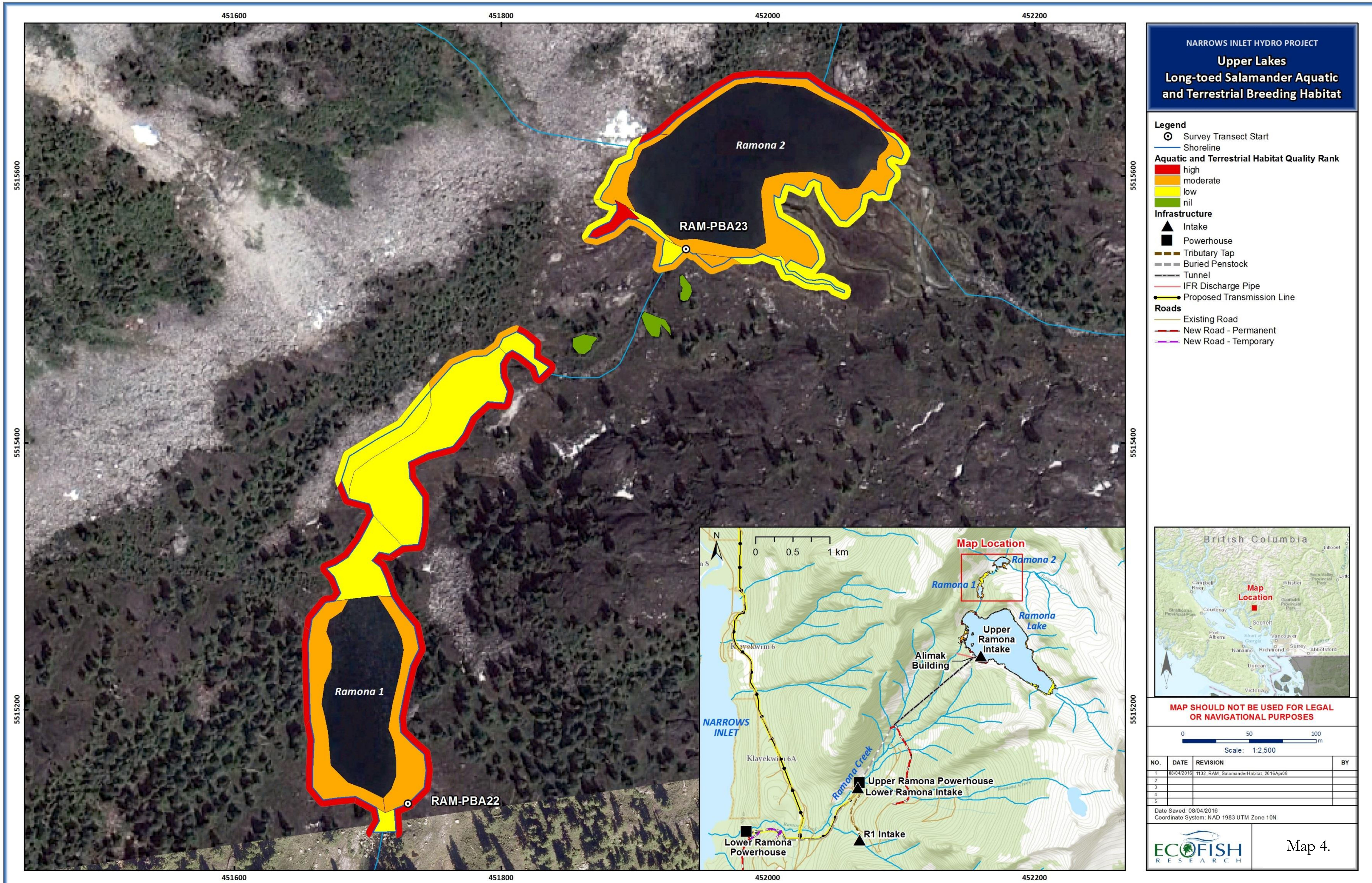

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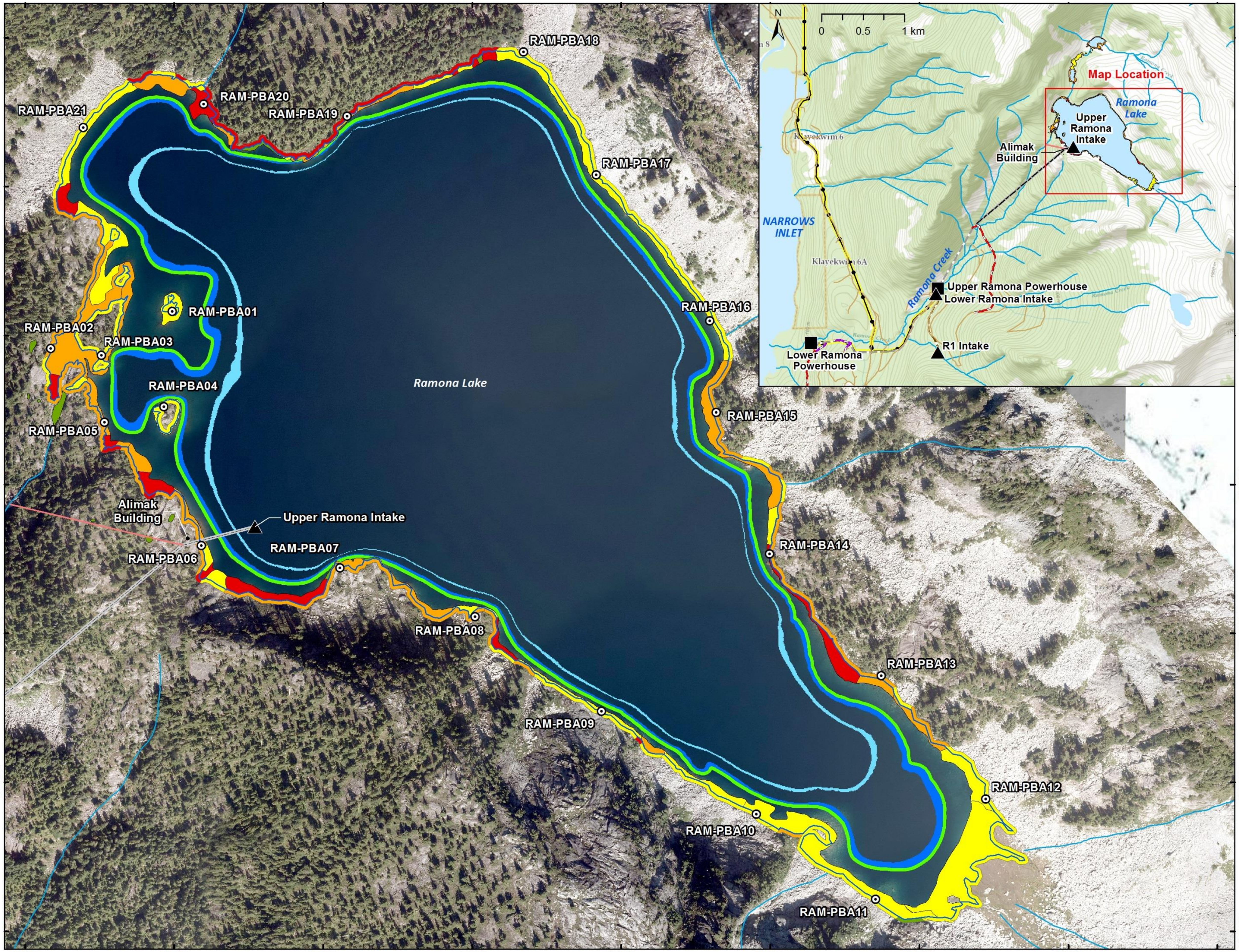
NARROWS INLET HYDRO PROJECT

Predicted changes to Ramona Lake Long-toed Salamander Aquatic and Terrestrial Breeding Habitat



Legend

- Survey Transect Start
- Shoreline

Aquatic and Terrestrial Habitat Quality Rank

Current Habitat

- high
- moderate
- low
- nil

Predicted Habitat Change

- Aquatic Habitat band at 23 m drawdown (1338.25 m - 1340 m)
- Aquatic Habitat band at 12 m drawdown (1349.25 m - 1351 m)
- Terrestrial Habitat band at 12 m drawdown (1351 m - 5 m horizontal)

Infrastructure

- Intake
- Powerhouse
- Tributary Tap
- Buried Penstock
- Tunnel
- IFR Discharge Pipe
- Proposed Transmission Line

Roads

- Existing Road
- New Road - Permanent
- New Road - Temporary

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 50 100 200 m

Scale: 1:5,000

NO.	DATE	REVISION	BY
1	08/04/2016	1132_RAM_PredictedChanges_SalmanderHabitat_2016Apr08	
2			
3			
4			
5			

Date Saved: 08/04/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 6.

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