November 21, 2014 Reference No. 1314470516-021-L-Rev0

Toby Seward, Community Development and Protective Services
City of Nanaimo
455 Wallace Street
Nanaimo, BC
V9R 5J6

COLLIERY DAMS, NANAIMO BC
CONSEQUENCE CLASSIFICATION

Dear Mr. Seward,

1.0 INTRODUCTION

As requested, this letter has been prepared to outline the proposed Dam Classification for the Middle and Lower Colliery Dams in Nanaimo, BC. The proposed classification, and basis for the classification, was addressed in the course of a number of meetings held between Golder Associates Ltd. (Golder), the Dam Safety Section of the Ministry of Forests Lands and Natural Resource Operations of the Province of BC (DSS), and certain representatives of the Colliery Dam Technical Committee (TC) - which comprised the City of Nanaimo (CON), Snuneymuxw First Nation (SFN), and the Colliery Dam Park Preservation Society (CDPPS). Based on discussions and information presented during these meetings, in May 2014 the DSS re-classified the dams as follows;

- The failure consequence classification of the Middle Chase River Dam (Middle Colliery Dam) was reduced from Extreme to High; and
- The failure consequence classification of the Lower Chase River Dam (Lower Colliery Dam) was reduced from Extreme to Very High.

This classification was assigned, subject to receipt of reports documenting the work presented at the various meetings. Since then, five reports have been prepared and submitted by Golder (Golder 2014a, b, c, d and e) and one report by Associated Engineering (AE, 2014) which document the studies carried out on the Colliery Dams in 2014. This letter provides the rationale for the proposed dam classification, primarily based on work documented in these previous reports and information presented in the meetings.

This report should be read in conjunction with the *"Information and Limitations of This Report"* which is included following the text of this report. The reader's attention is specifically drawn to this information, as it is essential that it is followed for the proper use and interpretation of this report.

2.0 METHODOLOGY

2.1 Criteria

The dam classification outlined in this letter has been carried out based on the requirements set out in the British Columbia Dam Safety Regulation and also with reference to the Canadian Dam Association (CDA) Guidelines. In particular, Schedule 1 of the BC Regulation sets out the classification criteria for dam classification (see Table 1, below).

Table 1: Dam Classification (British Columbia Dam Safety Regulation (B.C. Reg. 163/2011)

Dam Class	Population at Risk [Note 1]	Incremental Losses		
		Loss of Life [Note 2]	Environmental and Cultural Values	Infrastructure and Economics
Low	None[1]	There is no possibility of loss of life other than through *unforeseeable* misadventure.	Minimal short-term loss or deterioration and no long-term loss or deterioration of (a) fisheries habitat or wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance.	Minimal economic losses mostly limited to the dam owner's property, with virtually no pre-existing potential for development within the dam inundation zone.
Significant	Temporary only[2]	Low potential for multiple loss of life.	No significant loss or deterioration of (a) important fisheries habitat or important wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is highly possible.	Low economic losses affecting limited infrastructure and residential buildings, public transportation or services or commercial facilities, or some destruction of or damage to locations used occasionally and irregularly for temporary purposes.
High	Permanent[3]	10 or fewer	Significant loss or deterioration of (a) important fisheries habitat or important wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is highly possible.	High economic losses affecting infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to scattered residential buildings.

Dam Class	Population at Risk [Note 1]	Incremental Losses		
		Loss of Life [Note 2]	Environmental and Cultural Values	Infrastructure and Economics
Very high	Permanent[3]	100 or fewer	Significant loss or deterioration of (a) critical fisheries habitat or critical wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is possible but impractical.	Very high economic losses affecting important infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas.
Extreme	Permanent[3]	More than 100	Major loss or deterioration of (a) critical fisheries habitat or critical wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is impossible.	Extremely high economic losses affecting critical infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas.

Notes,
[1] There is no identifiable population at risk.
[2] People are only occasionally and irregularly in the dam-breach inundation zone, for example stopping temporarily, passing through on transportation routes or participating in recreational activities.
[3] The population at risk is ordinarily or regularly located in the dam-breach inundation zone, whether to live, work or recreate.

The main consequence categories set out in Table 1 have been individually assessed against the criteria in the table and are addressed in further detail in subsequent sections of this letter.

2.2 Analytical Background and Dam Failure Scenarios

In order to assess the dam failure consequences, an assessment was made of the form and extent of the dam failure. Dam failure scenarios were extensively studied as part of the work carried out earlier in 2014 in relation to the dam safety risk assessment (Golder 2014d). Due to the close proximity of the Middle and Lower Dams, cascading failure scenarios were considered, as suggested by the Canadian Dam Association guidance documents. Various failure scenarios were analyzed, the purpose of which was to assess various uncertainties, as a means to evaluate the potential extents of flooding.

Central to this process was the identification of valid potential "failure modes" for the dams and considered potential failure modes that led to downstream inundation, and thus, consequences. Dam failure modes that result in a slow release of water from the reservoir and no downstream flooding (and thus no consequences) were not considered. The failure modes of interest were dam breaches caused by either storm events, seismic events, or a broad category of "other" events, and included the cascading effects of a Middle Dam failure on the Lower Dam.

The key inputs to the risk assessment were developed with a combination of traditional deterministic analysis and, where necessary, subjective assessments based on input from specialists. These include:

- A site investigation to evaluate the current condition of the Lower Dam (Golder 2014a);
- Studies which assessed the stability of the Lower Dam, in particular during strong earthquake shaking (Golder 2014b). These analyses included dynamic soil structure interaction analyses (FLAC analyses); structural assessment of the performance of the concrete core of the dam and post seismic evaluations of the stability of the dam (SEEP/W and SLOPE/W);
- Hydrological and hydraulic studies were undertaken to evaluate potential storm events and return periods and to evaluate the hydraulic capacity of the existing spillways and other key hydraulic structures on the Chase River system (Golder 2014c);
- An assessment of the probability of dam breach, and the dam breach parameters (rate of breach and extent of breach) due to dam overtopping (Golder 2014c); and
- Dam Breach analyses were carried out to determine downstream flooding extents as a basis for evaluating consequences of dam failure (AE 2014 and Golder 2014c).

The various dam breach analyses resulted in a series of sensitivity scenarios, with the rate of breach being the key variable affecting the extent of downstream flooding.

The consequences of dam breach were assessed based on the predicted extent of downstream flooding, and included expected mortality rates, expected damage and expected evacuation effectiveness (Golder 2014c). In particular,

- Reported consequences are *incremental* consequences - meaning fatalities and economic impacts over and above those caused by the initiating flood event;
- Fatalities are reported as "expected values", which represents the probability of a fatality and may therefore not be a whole number. For example, if the expected fatalities for an event is 0.2, this means (when expressed in probabilities) that there is about a 80% chance of 0 fatalities, and a 20% chance of 1 fatality; and
- The reported consequences are based on a level of evacuation commensurate with the type of initiating event. For example, due to the reduced amount of warning time, earthquake induced dam failure would have a much lower rate of evacuation effectiveness than a flood induced dam failure. Similarly, those failure scenarios related to very fast dam breach durations would have correspondingly lower evacuation effectiveness than those scenarios based on slower dam breach durations.

Dam failure assessments were carried out for scenarios which considered sunny day earthquake induced failure and storm induced failure. The storm induced failure modes were based on 1000 year return period events and Probable Maximum Flood (PMF) events. The most severe flooding and most severe consequences were related to storm induced dam failures, and these events have been used as a basis for determination of the dam failure classification.

- For Middle Dam failure only, the most severe downstream *incremental* consequences are represented by Scenario 3 (SC3) which considers a fast beach (10 minute breach) of the Middle Dam during a PMF storm event (see Figure 2, Appendix B). For this scenario the incremental expected fatalities are 1.9. By way of comparison, for moderate failure (moderate breach duration) of the Middle Dam in the PMF event (SC19), the incremental expected fatalities reduces to 0.38; and
- For Middle Dam and Lower Dam failure, the most severe downstream *incremental* consequences are represented by Scenario 14 (SC14) which considers a fast beach of the Middle and Lower Dams during a PMF storm event (see Figure 3, Appendix B). For this scenario the incremental expected fatalities are 11. By way of comparison, for the moderate failure of the Middle Dam and Lower Dam in the PMF event (SC13), the incremental expected fatalities reduces to 1.0; and
- The risk of failure of the dams due to earthquakes was extensively evaluated (including extensive geotechnical investigations on the Lower Dam) as part of the studies conducted earlier this year, with the finding that the risks and consequences of failure due to earthquake hazards were much lower than those due to flooding (storm) hazards (Golder 2014, b and d). Similarly, the extent of flooding and the consequences related to the earthquake and "other causes" induced failure modes were significantly lower that the above storm induced failure modes and therefore do not control dam classification.

The above failure scenarios (SC3 and SC14) have been used as a basis for evaluation of the dam failure consequence classification, as indicated in the following sections. For further information on the various dam failure scenarios, and the input factors controlling the scenarios, the reader is referred to the risk assessment report (Golder 2014c).

3.0 CONSEQUENCES OF FAILURE

3.1 Loss of Life

As indicated in the previous section, the incremental *expected* loss of life ranges from 1.9 to 11 for the selected dam failure scenarios. In reference to the Dam Safety Regulation (Table 1) with respect to Loss of Life, these fatality rates would place the dams predominantly in the High category, to just slightly exceeding the boundary with the Very High category.

3.2 Environmental and Cultural

Based on a review of the descriptions provided in Schedule 1 of the BC Dam Safety Regulations, and the extent of flooding expected for the assumed failure scenarios (Figures 2 and 3, Appendix B), our assessment of the environmental and cultural consequences of the failure of the Middle Dam and Lower Dam are outlined in the following sections.

3.2.1 Environmental

A desktop environmental assessment was carried out as a basis for the consequence classification. Appendix A provides a background review of the aquatic and terrestrial environment within the areas of impact as described by the failure scenarios using available online database and literature sources.

3.2.2 Cultural

The recorded site archaeological database (RAAD) was accessed on October 15, 2014. There are no recorded archaeological sites present within the flood plain maps as shown on either Figure 2 or 3 (Appendix B). There is always the potential for the presence of unrecorded sites but it is not anticipated that any archaeological sites would be impacted.

3.2.3 Contaminated Fills in the Lower Dam

As described in previous reports (Golder 2014e), contaminated soils are present in the Lower Dam and are thought to represent a significant proportion of the dam fills. The soils, described as cinders, ash and coal slag, contain metals (barium and arsenic) and selected hydrocarbons at concentrations that exceed the standards described in the Contaminated Site Regulation.

Although not studied and analysed in detail, a breach of the Lower Dam is expected to result in a release of most, if not all, of the contaminants into the downstream portions of the Chase River and on to the inundated low-lying areas adjacent to the Chase River. The consequences of this release of contaminated soils have been considered in the consequence classification for the Lower Dam, as described in the next section.

3.2.4 Consequence Classification

Based on the review of the dam failure scenarios, it is likely that destruction of aquatic and terrestrial resources will occur and probable that the resulting flooding downstream from the dams would permanently alter or destroy habitat. The review of available online databases and literature sources suggest that the Study Area contains high value habitat and populations of many native species. It is Golder's opinion that the environmental consequences of dam failure would likely be classified as "high" under Schedule 1 of the BC Dam Safety Regulations. This classification is described as "*the significant loss or deterioration of the following*:

- *Important fisheries habitat or important wildlife habitat;*
- *Rare or endangered species; or*
- *Unique landscapes or sites of cultural significance.*

Restoration or compensation in kind is highly possible."

Golder has made the above statement with the limitation that an environmental assessment was not conducted.

For the Lower Dam, as discussed above, an additional risk relates to the presence of the contaminated soils contained within the dam. In the event of a dam breach, these fills are expected to be released to the downstream portions of the Chase River and also to the low-lying areas adjacent to the river which will be inundated in the event of a dam breach. Although the effects on such factors as downstream water quality due to the release of the contaminated soils into the downstream environment has not been studied, it is anticipated that clean-up of the contaminants would be required, and that this would severely increase the difficulty of restoration of the river and the surrounding areas following any full or partial breach of the Lower Dam.

Therefore, for the Lower Dam only, the environmental consequences are considered to be more closely represented by the description provided in the Dam Safety Regulation for Very High consequence dams, ie – "*Significant loss or deterioration of:*

- *critical fisheries habitat or critical wildlife habitat,*
- *rare or endangered species, or*
- *unique landscapes or sites of cultural significance, and*

restoration or compensation in kind is possible but impractical."

3.3 Infrastructure and Economics

The extents of flooding for the two dam breach scenarios under consideration are shown on the attached Figures 2 and 3 (Appendix B). These figures illustrate contours of flooding depth. The impacts to Infrastructure and Economics can be summarized as follows:

- The impacts to infrastructure (including public transportation, services and commercial facilities) is principally related to some damage to the John Barsby school, and to some bridges which serve local streets within the residential area.
- Based on the 2 metre flood depth contour, which represents the approximate depth at which 50% damage to a residential building would occur (AE, 2012), between 13 and 27 residences would sustain severe damage for the scenarios under consideration.
- As part of the risk assessment (Golder 2014d), the amount of damage was approximated at between $5.3M and $8.3M for the two scenarios (SC3 and SC14, respectively) under consideration.

Although the damages related to Infrastructure and Economics are not quantified in the Dam Safety Regulation (Table 1), the expected damages described above are considered to most closely match the qualitative descriptions provided in Table 1 under the *High consequence category, perhaps bordering on the Very High* consequence category (as for the Loss of Life category).

4.0 CONCLUSIONS AND RECOMMENDATIONS

Due to their proximity on the Chase River system, the Middle and Lower Colliery Dams have been considered together in terms of the expected extents of flooding and flooding scenarios have been developed which includes individual dam failure and cascading dam failure. The consequences of dam failure for both of these dams generally match the consequences presented in the BC Dam Safety Regulation under the High category, and for some categories, bordering on the Very High category.

As described in the reports and discussed in the preceding meetings, due to its closer proximity to the residential areas, and its position "as the last line of defence" in the event of dam breach, the Lower Dam has been determined by the risk assessment to be particularly important to community safety and is therefore considered to be of higher consequence (than the Middle Dam) in the life safety (Loss of Life) category. In addition, owing to the presence of contaminated soils, the Lower Dam is also of higher consequence (than the Middle Dam) in the

Environment category. On this basis, it is considered that the assigned consequence categories tentatively approved by DSS of for the Lower Dam of **Very High** and the Middle Dam of **High** are appropriate and should be confirmed and adopted for the dams.

5.0 CLOSURE

We trust that the factual information provided herein meets your present requirements. Should you have any questions regarding the above, please do not hesitate to contact us.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Bruce R. Downing, P.Eng.
Principal

ORIGINAL SIGNED

Herb H. Hawson, P.Eng.
Principal

ORIGINAL SIGNED

Shawn Redden, R.P.Bio.
Associate, Senior Fisheries Biologist

ORIGINAL SIGNED

Iain Jones (R.P. Bio., M.Sc., Dip. Tech.)
Associate

BRD/HHH/nnv

Attachments: Appendix A – *Desktop Environmental Assessment*
Appendix B - Flood Mapping

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IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

APPENDIX A

DESKTOP ENVIRONMENTAL ASSESSMENT

1.0 DESKTOP ENVIRONMENTAL ASSESSMENT

The following sections provide a background review of the aquatic and terrestrial environment within the areas of impact as described by the failure scenarios using available online database and literature sources.

1.1 Aquatics Assessment

1.1.1 Information Sources

Background fish and fish habitat in the Chase River and reservoirs upstream and downstream of the Lower and Middle Dams were reviewed using the online databases and available literature sources outlined below:

- BC Species and Ecosystem Explorer: Species and Ecosystem Search;
- Department of Fisheries and Oceans (DFO) – Master v3.1;
- Fisheries Inventory Data Queries (FIDQ) database records;
- Gofishbc – Archived fish stocking reports;
- British Columbia Ministry of Environment (BCMOE): Fish Inventory – Fish Information Summary System;
- BCMOE HabitatWizard and Fisheries Information Summary System (FISS);
- BCMOE iMAP BC;
- BCMOE EcoCat: The Ecological Reports Catalogue; and
- City of Nanaimo – Reports and Studies.

1.1.2 Fish Presence

The Study Area included the Chase River, Colliery #1 (Lower Dam) reservoir, and the Colliery #2 (Middle Dam) reservoir. Fish presence in the Study Area is summarized in Table A1 below.

Table A1: Fish Species Present Within the Study Area.

Name/Alias	Watershed Code	Waterbody Identifier	Fish Species Present
Chase River	920-389300	00000PARK	Rainbow/steelhead trout (*Oncorhynchus mykiss*), cutthroat trout (*O. clarkii*), lamprey (*Lampetra sp.*), three-spine stickleback/stickleback (general) (*Gasterosteus* sp.), sculpin (*Cottus* sp.), pumpkinseed sunfish (*Lepomis gibbosus*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), Chinook salmon (*O. tshawytscha*)
Lower Chase Reservoir (Colliery #1)	920-389300	00698PARK	Rainbow trout, cutthroat trout, coho salmon
Middle Chase Reservoir (Colliery #2)	920-389300	00712PARK	Rainbow trout, cutthroat trout, coho salmon

The Lower and Middle Dams on the Chase River create the Lower Chase Reservoir (Colliery #1) and the Middle Chase Reservoir (Colliery #2) respectively. The spillway located at the Lower Dam is an impassable barrier for migrating fish in the Chase River (Klohn Crippen Berger 2013). However, annual stocking events support populations of rainbow trout within Colliery #1 and Colliery #2 reservoirs. An estimated 1500 rainbow trout are stocked annually into Colliery #1 and Colliery #2 reservoirs (Klohn Crippen Berger 2013). In 1993, small populations of cutthroat trout and coho salmon were observed in Colliery #1 and Colliery #2 reservoirs. Given the fish barrier downstream of the Lower Dam, it is likely that these upstream populations were either introduced through stocking events or were non-anadromous residents.

The Chase River and its tributaries support a diverse population of fish species including rainbow trout/steelhead, cutthroat trout, lamprey, pumpkinseed sunfish, three-spine stickleback/stickleback general, sculpin, chum salmon, coho salmon, and Chinook salmon.

1.1.3 Listed Species and Ecological Communities

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has ranked two species observed within the Study Area (see Table A2) as endangered or threatened. COSEWIC rankings serve as recommendations for the federal government. The federal government used this information to make decisions on which species should be listed under SARA. The rankings "endangered" and "threatened" are defined by COSEWIC as follows:

- Endangered (E) – a species facing imminent extirpation or extinction; and
- Threatened (T) – a species likely to become endangered if limiting factors are not reversed.

The provincial government has designated three species within the Study Area as either "exotic" or "yellow" based on their status within BC. The designations "exotic" and "yellow" are defined by the provincial conservation status as follows:

- Exotic – a species that has been moved beyond their natural ranges as a result of human activity.
- Yellow – a species that is apparently secure and not at all at risk of extinction.

Table A2 below summarizes the species of special concern present in the Study Area and their applicable ranking.

Table A2: Listed Species Present Within the Study Area

Common Name	Scientific Name	BC List	SARA	COSEWIC
Pumpkinseed sunfish	*Lepomis gibbosus*	Exotic	-	-
Coho salmon	*Oncorhynchus kisutch*	Yellow	-	E (2002)
Chinook salmon	*Oncorhynchus tshawytscha*	Yellow	-	T (2006)

1.1.4 Fish Habitat

The fish habitat has been divided into five sections within the Study Area for the purpose of characterization: the Lower Chase River, a section south of Colliery #1 reservoir; Colliery #1 reservoir; the Middle Chase River between Colliery #1 and Colliery #2 reservoirs; Colliery #2 reservoir; and the Upper Chase River.

Golder (2011) characterized the Lower Chase River as providing high value fish habitat due to an abundance of overhanging vegetation, deep pools, side channels, and spawning areas. Colliery #1 and Colliery #2 reservoirs were considered as adequate fish habitat due to a low abundance of overhanging vegetation, steep littoral drop-offs, and a low degree of habitat complexity. Some spawning gravels are present in inlets, however the majority of the substrate exists as fines and is unsuitable for spawning. Golder (2011) describes the riparian vegetation of Colliery #1 and Colliery #2 reservoirs as underdeveloped with a low potential for establishment due to steep side-slopes.

The Middle Chase River was documented to provide high value fish habitat with abundant overhanging vegetation, deep pools, side channels, and spawning and foraging areas (Golder 2011). The Upper Chase River provides areas of valuable spawning, rearing, and over wintering habitats for migrating species (Golder 2011). However, the Upper Chase River contains small cascades that create partial fish obstructions and areas of high water flow not suitable for fish habitat.

1.2 Terrestrial Resources

1.2.1 Ecological Context

The Study Area lies within the Nanaimo Lowland Ecosection (Demarchi 1996). The Nanaimo Lowland Ecosection is part of the Eastern Vancouver Island Ecoregion, which is in turn part of the Georgia Depression Ecoprovince, all of which are encompassed in the Humid Temperate Ecodomain at the highest level of the province's ecological hierarchy (Demarchi 1996).

British Columbia has been classified into biogeoclimatic zones based on vegetation, geological and climatic conditions, and uses local climate and landform conditions to reflect the distribution and presence of specific plant and animal communities and ecosystems. The two dam sites (located in Colliery Dam Park) as well as the modelled flood zones (together now discussed as the Study Area) are located across two biogeoclimatic zones; the Coastal Western Hemlock (CWH) zone, very dry maritime (xm) subzone, and the Coastal Douglas-fir (CDF), moist maritime (mm) subzone.

The CWHxm experiences a warm climate characterized by moist, mild winters and dry summers (Green and Klinka 1994). Common tree species in the CWHxm forest canopy include Douglas-fir (*Psudotsuga menziesii*), western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*). Dominant understory plants include salal (*Gaultheria shallon*), red huckleberry (*Vaccinium parvifolium*), and a variety of mosses.

The CDFmm experiences a warm climate characterized by wet winters and dry summers (Green and Klinka 1994). Common tree species in the CDFmm forest canopy include Douglas-fir, grand fir (*Abies grandis*), and western red cedar. Dominant understory plants include salal, dull Oregon-grape (*Mahonia nervosa*), ocean-spray (*Holodiscus discolor*), and Oregon beaked-moss (*Kindbergia oregano*). Garry oak (*Quercus garryana*) and arbutus (*Arbutus menziesii*) may also occur within drier sites of the CDFmm.

1.2.2 Vegetation

Golder (2011) and Klohn Crippen Berger (2013a) characterize the habitat in Colliery Dam Park as mature Douglas-fir, western red cedar, and western hemlock. Deciduous trees, including big leaf maple (*Acer macrophyllym*), red alder (*Alnus rubra*), and arbutus, are interspersed throughout, particularly along the banks of the reservoirs and in riparian corridors. The understory is largely composed of salal, dull Oregon grape, red huckleberry, and sword fern (*Polystichum munitum*). Vegetation communities within wetland habitat is dominated by hardhack (*Spiraea douglassii*), bulrush (*Scirpus* sp.), and cattail (*Typha* sp.; Golder 2011; Klohn Crippen Berger 2013a).

The following introduced species were observed within the Middle and Lower Reservoir areas by Golder (2011):

- Himalayan blackberry (*Rubus armeniacus*); and
- Scotch broom (*Cytisus scoparius*).

The area outside of the Colliery Dam Park boundary in the Study Area is mostly urban residential development with little natural vegetation cover remaining. Based on high level review of Google Earth imagery, small stands of coniferous and deciduous trees ae located in isolated stands throughout the urban residential area, separated by buildings and streets. A corridor of riparian vegetation follows the Chase River from the Lower Colliery Dam eastward towards its confluence with the ocean.

1.2.3 Wildlife

Herptiles

Amphibians in British Columbia can be grouped into aquatic breeding obligates (frogs, toads, newts and mole salamanders / Ambystomatidae) and terrestrial breeding obligates (lungless salamanders / Plethodontidae; MFLNRO and MOE 2014). Amphibians occurring in the terrestrial environment generally require moist habitat with cover objects such as logs, shrubs, tree hollows, and rock crevices, to provide thermoregulatory and shelter sites.

An amphibian survey was completed by Klohn Crippen Berger on April 4 and 5, 2013 within the Colliery Dam Park in the Lower and Middle reservoirs. Five observations of amphibians were recorded, including one observation of northwestern salamander (*Ambystoma gracile*) breeding and two provincially/ federally listed species, northern red-legged frog (*Rana aurora aurora*) and wandering salamander (*Aneides vagrans*; Table A3; Klohn Crippen Berger 2013b).

Table A3: Results of Klohn Crippen Berger 2013 Amphibian Survey

Species	Life Stage	BC List[1]	COSEWIC[1]	SARA[1]
Northern red-legged frog, *aurora* (*Rana aurora aurora*)	Adult	Blue	SC (2004)	1-SC (2005)
Pacific tree frog (*Pseudacris regilla*)	Adult	Yellow	-	-
Wandering salamander	Adult	Blue	SC (2014)	-

Species	Life Stage	BC List[1]	COSEWIC[1]	*SARA*[1]
(*Aneides vagrans*)				
Western red-backed salamander (*Plethodon vehiculum*)	Adult	Yellow	-	-
Northwestern salamander (*Ambystoma gracile*)	Egg mass	Yellow	NAR (1999)	-

[1] Source: BC CDC (2014; internet site)

We note that the Klohn Crippen Berger surveys were conducted late in the typical northern red-legged frog breeding season, and therefore may have not recorded red-legged frog egg masses. Given the large size of the reservoirs, visual observations of tadpoles may have also been difficult.

Klohn Crippen Berger (2013) assessed the habitat availability for aquatic amphibian species in the Middle and Lower reservoirs within Colliery Dam Park as low due to limited littoral habitat and emerging aquatic vegetation for egg mass attachment.

Reptiles with ranges that overlap Colliery Dam Park and the Study Area include common garter snake (*Thamnophis sirtalis*), northwestern garter snake (*T. ordinoides*), western terrestrial garter snake (*T. elegans*), and northern alligator lizard (*Elgaria coerulea*). Suitable reptile habitat generally provides access to food sources (i.e., small mammals, amphibians, invertebrates), thermoregulatory habitat such as sunning outcrops and cover objects, shelter from predators, and access to hibernation sites (MFLNRO and MOE 2014b). Vegetated parts of the Study Area provide suitable habitat for the four species of reptiles noted, however, there is not any site specific information available to confirm species presence. Golder (2011) and Klohn Crippen Berger (2013) did not report observations of reptiles in the site.

Birds

Passerine species use a variety of habitat types depending on life requisites such as nesting sites and food sources. Trees and shrubs within the Study Area provide nesting habitat for passerines, which forage on fruit, seeds, and insects. Specific information on occurrence and nesting status of passerines is not available for the Study Area.

Two osprey (*Pandion haliaetus*) nests have been recorded within the Colliery Dam Park area, one located on the southwestern end of the Middle Reservoir and the second nest in between the Middle and Upper reservoirs, just south of the Nanaimo Parkway (Wildlife Tree Stewardship 2014; internet site). Bald eagles (*Haliaeetus leucocephalus*) have also been observed within Colliery Dam Park (Klohn Crippen Berger 2013a). Nests for bald eagles have been recorded within 2 km of the Study Area within the nearby Westwood Park (Wildlife Tree Stewardship 2014). Other species of raptors may use the Study Area for nesting and/or foraging, however, there is not any information on species occurrence and seasonal habitat use.

Several species of waterfowl are expected to use waterbodies within Colliery Park for nesting and possibly during migration and winter. Fish occurring within the reservoirs provide prey items for diving ducks such as mergansers or goldeneyes. The area also may provide suitable foraging habitat for other water associated

birds. Riparian vegetation within the urban areas of the Study Area may also provide nesting and foraging habitat for both waterfowl and other water associated birds.

During a site visit and a waterbird survey within Colliery Dam Park, great blue heron, *fannini* subspecies (*Ardea herodias fannini;* provincially blue-listed and federally designated as Special Concern [1-SC] under *SARA*), marbled murrelet (*Brachyramphus marmoratus*; provincially blue-listed and federally designated as Threatened (1-T) under *SARA*), mallard, and common merganser (*Mergus merganser*) were recorded (Klohn Crippen Berger December 2013a; 2013b).

Mammals

Small mammals, such as insectivores and rodents, are expected to occur throughout vegetated habitat within the Study Area. Large mammals, such as black bear (*Ursus americanus*), cougar (*Puma concolor*) and Columbia black-tailed deer (*Odocoileus hemionus columbianus*), could also occasionally occur within or near Colliery Dam Park and riparian habitat downstream of the Lower Reservoir dam.

Discussions with residential park users noted observations of river otters (*Lontra canadensis*) that use the river between the Middle and Lower reservoirs (Klohn Crippen Berger 2013a).

Invertebrates

Invertebrates such as dragonflies and damselflies are often associated with wetted areas such ponds and streams. No records of listed invertebrates for the Study Area were found in a search of the BC CDC database (Government of BC 2014). Information on listed species of invertebrates that have been recorded for the Study Area is not available.

1.2.4 Species at Risk

The BC CDC provides records of mapped known occurrences of federally and provincially designated flora and fauna species. Six records of designated species exist within 1 km of the Study Area, including four non-sensitive occurrences (Government of BC 2014). Three of these species are provincially blue-listed, and one is provincially red-listed with a federal designation of Endangered (1-E) under *SARA* (Table A4; BC CDC 2014, internet site).

Table A4: Occurrences of Federally and/or Provincially Designated Species within 1 km of Study Area

Common Name	Scientific Name	BC List[1]	COSEWIC[1]	*SARA*[1]
Chaffweed	*Anagallis minima*	Blue	-	-
Bog Bird's-foot Lotus	*Hosackia pinnata*	Red	E (MAY 2004)	1-E (2005)
Howell's Violet	*Viola howellii*	Blue	-	-
Slimleaf Onion	*Allium amplectens*	Blue	-	-

[1] Source: BC CDC (2014; internet site)

One historical occurrence and one masked occurrence were recorded within 1 km of the area. Some species at risk occurrences are deemed sensitive by the BC Ministry of Environment and information is not readily available for the public. Requests for this information can be made to the BC CDC. These two occurrences are:

- Howell's violet (*viola howellii*) observed in 1955; and
- Masked occurrence ID 365931 (Government of BC 2014; internet site).

Klohn Crippen Berger (2013a; 2013b) recorded four provincially/ federally designated species within the Project area (Table A5). As mentioned earlier, the blue-listed wandering salamander (*Aneides vagrans*) was observed during amphibian surveys in April 2012 (Klohn Crippen Berger 2013b). This salamander utilizes downed logs, crevices, or sloughed bark as primary habitat, and could potentially be found throughout naturally vegetated parts of the Study Area. The blue-listed northern red-legged frog, *aurora* subspecies, was also observed during amphibian surveys in terrestrial habitat (Klohn Crippen Berger 2013b; Table A5). This frog travels large distances between seasonal habitats, making use of a variety of standing or slow-flowing waterbodies.

During Klohn Crippen Berger's December 2012 site visit, marbled murrelet, a listed species, was recorded (Klohn Crippen Berger 2013a; Table A5). This bird could potentially use mature forest stands within the Colliery Dam Park for nesting habitat, while using riparian corridors to complete their daily migrations to the ocean to feed. Great blue heron, *fannini* subspecies, a provincially/federally listed bird, was also observed during this site visit (Klohn Crippen Berger 2013a; Table A5). This species uses shallow wetted areas for foraging, and mature forest stands for nesting; heron nests were not observed during a Golder site visit (2011).

Table A5: Occurrences of Federally and/or Provincially Designated Species Observed During Site Visits and Surveys by Klohn Crippen Berger

Common Name	Scientific Name	BC List[1]	COSEWIC[1]	*SARA*[1]
Wandering salamander	*Aneides vagrans*	Blue	SC (2014)	-
Northern red-legged frog, *aurora* subspecies	*Rana aurora aurora*	Blue	SC (2004)	1-SC (2005)
Marbled murrelet	*Brachyramphus marmoratus*	Blue	T (2012)	1-T (2003)
Great blue heron, *fannini* subspecies	*Ardea herodias fannini*	Blue	SC (2008)	1-SC (2010)

[1] Source: BC CDC (2014; internet site)

APPENDIX B

FLOOD MAPPING

CITY OF NANAIMO
THE HARBOUR CITY

Associated Engineering

Chase River Dam Breach Flood Inundation Study
SC14 - Maximum Flooding Depth, Extents and Damages
Probable Maximum Flood, Middle Dam Breach (10 min), Lower Dam Breach (10 min)

Figure 2
DATE: Tuesday, September 30, 2014
SCALE: 1:5000

CITY OF NANAIMO
THE HARBOUR CITY

Associated Engineering

Chase River Dam Breach Flood Inundation Study

SC3 - Maximum Flooding Depth, Extents and Damages

Probable Maximum Flood, Middle Dam Breach (10 min), No Lower Dam Breach

Figure 3

DATE: Tuesday, September 30, 2014

SCALE: 1:5000