# 8. FISH HABITAT OFFSETTING PLAN

## 8.1. LNG Canada's Approach to Offsetting

LNG Canada is committed to offsetting Project-related impacts to fish and fish habitats that contribute to the sustainability and ongoing productivity of CRA fisheries. It proposes to do so by implementing a fish habitat offsetting plan that is expected to increase the availability and quality of spawning, rearing, migratory, and overwintering habitats for the local eulachon, salmon, trout, and char populations most directly affected by construction and operation of the LNG facility. The sections below describe LNG Canada's approach to offsetting.

### 8.1.1. Consistency with Fisheries and Oceans Canada Policy

LNG Canada has developed an offsetting plan that is consistent with DFO's Fisheries Protection Policy Statement (DFO 2013a) and DFO's Fisheries Productivity Investment Policy: A Proponents Guide to Offsetting (2013b). This has been achieved by:

- Selecting offsets that support provincial, federal, and Haisla Nation fisheries management objectives
- Including offsets that support local habitat restoration priorities
- Choosing offsets that will provide tangible conservation outcomes for fish and fish habitat and can be reasonably expected to counterbalance the loss of fish habitat and fisheries productivity
- Including offsets that restore or enhance existing habitats or create new habitats that were previously terrestrial in nature
- Including offsets that specifically address the factors most likely limiting local fish production within and adjacent to the LNG facility footprint
- Prioritizing inclusion of "in-kind" offsets (i.e., those that replace the type, quantity, and quality of habitat lost or altered for the local fish populations most directly affected by the project)
- Including offsets that restore areas that have been affected by previous environmental damage and where no other responsible entity exists (i.e., orphaned sites)
- Selecting offsets that provide self-sustaining benefits to fish production over the long-term

- Including sufficient offsets to address the time lag until newly created or enhanced habitats become fully functional. and the inherent uncertainty associated with successfully replacing lost production of CRA fisheries through enhancement or restoration of existing fish habitat and creation of new fish habitat

#### 8.1.2. Consistency with Local Fisheries Management Objectives and Restoration Priorities

LNG Canada has met with MFLNRORD in earlier versions of the offsetting plan and with the Haisla Nation, and DFO throughout the development of the plan to identify federal, provincial, and Haisla Nation fisheries management objectives for the Kitimat River, and align its offsetting plan with those objectives. Objectives that relate directly to the Kitimat River and its estuary include:

- Rebuild weak wild runs of north coast chum salmon while providing opportunities to harvest surplus stock (DFO 2015)
- Prevent or minimize impacts of development activities on fish populations and fish habitat (Kalum LRMP 2002)
- Manage existing populations of vulnerable and/or distinct fish stocks and species for their healthy perpetuation (Kalum LRMP 2002)
- Rehabilitate fish populations and/or habitat where degraded and, where appropriate, undertake enhancement projects (Kalum LRMP 2002)
- Provide a range of opportunities for consumptive and non-consumptive use of fish (Kalum LRMP 2002)
- Manage resource development activities to minimize negative impacts to surface and groundwater quality (Kalum LRMP 2002)
- Manage human activities to maintain or enhance water quality and minimize water pollution (Kalum LRMP 2002)
- Manage human activities to maintain hydrological stability (Kalum LRMP 2002)
- Re-establish Kitimat River estuary channel connectivity (LKWPM 2013)
- Support Kitimat River eulachon restoration (eulachon is the priority for Haisla Nation, and salmon are secondary; M. Jacobs, Haisla Fisheries Commission, LKWPM 2013)

The consultations with local stakeholders and regulators have also provided the opportunity to understand habitat restoration priorities in the lower Kitimat River and its estuary. These priorities have been articulated in results of the LKWPM, held January 10, 2013 in Terrace British Columbia, which included members of the Haisla Fisheries

Commission, DFO, and the MFLNRORD. Thirty-eight separate projects were identified during this meeting. They can be roughly divided into three categories:

- Improved information/research/pre-assessment projects (i.e., projects that increase the likelihood of successfully restoring, augmenting, or managing local fish stocks)
- Habitat enhancement projects (i.e., projects that augment natural fish production through hatchery production or existing fish habitat improvement)
- Habitat restoration projects (i.e., projects that fix degraded habitat)

LNG Canada evaluated each of these 38 projects. A list of additional offset options was compiled based on work conducted during baseline surveys and offsetting-specific site visits between 2013 and 2015. From these sources, LNG Canada included in its offsetting plan those projects that:

- Are consistent with the LNG facility footprint, corresponding construction, and water management plans during operations
- Target the physical, biological, or chemical factors most likely limiting fish production in the Kitimat River and its estuary
- Are technically feasible and designed to be self-sustaining over the long-term
- Provide cost-effective means for achieving the habitat gains needed to counterbalance unavoidable habitat losses

#### 8.1.3. Targeting Factors Limiting Fish Production

Fully understanding the factors that limit fish production in any system is extremely difficult because fish production is controlled by a range of biotic and abiotic factors, all of which vary and interact in time and space. Biotic factors controlling fish production include the availability of prey (primarily drifting invertebrates for salmon and trout); the density of competitors for food, space, and mates; and the density of predators. Abiotic factors controlling fish production include water temperature, total suspended solid concentrations, DO concentrations, concentrations of dissolved nutrients that control primary productivity (i.e., phosphorus, carbon, and nitrogen), and the quantity and quality of physical habitat (e.g., water depth, water velocity, substrate composition, and cover).

In the development of this fish habitat offsetting plan, LNG Canada has assumed that: 1) the quantity and quality of summer rearing and overwintering habitats are the factors most likely limiting the freshwater production of coho salmon, the most abundant juvenile salmon species in the watercourses and waterbodies affected by the LNG facility footprint; and 2) the quantity of spawning habitat is the factor most likely limiting the freshwater production of chum and pink salmon. Management and conservation initiatives for eulachon may be restrained due to limited scientific knowledge base in the

Traditional Territory of the Haisla Nation. These assumptions are based on the following lines of evidence:

- Newly emerged fry of eulachon, pink salmon and chum salmon migrate or passively drift to the estuary immediately after hatching, while coho salmon have an extended freshwater juvenile life-stage
- Depth of most ponds, pools, and wetlands in the Beaver Creek, Anderson Creek, and Moore Creek watersheds in winter are generally less than 0.5 m, thereby limiting the space and DO concentrations needed by juvenile coho salmon to survive the winter
- Number, depth, and spatial extent of ponds, pools, and wetlands preferred by juvenile coho salmon for rearing diminishes greatly during the summer when flows are lowest

Based on these assumptions, offset projects included in this plan focus on the creation of new, or enhancement of existing, spawning, rearing and overwintering habitat for pink, chum, and coho salmon. The euchalon complementary program will benefit management and conservation initiatives in the traditional territory of the Haisla Nation. The proposed offset projects will also benefit other local species in the area such as Dolly Varden and rainbow trout. Several offset projects also aim to improve fish access to these new or existing habitats by removing existing barriers to fish migration (e.g., protective dykes).

#### 8.1.4. Acknowledging the Inter-connectivity of Existing Estuarine Habitats

LNG Canada recognizes the inter-connectivity of freshwater habitats in the lower Kitimat River. This includes the interaction of habitats in Beaver, Anderson, and Moore creeks, as well as their inter-connectivity with the Kitimat River and its various side channels. For example, some fish originating from Anderson Creek and the Kitimat River are known to rear in Beaver Creek. Conversely, some fish originating from Beaver Creek, particularly juvenile coho salmon, migrate between lower Beaver, Anderson and Moore creeks with the daily and seasonal availability of summer rearing and overwintering habitat.

The ability to move between the diversity of habitats in the Kitimat River estuary is currently limited by dykes that were built several decades ago to protect existing infrastructure (e.g., the former Alcan site, now Rio Tinto, and transmissions lines) from damage due to potential watercourse migration in the Kitimat River estuary. Therefore, LNG Canada's offset plan includes measures to remove these barriers and restore natural connectivity of channels in the lower estuary area.

LNG Canada has taken an integrated ecosystem approach to offsetting because of this inter-connectivity. This means the offset projects included in the plan provide a mix of migratory, spawning, rearing and overwintering habitats focused in the Beaver, Anderson, and Moore Creek watersheds and in the lower Kitimat River. The intent of this approach is to maintain the overall diversity and integrity of the Kitimat River estuary ecosystem and its ability to produce the eulachon and salmon species valued by the people of Kitimat and Haisla Nation.

#### 8.1.5. Acknowledging Uncertainty and Time Lags

LNG Canada acknowledges that the successful offsetting of lost fish production due to destruction or permanent alteration of fish habitat has inherent uncertainties. These inherent uncertainties come from three main sources:

- Difficulty understanding the relationships between fish production and physical habitat
- Time lag between when habitat creation, restoration, or enhancement efforts are complete, and when the habitat becomes fully functional and maximizes fish production
- Assumption that we fully understand and can replicate the physical habitat features that fish actively select for their different life stages (e.g., spawning, rearing, overwintering)

The approach taken to address uncertainty and time lags is seven-fold:

1. Focus offsets in the watersheds, and for the local fish populations most directly affected by the project
2. Build offset projects during construction of the LNG facility
3. Provide offsets that improve the temporal availability of habitat to fish
4. Provide a mix of spawning, rearing, and overwintering habitat similar to that lost due to the construction of the LNG facility
5. Provide more offset habitat than will be lost or altered by the LNG facility (i.e., gain-to-loss ratios greater than 1:1)
6. Include offset projects that address past impacts to habitat in the Kitimat River estuary and, therefore, are highly likely to improve fish production (e.g., removal of existing fish barriers)
7. Provide a complementary measure (Section 8.18 Eulachon Research Project)

In considering potential offsetting options for the LNG facility, LNG Canada has taken into account the following hierarchy of priorities when selecting offset projects:

1. In-kind habitat in the immediate vicinity of affected habitats, benefiting the affected fish species and life stages (i.e., spawning, rearing, and overwintering habitat in Beaver and Anderson creeks and in the Kitimat River side channels to benefit of chum, pink, and coho salmon, and potentially eulachon)

2. Out-of-kind habitat in the same region of affected habitats, benefiting the affected fish species and life stages (i.e., salt-marsh restoration in Minette Bay)

LNG Canada proposes the following offset-to-impact ratios to address the inherent uncertainty and time lags associated with offsetting unavoidable habitat losses and associated reductions in fisheries productivity:

- 2:1 for salmonid spawning habitat
- 2:1 for mainstem watercourses that provide overwintering, migratory, and/or rearing habitats
- 2:1 for off-channel wetlands/ponds that provide overwintering habitats
- 2:1 for estuarine habitats
- 1:1 for off-channel watercourses and wetlands that provide rearing, feeding, and refuge habitats only during higher water periods (i.e., areas that do not provide summer rearing or overwintering habitat for salmonids)

These ratios, combined with hydraulic modelling of offset design performance (Section 8.4 Verification of Design Performance and Appendix 9) and LNG Canada's commitment to build offset projects before and during construction (Section 4.6 Schedule and Sequencing), increase the certainty that the offsetting plan will meet its goals, and maintain or increase fisheries productivity in the lower Kitimat River estuary.

LNG Canada's offset plan also includes projects to replace habitat that will be permanently lost under the LNG facility footprint with similar or better habitat for the salmon populations that currently use Beaver and Anderson creeks for spawning, rearing, and overwintering. An example of this productivity-based approach is the deepening of existing off-channel wetland habitat to increase the duration of their use by juvenile coho salmon. Based on the habitat mapping for this project, over 75% of the existing off-channel wetland habitat in the lower Kitimat River estuary (including Beaver Creek) is only seasonally accessible to fish during spring and fall freshets. As a result, the offset plan includes the creation of perennial off-channel watercourses and wetland/pond complexes. The proposed offset program will increase the available area of perennial habitats during summer low flow conditions by 65%, relative to current conditions.

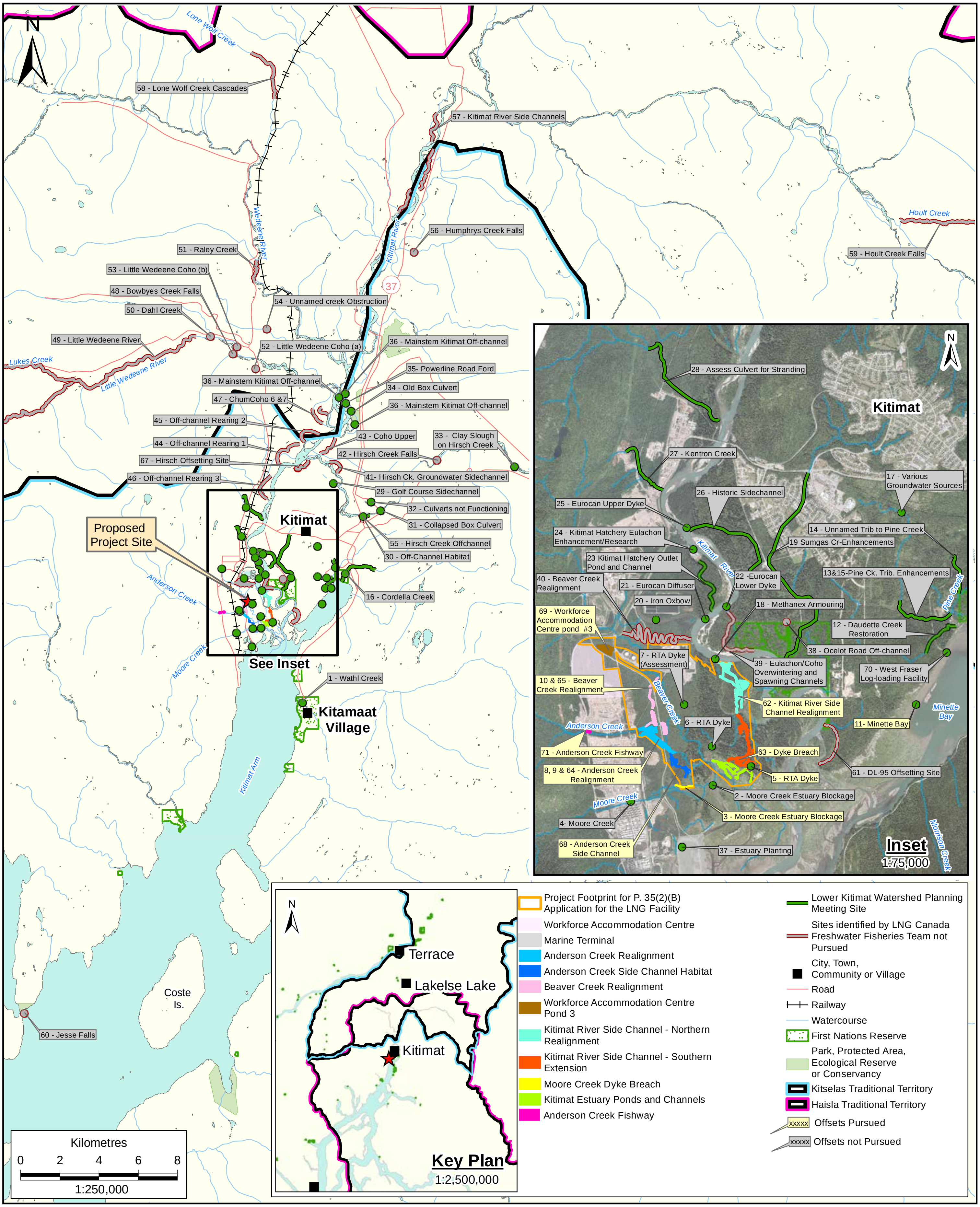
## 8.2. Offset Options Identification and Screening

### 8.2.1. Options Identification

Offset options were compiled from two main sources: the LKWPM held January 10, 2013 and by the freshwater fisheries team members during baseline surveys, desk-top reviews, and offsetting-specific site visits between 2013 and 2015. Potential offset projects assessed by LNG Canada's freshwater fisheries team included those in LNG Canada's Conceptual Fish Habitat Offsetting Plan and those proposed by the LKWPM. Options identified by both the LKWPM and LNG Canada's freshwater fisheries team are the result of existing knowledge of freshwater and estuarine habitats, and their use by fish, in Beaver, Anderson, and Moore creeks, and in the lower Kitimat River watershed.

The LKWPM included members of the Haisla Fisheries team, DFO, and MFLNRORD. Thirty-eight separate fish habitat enhancement/restoration projects were identified at this workshop (Appendix 7 Freshwater and Estuarine Fish Habitat Offsetting Options Compilation and Screening). The spatial distribution of these projects ranged from the Kitamaat Village, including Wathl Creek, to the powerline crossing just north of the Cable Car Subdivision (LKWPM 2013), a location approximately 15 km upstream of the Kitimat River estuary (Figure 8-1).

Another 34 potential offset projects were identified by the Stantec freshwater fisheries team. The spatial distribution of these projects range from Jesse Falls on Douglas Channel in the south to Lone Wolf Creek in the north (Figure 8-1).

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*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**LOCATION OF EVALUATED FRESHWATER OFFSETTING OPTIONS**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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### 8.2.2. Options Screening

Each offsetting option was qualitatively screened for its biological relevance, technical feasibility, consistency with federal and provincial policies, compatibility with the LNG Canada project footprint and water management plans, and potential land ownership conflicts. Options in obvious conflict with federal and provincial policies (e.g., removal of natural barriers to fish passage), or with the constructability of the LNG facility were dropped from further consideration. Options located on private land were carefully considered.

Those options passing through this initial screening process were prioritized based on their:

- Contribution to offset unavoidable habitat losses associated with the LNG Canada project
- Proximity to affected habitats and the local fish populations they support
- Opportunities provide long-term benefits to fish
- Ability to benefit multiple fish species and life stages
- Requirements for long-term maintenance
- Likelihood for acceptance by DFO and Haisla Nation
- Ability to access private land

Options provided by the LKWPM were all considered to be acceptable to DFO and Haisla Nation as they were identified during their participation in the LKWPM workshop.

An important consideration during this screening and prioritization process was proximity of the offset project to the habitat lost or altered by the Project. Offset projects in or close to the area of impact while also providing similar habitat to that affected by the project were given highest priority. These types of "in-kind" offsets have the greatest potential to benefit the fish species and populations most directly affected by the habitat losses. Options located farther from the affected habitat, providing little gain, and/or benefiting fish populations not directly affected by the project were given lower priority. Although not included in the offset plan, these lower priority "out-of-kind" options are considered potential contingencies should any of the offset projects fail to be stable or not provide the anticipated benefits to fish.

### 8.2.3. Options Selection

Ten offset projects, not including the complementary eulachon research project, have been selected for inclusion in the offsetting plan for LNG Canada's LNG facility. Offsets include creek realignments, construction of off-channel habitats, dyke breaches, habitat complexing, and salt marsh restoration. In addition to newly constructed habitats, the offset program also includes four types of habitat enhancements:

- Expanding the physical footprint of existing habitat features
- Directing higher flows into newly expanded habitats
- Increasing complexity of habitats through placement of LWD and engineered logjams
- Improving fish access to habitat through creating breaches in dykes and constructing fishway

Nine of the offset projects, including two proposed by the LKWPM (Moore Creek Estuary Dyke Breach #2 and Rio Tinto dyke breach #1), are in the immediate vicinity of the LNG facility (Figure 8-1 and Figure 8-2); these are:

- Beaver Creek realignment (including the Beaver Creek wetland connector) (Option #65 in Figure 8-1)
- Beaver Creek Off-channel Habitats–Workforce Accommodation Centre Pond 3 (Option #69)
- Anderson Creek realignment (Option #64)
- Anderson Creek fishway at Alcan Road (Option #71)
- Anderson Creek Side Channel (Option #68)
- Moore Creek Estuary Dyke Breach #2 (Option #3)
- KRSC Northern Realignment (Option #62)
- KRSC Southern Extension, including Rio Tinto dyke breach #1 (Option #5)
- Kitimat River estuary pond and channels, including an additional Rio Tinto dyke breach (Option #63)

The Beaver Creek realignment and the Anderson Creek realignment were selected because they provide new or enhanced spawning, rearing, and overwintering habitat for pink, coho, and chum salmon divert water around the LNG facility, and hydraulically connect WAC Pond 3 to the wetland/pond complexes created as part of the WAC offset plan and Beaver Creek. All of these options will benefit the coho, pink, and chum salmon that previously used habitat in Beaver Creek for rearing and overwintering and Anderson Creek for spawning.

The only offset project not located in the immediate vicinity of the LNG facility, but still within the lower Kitimat River estuary, is the LWD removal/salt marsh restoration in Minette Bay (Option #11 in Figure 8-1 and Appendix 7). This salt marsh restoration project (Figure 8-2 and Figure 8-3) is intended to benefit the same fisheries that would be affected by the LNG facility development. The LWD removal will allow the salt marsh vegetation to regenerate, thereby increasing refugia habitat and invertebrate prey production for juvenile salmonids in the Kitimat River estuary. LWD removals from salt marshes in Minette Bay was also identified as a priority habitat restoration opportunity by the LKWPM and will benefit juvenile salmonids in the Kitimat River estuary by allowing the marsh vegetation to regenerate thereby increasing refugia habitat and invertebrate prey production. The remaining three projects will provide new or enhanced spawning, rearing, and/or overwintering habitat, primarily for coho salmon but also potentially for chum and pink salmon and resident and anadromous trout.

Table 8-1 presents an overview of the types of habitat that each of the offset projects will provide to salmon and trout species in the lower Kitimat River watershed and estuary.

**Table 8-1 Summary of Habitat Types Provided by the Selected Offsetting Projects**

| Offset Project | Habitat Type Created/Enhanced | | | |
|---|---|---|---|---|
| | Rearing | Spawning | Overwintering | Migratory |
| Beaver Creek Realignment | ✓ | | ✓ | ✓ |
| Beaver Creek Off-channel Habitats (WAC Pond 3) | ✓ | | ✓ | |
| Anderson Creek Realignment | ✓ | ✓ | | ✓ |
| Anderson Creek Fishway | | ✓ | | ✓ |
| Anderson Creek Side Channel | ✓ | ✓ | ✓ | ✓ |
| Moore Creek Dyke Breach | | | | ✓ |
| KRSC Northern Realignment and Southern Extension | ✓ | ✓ | ✓ | ✓ |
| Kitimat River Estuary Pond and Channels | ✓ | | ✓ | ✓ |
| Kitimat Estuary Channel and Pond Enhancements | ✓ | | ✓ | ✓ |
| Salt Marsh Restoration (LWD removal) | ✓ | | | ✓ |


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*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**PROPOSED FRESHWATER AND ESTUARINE OFFSET LOCATIONS**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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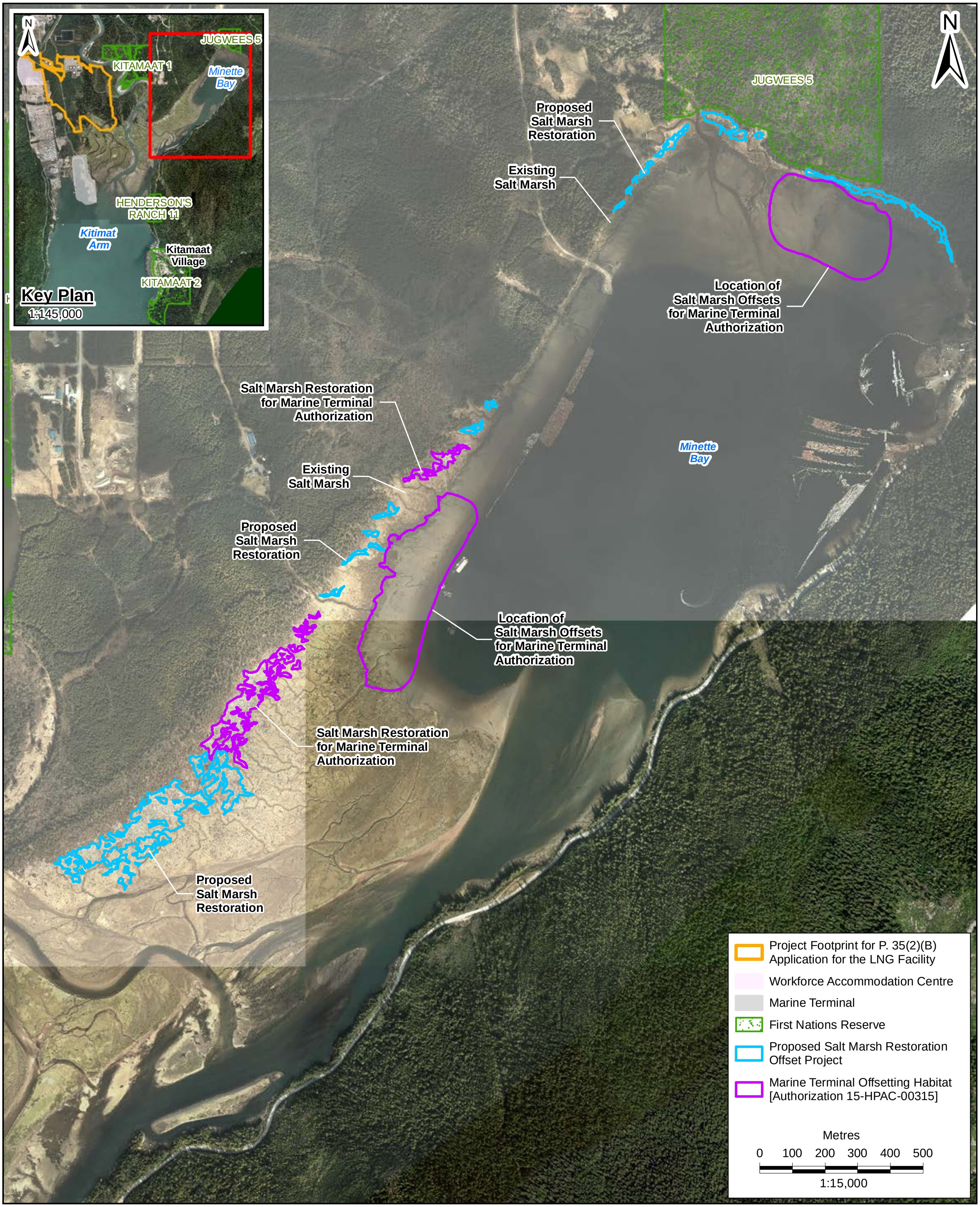


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*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**PROPOSED SALT MARSH RESTORATION AT MINETTE BAY**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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**Figure 8-4 Process for Discounting Fish Habitat Offset Contributions (Deleted)**

The selected offsetting projects support the sustainability, diversity and ongoing productivity of affected CRA and supporting fisheries in the Kitimat region, provide similar key ecosystem functions to the existing habitat being affected, and sustain beneficial effects that are expected to outlive Project effects. These new and enhanced habitats represent appropriate options for offsetting Project-related residual *serious harm to fish*. They are technically feasible, and complement the existing environment by providing a variety of habitat types and expanding the temporal use of this habitat to support the different life stages of local fish populations.

Reasons for excluding the remaining projects from further consideration are presented below with the number of options excluded for each reason in brackets (many options were excluded for more than one reason):

- Incompatible with the LNG Canada footprint and/or water management plan (5)
- Incompatible with the other offsetting project locations and/or water diversions (2)
- Land ownership conflicts with Rio Tinto and Kitimat LNG properties and "non-orphaned" roads/stream crossings (17)
- Engineering constraints and/or long-term stability risks (9)
- Potential water quality issues associated with previous industrial contamination (8)
- Existing fish habitat with only small potential habitat gains from enhancement (16)
- Already completed, started, or slated for construction by some other entity (5)
- Potential impacts to other infrastructure (3)
- Incompatibility with current DFO policy (10)

While the remaining projects are not being carried forward for implementation, some could serve as contingencies should any of the offset projects built by LNG Canada be physically unstable or not provide the anticipated benefits to fish. These contingency options are described in greater detail in Section 8.23 (Contingency Measures).

## 8.3. Design Approach

The following sections provide details on the offsetting design approach for watercourse realignments, habitat complexing, converting seasonal to perennial off-channel habitats, and riparian restoration. In general, the overall objectives of the offset program have been to provide habitats that meet the spawning habitat criteria identified in Instream Flow Study Guidelines: Technical and Habitat Suitability Issues, including fish preference curves (Washington Department of Fish and Wildlife 2004) and the characteristics of "good quality" salmonid habitats as identified in Watershed Restoration Circular No. 8: Fish Habitat Assessment Procedures (Johnston and Slaney 1996; Table 5:

Diagnostics of salmonid habitat condition at the reach level). Some of the parameters that are characteristic of good quality salmonid habitat include:

- More than two pieces of LWD per bankfull width
- More than 20% LWD cover in pools
- Percent pool by area greater than 55%
- Gravel and cobble dominated substrates with sand or small gravel rarely subdominant

As discussed below, both the spawning and the general habitat criteria have been incorporated into the habitat designs.

#### 8.3.1. Watercourse Realignments

The physical requirements for coho and pink salmon spawning were key drivers for the Anderson Creek realignment and KRSC northern realignment channel designs. For the Anderson Creek realignment, this process used available flow data for August/September (targeting pink salmon spawning) and September/October (targeting coho salmon spawning). Controlled flows from the inlet structure were used for the KRSC northern realignment channel design.

Based on these flow data, the design for watercourse realignments included:

- A multi-stage channel, with the first stage of the channel designed to accommodate low flow conditions, including spawning periods, and with an upper stage (bankfull) to accommodate higher flows
- Preferred flow depth and velocity based on the Instream Flow Study Guidelines: Technical and Habitat Suitability Issues (Washington Department of Fish and Wildlife 2004) including fish preference curves
- Target water depth and velocities for coho salmon spawning of 0.6 m and from 0.3 to 0.6 m/s, respectively
- Target water depth and velocity for pink salmon spawning of 0.3 m and 0.4 m/s, respectively
- Average flows in the first stage (low flow) channel for spawning habitats were:
    - o 1.81 $m^3$/s for pink salmon spawning
    - o 4.25 $m^3$/s for coho salmon spawning

Hydraulic modelling of the spawning areas indicates that flow depths will fall within the target range of 0.3 m to 0.6 m and flow velocities will fall within the target range of 0.3 m/s to 0.6 m/s during the coho salmon spawning period. For the pink salmon spawning period, an approximate flow depth of 0.3 m and velocity of 0.4 m/s is expected. With the placement of appropriate gravel substrate and the known available future bedload contributions, the proposed design provides suitable and self-sustaining spawning areas in Anderson Creek and the KRSC for both coho and pink salmon.

#### 8.3.2. Non-Mainstem Channel Habitats

Natural channel design principles were used to inform the design of the offset watercourses (Appendix 8). Natural channel design uses geomorphic and engineering principles to design channels that work in the environment in which they are constructed. The natural templates of the streams and creeks in the Kitimat valley were used to inform the designs that will be applied at each site. If a watercourse is currently present at the offsetting locations, the site-specific conditions of that watercourse have been considered in the enhancement design. To the extent possible, channel planforms were designed to follow the planform of the channel being enhanced to reduce impacts to riparian areas. Where new channels were being created, a stable meandering pattern was employed.

#### 8.3.3. Habitat Complexing

Habitat complexing is incorporated into the offsetting designs to stabilize banks and riparian areas, and provide cover for fish. It involves providing LWD at levels greater than two pieces per bankfull width. The benefits of habitat complexing in habitat restoration programs has been demonstrated by Keeley et al. (1996), who completed a literature review of habitat restoration programs that reported fish abundance information as part of a study funded by the provincial Watershed Restoration Program. They conducted statistical analyses on the data from their literature review to develop a baseline of predicted returns for fish production resulting from habitat restoration works. For rearing habitat enhancements that included habitat complexing, the study found: a 77% increase in coho salmon young-of-year densities; a 52% increase in steelhead young-of-year densities; and, a 130% increase in steelhead parr densities. After completion of mainstem habitat enhancement works, stream-resident juvenile salmonid densities increased by 50% (Keeley et al. 1996).

Whiteway et al. (2010) conducted an expanded meta-analysis on the effectiveness of instream structures on salmonid abundance, using information from 211 stream restoration projects. The results supported the findings of Keeley et al. (1996): 73% of the projects with in-stream structures resulted in increased local salmonid densities and 87% of the projects in increased biomass (average effect size of 0.51 [167%] and 0.48 [162%]). Roni et al. (2010) found a biological response of 0.37 coho smolts per $m^2$ of restored habitat was a good predictor of the benefits of habitat restoration programs. Ogston et al. (2014) found the Whiteway et al. (2010) relationship predicted the coho smolt production at individual restored sites in the Chilliwack River very well (smolt density ranged from 0.17 to 0.75 smolts per $m^2$).

Several in-channel habitat structures were used in the designs. The constructed habitat structures incorporated into the designs include: constructed log riffles, log sills, in-channel large wood debris, cover logs, rootwads, and woody debris toe protection. Most habitat structures will be constructed using natural materials, such as wood, rock, and coconut fiber matting. Each habitat structure will fulfill specific design functions related to controlling flow direction, maintaining pool features, dissipating flow energy, providing channel stability, enhancing aquatic habitat, or combinations thereof. Materials available on-site for re-use include: logs, root wads, LWD, sod mats, and some suitable shrub transplants. Boulders encountered by chance during grading operations can also be incorporated into instream structures. Where possible, substrate materials and wood from existing watercourses will be used to introduce and encourage growth of aquatic organisms that could hasten productivity for the habitat. For this project, structures using wood as a principal element have been emphasized, as wood has been the most common in-channel habitat element observed in the natural streams in the Kitimat valley. Schematics of these structures are presented on the Drawing Detail Sheets in Appendix 8. The final placement and quantity of in-channel habitat structures may be optimized during detailed design or construction without altering the overall habitat objectives.

Constructed log riffles are in-water structures that are constructed of logs and riffle substrate. These structures are intended to maintain the channel grade and provide habitat diversity through the incorporation of both wood and stone in the channel bed. Log sills will help hold the grade at the bottom of riffles, add carbon to the system, help form scour pools and provide under-cut cover for fish habitat. In-channel LWD structures add carbon to the system, help form scour pools and provide cover for fish habitat. Both structures will be made from logs sourced either on-site or from the project footprint.

Woody debris toe protection, with or without sod mats, will be used to enhance selected stream banks situated along the outside of meanders in pools. These are structures composed of woody debris and soil below the normal water level and into the bed of the channel, and a soil/sod mixture near and above the normal water level. These structures are excellent habitat features, providing cover and refuge for fish, as well as a carbon source to promote benthic invertebrate communities. The treatment also roughens the stream bank, thereby reducing nearbank shear stress and bank erosion potential. Live plantings will be installed near the bankfull stage to promote eventual root penetration and development, and help establish a living structure to provide long-term bank stabilization, shade, and riparian habitat. The wood portion of the treatment may be constructed at a relatively steep slope, allowing deeper pools that are more useful to overwintering fish species (a desired characteristic in these watercourses).

A double log step pool structure is primarily used for grade control and to promote fish passage. This structure serves to maintain the integrity of the upstream riffle while promoting scouring in the downstream pool. The structure consists of a header and footer log pair placed across the stream channel at the beginning of a meander bend. A second header and footer log pair is placed downstream at the centre point of the meander. The logs are plated with filter fabric, and back filled with riffle substrate mixture. A scour pool is constructed downstream of each log pair. The scoured areas provide deeper water and undercut habitat and provide a resting place for fish travelling upstream.

LWD not providing a structural function in the design will consist of logs and rootwads that are a minimum of 0.3 m in diameter. Rootwads will have a length of at least 3 m and logs will have a minimum length of 6 m. Cedar, spruce, hemlock or other coniferous tree species will be selected and set aside during clearing of the proposed facility site to be used as LWD. LWD will be anchored by ballasts (boulders and/or other logs) and/or buried within the channel bank to prevent movement of the log structure. Ballasts will be tied using high strength galvanized cable (5/8 inch) or 16 mm rebar or equivalent. The cable will be wrapped around or drilled through the ballast boulders and logs. Boulders used to anchor log structures will be used as "deadman" (buried) as indicated on the design drawings.

Boulders, ranging in size from 0.5 to 1.0 m in diameter, will be placed singly, in pairs or in clusters as part of riffles and vortex weirs to provide hydraulic complexity within the channels and ponds. They will also be used to anchor log structures and LWD, and will be embedded a minimum of one third of their diameter or 0.3 m into the surrounding substrate.

#### 8.3.4. Off Channel Wetlands

The majority of off-channel wetlands and ponds in the lower portions of Anderson Creek and Beaver Creek are shrub swamps that do not provide year-round rearing habitats. Where deeper ponds exist, they are generally less than 0.5 m deep in winter, thereby limiting the space and DO concentrations needed for juvenile coho salmon overwintering. A significant strategy of the offset program is to increase the spatial quantity and temporal availability of overwintering habitat by increasing the amount of deeper off-channel wetlands and pools.

Johnston and Slaney (1996) report good salmonid habitat as having more than 55% pool habitat by area. The LNG Canada fish habitat offsetting plan provides more than 55% pool habitat by area. Many of the offset ponds have been designed with a depth of 1 m or more, increasing opportunities for groundwater contact in summer and winter, and improving water quality in the winter months.

#### 8.3.5. Riparian Restoration

Efforts will be made to avoid disturbing existing vegetation that will be within the riparian areas of the proposed fish habitats. Where disturbance of riparian vegetation occurs, a staged approach to restoration will occur:

- Immediately following construction of the offset habitats, 300 mm to 450 mm of salvaged or imported topsoil will be placed over all disturbed areas
- Areas of moderate to high erosion risk will be seeded with a seed mix that meets MFLNRORD standards, this seeding may include hydroseeding
- Wetland planting and live staking will occur following construction of offset habitats as soon as appropriate seasonal conditions allow
- Natural recovery of the riparian vegetation will be allowed to occur for up to one year
- Following one growing season, in-fill planting will occur, as required, around naturally generating vegetation to bring the plant spacing within the riparian areas up to the average on-centre spacing targets identified in Table 8-2.

**Table 8-2 Native Species Identified for Replanting by Zone**

| Planting Zone | Species | | Minimum Size | Avg. On-Centre Spacing (m) | Approximate Percentage |
|---|---|---|---|---|---|
| | Common Name | Scientific Name | | | |
| Zone A | Sitka willow | *Salix sitchensis* | Live stake[1] | 0.75 | 30 |
| | Red-osier dogwood | *Cornus stolonifera* | Live stake | 0.75 | 30 |
| | Hardhack | *Spirea douglasii* | No. 1 pot[2] | 1.25 | 20 |
| | Salmonberry | *Rubus spectabilis* | No. 1 pot | 1.25 | 20 |
| Zone B | Hardhack | *Spirea douglasii* | No. 1 pot | 1.25 | 40 |
| | Salmonberry | *Rubus spectabilis* | No. 1 pot | 1.25 | 35 |
| | Black twinberry | *Lonicera involucrata* | No. 1 pot | 1.25 | 20 |
| | Western redcedar | *Thuja plicata* | No. 2 pot[3] | 3.5[4] | 1 |
| | Western hemlock | *Tsuga heterophylla* | No. 2 pot | 3.5 | 2 |
| | Black cottonwood | *Populus trichocarpa* | Live stake[1] | 3.5 | 2 |
| Zone C[5] | Salal | *Gaultheria shallon* | No. 1 pot | 1.25 | 10 |
| | Sitka spruce | *Picea sitchensis* | No. 2 pot | 3.5 | 15 |
| | Western red cedar | *Thuja plicata* | No. 2 pot | 3.5 | 15 |
| | Western hemlock | *Tsuga heterophylla* | No. 2 pot | 3.5 | 15 |
| | Black cottonwood | *Populus trichocarpa* | Live stake | 3.5 | 10 |

| Planting Zone | Species | | Minimum Size | Avg. On-Centre Spacing (m) | Approximate Percentage |
|---|---|---|---|---|---|
| | Common Name | Scientific Name | | | |
| Zone W1 | Broadleaf cattail | *Typha latifolia* | Bare root | 0.5 | 50 |
| | Small-flowered bulrush | *Scirpus microcarpus* | Plug | 0.5 | 20 |
| | Beaked sedge | *Carex rostrata* | Plug | 0.5 | 15 |
| | Sitka sedge | *Carex sitchensis* | Plug | 0.5 | 15 |
| Zone W2 | Lynby's sedge | *Carex lyngbyei* | Plug | 0.5 | 100 |

NOTES:

[1] Live stakes to be minimum 1 m in length, have 5 nodes, with 65% to 70% of live stake to be covered by topsoil when planted. Can be replaced with No. 1 pot.

[2] No. 1 pot = 1 gallon container

[3] No. 2 pot = 2 gallon container

[4] Trees to be planted in groups of 2-5 at designated spacing. Sufficient spacing to be provided between groups to allow for development of a shrub layer.

[5] Zone C planting percentage less than 100% to account for natural recruitment.

Immature trees, shrubs and emergent marsh plants may be salvaged from areas within the full LNG Canada Export Terminal footprint to be cleared and grubbed, for use in the riparian restoration. The contractor will assess the opportunity to reuse salvaged plants prior to ordering nursery grown materials. All container grown plants must be from stock originating within the Kalum Forest District.

Based on the site conditions around the offset projects, five planting zones have been identified:

- Zone A—Low Bench Riparian: Areas with prolonged periods of flooding in fall and spring and high water table. Zone A also applies to areas with restrictions on vegetation height
- Zone B—Mid Bench Riparian: Areas with occasional flooding during freshet or following storm events and high water table
- Zone C—High Bench Riparian: Areas not subject to flooding but with occasional high water table
- Zone W1—Freshwater marsh: Water depths from saturated soils to 40 cm standing freshwater (typically located around the perimeter of deeper overwintering habitats)
- Zone W2—Estuarine marsh: Flooded at high tide and dewaters at low tide

The plant species and planting density targets for each zone are identified in Table 8-2.

## 8.4. Verification of Design Performance

Hydraulic modelling of the fluvial offset habitat projects was completed using TUFLOW 2010. The objective of the modelling was to increase certainty around:

- Water levels and habitat areas during a 1-in-1.5 year flow event (i.e., a high flow channel forming event)
- Water levels and habitat areas during summer low flow periods
- Target water depths and velocities in areas intended for coho and pink salmon spawning
- Habitat complexing features in the wetted portion of the channel and functional during low flow conditions
- Connectivity, and therefore fish passage, between mainstem and off-channel habitats is maintained during low flow conditions

The outcome of this modelling is intended to increase the understanding and confidence in the hydraulic performance and habitat functionality of the fluvial offset habitats. A letter report summarizing the hydrologic and hydraulic assessment of the offset projects, including a discussion of the watershed hydrology and groundwater inputs to the model and results of the modelling is provided in Appendix 9.

## 8.5. Habitat Gains and Accounting for Underlying Habitat in Fish Habitat Offset Areas (Deleted)

This section, including Figure 8-4 (Process for Discounting Fish Habitat Offset Contributions), has been deleted as it no longer is applicable. All existing fish habitat affected by construction of the offset habitats has been deemed serious harm to fish and is accounted for in Section 7 (Effects on Fish and Fish Habitat from Construction of the LNG Facility and Offsets).

## 8.6. Beaver Creek Realignment

### 8.6.1. Background

The Beaver Creek realignment will relocate reaches 1 and 2 of the mainstem channel of Beaver Creek from its current alignment, which is within the proposed LNG facility footprint, to an alignment west of the haul road and east of the Rio Tinto rail line (Figure 8-5). The three primary offsetting design objectives for the new Beaver Creek mainstem are to:

- Maintain an effective migratory corridor for coho salmon, rainbow trout, and Dolly Varden char to move to existing spawning habitats in the upper reaches of the watershed, upstream of the project footprint

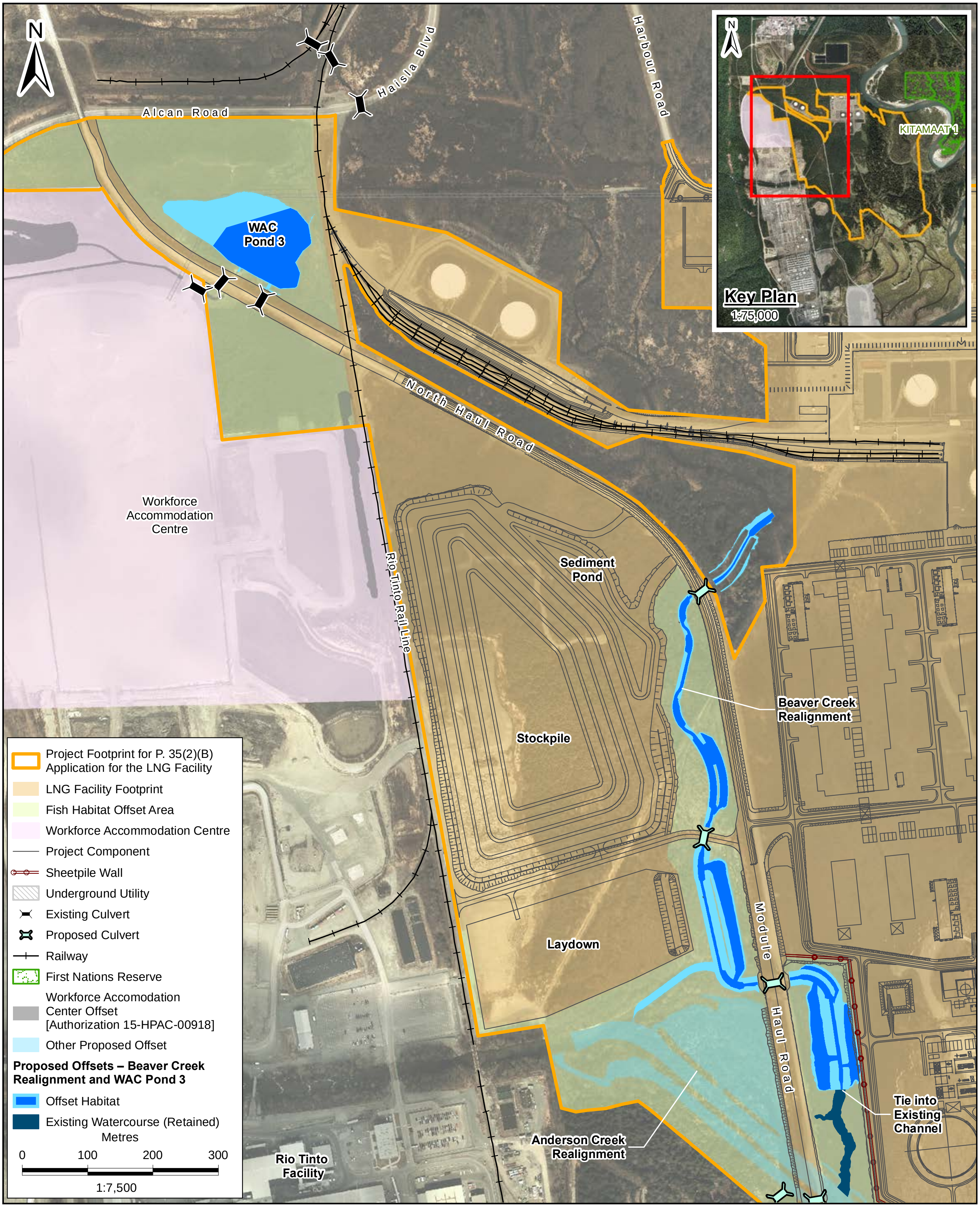
- Re-establish and/or create mainstem overwintering and rearing habitats for coho salmon, rainbow trout, and Dolly Varden char
- Provide juvenile coho salmon perennial rearing habitats in off-channel wetlands.

Existing aquatic habitats within the corridor of the realignment consist of seasonally inundated and perennial wetlands There are three seasonal unconnected wetlands, located south of the haul road, east of the Rio Tinto rail line and north of the utility corridor, that are flooded in fall and spring, freeze over in winter, and are either dry or isolated from mainstem habitats in summer. These wetlands have poor accessibility for fish. In the southern wetland.

The wetland south of the utility corridor is accessible to fish via culverts under the existing haul road. Fish sampling shows that coho salmon broadly use this area for rearing and feeding; however, a more limited area of the wetland is useable habitat in winter (due to ice cover and low water temperatures over most of the wetland) and spring (due to DO concentrations below 3 mg/L).

#### 8.6.2. Offset Design and Benefits to Fish

The proposed Beaver Creek realignment is approximately 1.27 km long starting at the southwest corner of the proposed administration and service building area of the LNG facility, near the existing break between reach 2 and reach 3 of the Beaver Creek mainstem (Figure 8-5). As the realignment channel has been shortened as a result of the reduced LNG facility footprint and habitat avoidance efforts in early 2016 (Section 6 Avoidance Measures), the chainage begins at Station 0 + 829, with the chainage from 1 + 050 to the end at 2 + 100 remaining generally consistent with the designs submitted in March 2016 and October 2016.

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*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**PROPOSED BEAVER CREEK REALIGNMENT AND WAC POND3 OFFSET LOCATION**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

| | |
|---|---|
| PROJECTION: UTM9 | DRAWN BY: SS |
| DATUM: NAD 83 | CHECKED BY: WP |
| DATE: 27-JUL-17 | FIGURE NO. **8-5** |

From the existing Beaver Creek channel, the realignment channel will direct flows southwest for 220 m, passing under the north haul road, and then turning south for 600 m running parallel with the north haul road and the module haul road. At Station 1 + 600, the realignment channel turns east and follows the former Anderson Creek channel alignment for 340 m before the bed elevation of the new Beaver Creek channel meets the bed elevation of the old Anderson Creek channel at Station 1 + 945. Before this connection occurs, the existing Anderson Creek will have been relocated as per the proposed Anderson Creek realignment (Section 8.8 Anderson Creek Realignment). The Beaver Creek realignment would then flow in the former Anderson Creek channel for 155 m before it reaches the confluence with the new Anderson Creek realignment east of the module haul road near the southwest corner of the proposed LNG processing and storage site (Figure 8-5).

Three open bottom arch culverts with lengths ranging from 23 m to 60 m will be constructed within the Beaver Creek realignment for road crossings. The culverts will have a 7 m to 7.7 m span with a rise of 3 m to 3.5 m and 0% grade. The sizing of the culverts was based on two primary design criteria:

- Conveyance of the estimated 1-in-100 year flow
- Maximum average velocities that allow upstream passage of juvenile coho salmon

Fish Passage Design for Road Crossings (Caltrans 2007) was used to establish the high flow design criteria for the Beaver Creek road crossings. The design criteria are provided in Table 8-3.

**Table 8-3 Fish Passage Design Criteria for Beaver Creek Culverts**

| Species/Life Stage | Fish Passage Design Criteria[1] | |
|---|---|---|
| | Percentage of 2-year Recurrence Interval Flow | Maximum Average Water Velocity (m/s) |
| Adult Anadromous Salmonids | 50% | 1.2 |
| Adult Non-Andromous Salmonids | 30% | 0.9 |
| Juvenile Salmonids | 10% | 0.3 |

NOTE:

[1] Criteria from Caltrans 2007.

All proposed culverts along the Beaver Creek realignment will be maintained for the life of the LNG facility and considered for eventual decommissioning or replacement as described in Section 4.4.4 (Other Maintenance and Monitoring). All connections between the channel and side pools will be inspected and blockages will be removed as required.

The new channel will exhibit a meandering planform morphology, with pool, riffle and run habitats incorporated into the longitudinal profile (Appendix 8). The proposed cross-section consists of a 2-stage channel. The high flow stage channel width is 8 m and bankfull width is 14 m; this is consistent with the existing Beaver Creek mainstem channel which is 16.3 m wide in reach 1 (B1) and 11.5 m wide in reach 2 (B2). The overall gradient of the channel is approximately 0.1%; however, grade varies between 0.07% and 0.58% and depends on habitat type and channel reach. A low flow stage channel, with a channel bottom width of 2 to 3 m, has been incorporated into the channel cross section to improve flow connectivity (and wetted habitat) during low flow periods. Average residual pool depth is 0.7 m and bankfull depth is 2.3 m. Pool depths have been increased in the new alignment to reduce the risk of freezing to the channel bed, and increase the availability of pool habitat during lower flow periods.

The channel is designed to mimic processes in the existing Beaver Creek channel and overflow its banks at specified locations to inundate off-channel habitats. Given the low grade of the Beaver Creek design (less than 0.1%), it is expected that during higher flow periods, the reach of the Beaver Creek realigned channel between the north haul road and the plant site bund wall will overtop the stage two channel banks and temporarily inundate the floodplain area. This overtopping mimics the existing reach of Anderson Creek and will maintain the ecological function in this area.

The following specific design criteria were used in development of the Beaver Creek realignment:

- Channel edges will be armoured to reduce potential for lateral migration of the creek
- Streambed will be armoured with cobble and gravel to prevent erosion, and promote invertebrate production. This will also provide spawning opportunities where flow and gradient conditions are appropriate
- Cobbles and small boulders will be located intermittently throughout the channel to provide cover for fish and help retain the finer gravels
- Rock weirs will be located at the upstream end of each pool to aid in gravel retention in the upstream channel and promote scour at the pool inlet, thereby reducing potential sediment build-up downstream of the weir)
- Habitat complexing will be achieved through placement of V-shaped weirs, vortex weirs, LWD bank stabilization structures, flow parallel log jams, LWD, deflection logs, undercut bank structures (lunkers), and triangular log jams. These habitat structures improve rearing habitat quality, hydraulic complexity, invertebrate production, channel stability and overall fish density
- A riparian area, extending 20 m to 30 m from top-of-bank, will be provided on both sides of the channel where possible

- Where planting is necessary to achieve a functioning riparian area, the restoration measures will use native species of trees, shrubs, and emergent wetland vegetation to meet the design criteria described in Section 8.3.5 (Riparian Restoration)

The variety of habitat features identified above are intend to improve habitat quality and complexity in the realigned channel.

The design depth of the proposed realignment is such that the new channel bed elevation is expected to be below the elevation of the water table; as a result, the channel is anticipated to be wetted throughout the year. The in-channel pools will be excavated to a depth where a minimum 0.5 m residual water depth is expected to be maintained except during extreme drought conditions. Downstream of the point where Beaver Creek enters the old Anderson Creek channel, peak flows will be diverted from Anderson Creek to augment flows in Beaver Creek. This is intended to allow the braided nature of the former Anderson Creek to be maintained.

The proposed Beaver Creek realignment will retain connectivity for adult salmonids moving between the Kitimat River estuary and upstream spawning habitats of Beaver Creek (i.e., it will maintain the migratory habitat values of the existing Beaver Creek). It will also provide mainstem and off-channel overwintering and feeding habitats for juvenile salmonids (i.e., it will offset the unavoidable loss of mainstem and off-channel habitat in Beaver Creek under the LNG facility footprint). The realigned channel is low gradient and designed to have mainstem riffle, run, and pool morphology features. The thalweg has been oriented to one side of the channel to allow for construction of artificial undercut banks (lunkers) on outside bends, and maximize the cover and shading provided by riparian vegetation. In addition, off-channel wetlands will provide habitat diversity to support various fish species and life stages. From stations 1 + 250 to 1 + 360, 1 + 440 to 1 + 650, and 1 + 770 to 1 + 940 of the Beaver Creek realignment, new off-channel ponds and wetlands will be created to provide rearing and overwintering habitats for juvenile coho salmon. The ponds will be designed to include a wetland edge around the perimeter, and include LWD and rootwad islands for in water complexity and cover.

Engineering design drawings, including plan, profiles, sections, and details, for the Beaver Creek realignment, including the off-channel ponds, and wetland areas are provided in Appendix 8.

#### 8.6.3. Contribution to Habitat Balance

Table 8-4 describes the areas of habitat created by construction of the Beaver Creek realignment and its contribution to the offset program. The mainstem watercourse habitat in Beaver Creek includes the area of existing habitat from the former Anderson Creek bed that would now be part of the Beaver Creek system (note: this area of

Anderson Creek is considered to be serious harm to fish resulting from the Anderson Creek offsetting works). It is expected that portions of the run habitats may provide spawning opportunities for coho and pink salmon; however, there is uncertainty about the long-term bedload movement from upper areas of the watershed into the realigned channel to maintain the availability of spawning gravels in lower Beaver Creek. Therefore, no spawning habitat gains are incorporated into the habitat balance.

**Table 8-4 Areas of Habitat Created by the Beaver Creek Realignment**

| Habitat Type | Habitat Value | Low Flow Area ($m^2$) | High Flow Area ($m^2$) |
|---|---|---|---|
| Mainstem watercourse | • Rearing<br>• Overwintering | 6,737 | 15,281 |
| Off-channel wetland: perennial | • Rearing<br>• Overwintering | 9,463 | 13,146 |
| | **Totals** | **16,200** | **28,427** |

## 8.7. Beaver Creek Off-Channel Habitats (Workforce Accommodation Centre Pond 3)

### 8.7.1. Background

The proposed Beaver Creek off-channel habitat, also referred to as WAC Pond 3, consists of a new wetland/pond complex located north of the WAC and north haul road (Figure 8-5). The new wetland/pond complex will be hydraulically connected to the fish habitat offsets constructed for the workforce accommodation centre (authorized under 15-HPAC-00918), and to a tributary to reach 3 of Beaver Creek. Together with the workforce accommodation centre pond, the new wetland/pond complex will form a series of channels and wetland/ponds that will provide rearing and overwintering habitats to fish moving out of the Beaver Creek mainstem.

### 8.7.2. Offset Design and Benefits to Fish

The Beaver Creek off-channel habitats will be a wetland/pond complex with a surface area of 19,561 $m^2$, consisting of 11,779 $m^2$ of perennial off-channel wetland/pond habitat and 7,782 $m^2$ of seasonal wetland habitat, with a 99 $m^2$ channel connecting the offset to Beaver Creek tributary B3-5.

The perennial portion of the wetland/pond complex will be excavated to a minimum depth of 0.5 m and maximum depth of 1.5 m to provide overwintering and perennial rearing habitat for fish. The shallows around the perimeter will have a gentle grade to promote colonization by emergent wetland vegetation. Specific design criteria used in development of the off-channel habitats include the following:

- The inlet to the pond/wetland will be armoured to reduce potential erosion

- Edges of the pond/wetland will be planted with emergent wetland vegetation
- Habitat complexing will be achieved through placement of root wads and other LWD
- Pond cut slopes will be at grades of approximately 3H:1V to maintain bank stability without the need for armouring
- Where not constrained by existing infrastructure, a riparian area consistent with the Environmental Protection and Management Guidelines (OGC 2015) has been integrated into the layout
- Portions of this offset are located adjacent to a powerline ROW and, therefore, has a height restricted riparian zone (Figure 7-2). Riparian vegetation in this area will be limited to low growing vegetation. Additional complexing in the form of in-channel LWD has been incorporated into the offset design in these areas to produce cover and refuge habitats that will help to balance the reduced function of the riparian area.

The proposed pond/wetland complexes will provide off-channel overwintering and feeding habitats for juvenile coho salmon. Under average climate conditions, connectivity between the proposed Beaver Creek off-channel habitat (WAC pond 3) and Beaver Creek is expected between September and early June (i.e., connectivity may be limited between mid-June and the end of August).

Engineering design drawings, including plan, profiles, sections, and specifications, for the Beaver Creek off-channel habitats are provided in Appendix 8.

#### 8.7.3. Contribution to Habitat Balance

Table 8-5 describes the areas of habitat created by Beaver Creek Off-Channel Habitats (WAC pond 3) and its contribution to the offset program.

**Table 8-5 Areas of Habitat Created by the Beaver Creek Off-Channel Habitats**

| Habitat Type | Habitat Value | Low Flow Area ($m^2$) | High Flow Area ($m^2$) |
|---|---|---|---|
| Off-channel wetland: perennial | • Rearing<br>• Overwintering | 11,779 | 11,779 |
| Off-channel wetland: seasonal | • Rearing | 0 | 7,782 |
| Off-channel watercourse | • Rearing<br>• Overwintering | 69 | 99 |
| | **Totals** | **11,848** | **19,660** |

## 8.8. Anderson Creek Realignment

### 8.8.1. Background

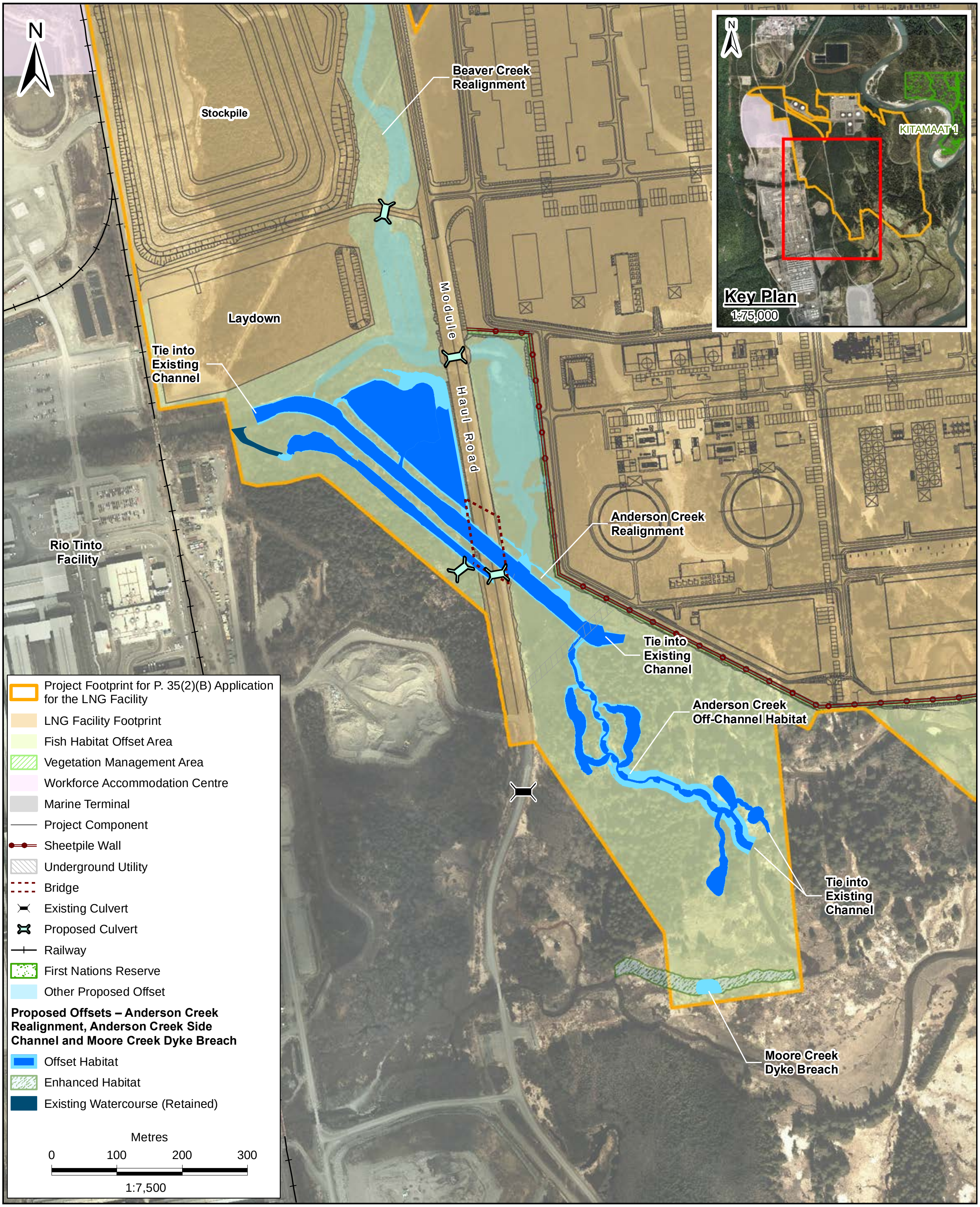
As a result of historical works and modifications by other parties, the majority of Anderson Creek downstream of Alcan Road has been straightened and constrained by dykes; the dykes limit natural meandering and the complexity of the fish habitat in the creek. The channel has high bedload supply and this has been dredged in the past to maintain flow conveyance capacity, particularly at the existing rail and haul road bridges. Despite the modifications and dredging, Anderson Creek currently provides important spawning opportunities for pink and coho salmon and supports rearing for a number of other fish species in the section of channel that is going to be realigned (Section 5.4.2.1 Anderson Creek Mainstem).

The Anderson Creek realignment will shift a portion of the mainstem channel from its current alignment, which flows east and then south, to a new diagonal alignment in a southeastern direction (Figure 8-6). The realigned channel will pass under the module haul road through a new bridge with the hydraulic capacity to convey 1-in-100 year flow events. Downstream of the new haul road crossing, the realigned Beaver Creek will enter the new channel; the design was based on criteria outlined in Section 4.3.11.2 (Module Haul Road). The combined creeks will then flow southeast to the Kitimat River estuary, where it will tie back into its existing channel. The realignment is necessary to create the appropriate grade to connect with the Beaver Creek realignment.

### 8.8.2. Offset Design and Benefits to Fish

Approximately 900 m of the existing Anderson Creek will be realigned to create additional spawning habitat and facilitate the Beaver Creek realignment and tie-in. The realignment will start between the Rio Tinto rail bridge and the Module Haul Road and flow southeast for 628 m (Appendix 8).

The realigned Anderson channel will pass under a new bridge on the module road, about 250 m south of the existing bridge. It will then meet up with the Beaver Creek realignment at station 2 + 560. From this confluence, the channel continues until station 2 + 690, at which point it will rejoin the existing Anderson Creek channel. A proposed new side channel to Anderson Creek will be tied into the Anderson Creek realignment at station 2 + 670 (see Anderson Creek Side Channel in Section 8.10 and Anderson Creek Fishway in Section 8.9).

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*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**PROPOSED ANDERSON CREEK REALIGNMENT, ANDERSON CREEK SIDE CHANNEL AND MOORE CREEK DYKE BREACH OFFSET LOCATIONS**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

| | |
|---|---|
| PROJECTION: UTM9 | DRAWN BY: SS |
| DATUM: NAD 83 | CHECKED BY: WP |
| DATE: 26-JUL-17 | FIGURE NO.: 8-6 |

The planform of the Anderson Creek realignment design is mainly straight with occasional bends. In-channel habitat will consist of pool, riffle and run units. The channel will have a three stage cross-section. The third stage channel base width will vary between 20 m and 25 m, and bankfull widths will range between 26 m and 34 m. The second stage channel will be constructed with an average channel base width of 10 m and a depth of 0.3 m. A low flow channel (first stage) will be excavated into the channel bottom of the realignment, with an average width of 3 m and a depth of 0.3 m. The low flow channel has been included throughout the alignment to maintain hydraulic connectivity during low flow periods.

The overall gradient in the Anderson Creek realignment will be less than 1.0%; however, the grade will vary depending on individual habitat types. For example, average riffle gradient is 5% and average run/glide gradient varies between 0.4 and 0.94%. In addition to the mainstem channel, two off-channel rearing habitat ponds will be created and connectivity to an existing side channel, located at station 2 + 630, will be maintained.

Design of the Anderson Creek realignment has focused on increasing spawning capacity in the system, improving the bedload movement through this lower section of the creek, and providing a technically feasible solution for the realignment of Beaver Creek. This design considers feedback from Haisla Nation and DFO on the importance of Anderson Creek spawning habitats to the productivity of local salmon populations.

The spawning habitats in the realignment have been designed to meet the requirements of pink and coho salmon (Washington Department of Fish and Wildlife 2004); however, it is expected that other species, such as chum salmon, will also benefit. By reducing the need for maintenance dredging, it is expected that more consistent run sizes can be realized. Habitat features such as LWD, root wads, and engineered log jams have been incorporated into the design to provide increased habitat diversity and hydraulic complexity, improve rearing habitat quality, and overall fish density.

In addition to the design criteria in Section 8.3.1 (Watercourse Realignments), the following design components were used in the Anderson Creek realignment:

- Channel has been designed to convey the 1-in-100 year flood event without impacting surrounding infrastructure
- Additional engineering effort went into the design to provide seasonal high flows into the nearby realigned Beaver Creek to maintain the complexity of the habitats within the Beaver Creek realignment
- Flow events between bankfull flow (estimated to be the 1-in-1.5 year return period event) and the 1-in-100 year flow event will not be wholly contained within the realigned channel banks and will inundate the adjacent floodplain during higher flood events – this design approach reduces the flood risk to adjacent infrastructure while allowing the floodplain to maintain its ecological function

- Pool depths have been designed to reduce the risk of freezing, and provide overwintering habitat at the winter flow volumes observed in the creek
- Rock weirs have been located at the upstream end of each pool to aid in gravel retention, and promote scour of potential sediment build-up downstream of the weir at the pool inlet
- Areas suitable for spawning habitat have been located directly downstream of riffles
- Small boulders and cobbles will be located in potential spawning areas to help retain gravels suitable for spawning pink and coho salmon
- Cut slopes, where not armoured using riprap or other techniques, will be hydroseeded and vegetated for bank stability. Where not constrained by existing or proposed site infrastructure, a 30 m riparian buffer zone will be provided as described in Section 8.3.5 (Riparian Restoration)
- The new bridge proposed will have the capacity to convey the 1-in-100 year flows
- Two new seasonal wetlands will be created on the south side of the realigned Anderson channel

The Anderson Creek realignment includes the creation of two off-channel ponds and provides connections that will supply water to existing wetland areas on the north and south sides of the new channel. Connection to off-channel rearing habitat pond 1 is provided at stations 2 + 150 and 2 + 285, and connectivity to an existing side channel will be re-established at the start of the realignment to allow a small portion of flows from Anderson Creek into pond 2 on the south side of the new channel. Pond 1 will be connected with existing wetland habitat and will include LWD and rootwad island complexing, and single LWD rootwad structures in the pond design to improve habitat. In addition, two culverts will be installed to maintain flows into the wetland south of the realigned creek (Figure 8-6).

Engineering design drawings, including plans, profiles, sections, and specifications for the Anderson Creek realignment are provided in Appendix 8.

#### 8.8.3. Contribution to Habitat Balance

The proposed Anderson Creek realignment will result in the relocation of existing habitat, the creation of new habitat, and the enhancement of an existing side channel. Table 8-6 describes the areas of habitat created and their contribution to the offset program.

## Table 8-6 Areas of Habitat Created by the Anderson Creek Realignment

| Habitat Type | Habitat Value | Low Flow Area ($m^2$) | High Flow Area ($m^2$) |
|---|---|---|---|
| Mainstem: riffle-run sequence | • Spawning<br>• Rearing<br>• Overwintering | 6,477 | 7,112 |
| Mainstem: other | • Rearing<br>• Overwintering | 8,127 | 10,180 |
| Off-channel wetland: perennial | • Rearing | 18,291 | 21,788 |
| | **Totals** | **32,895** | **39,080** |

NOTE:

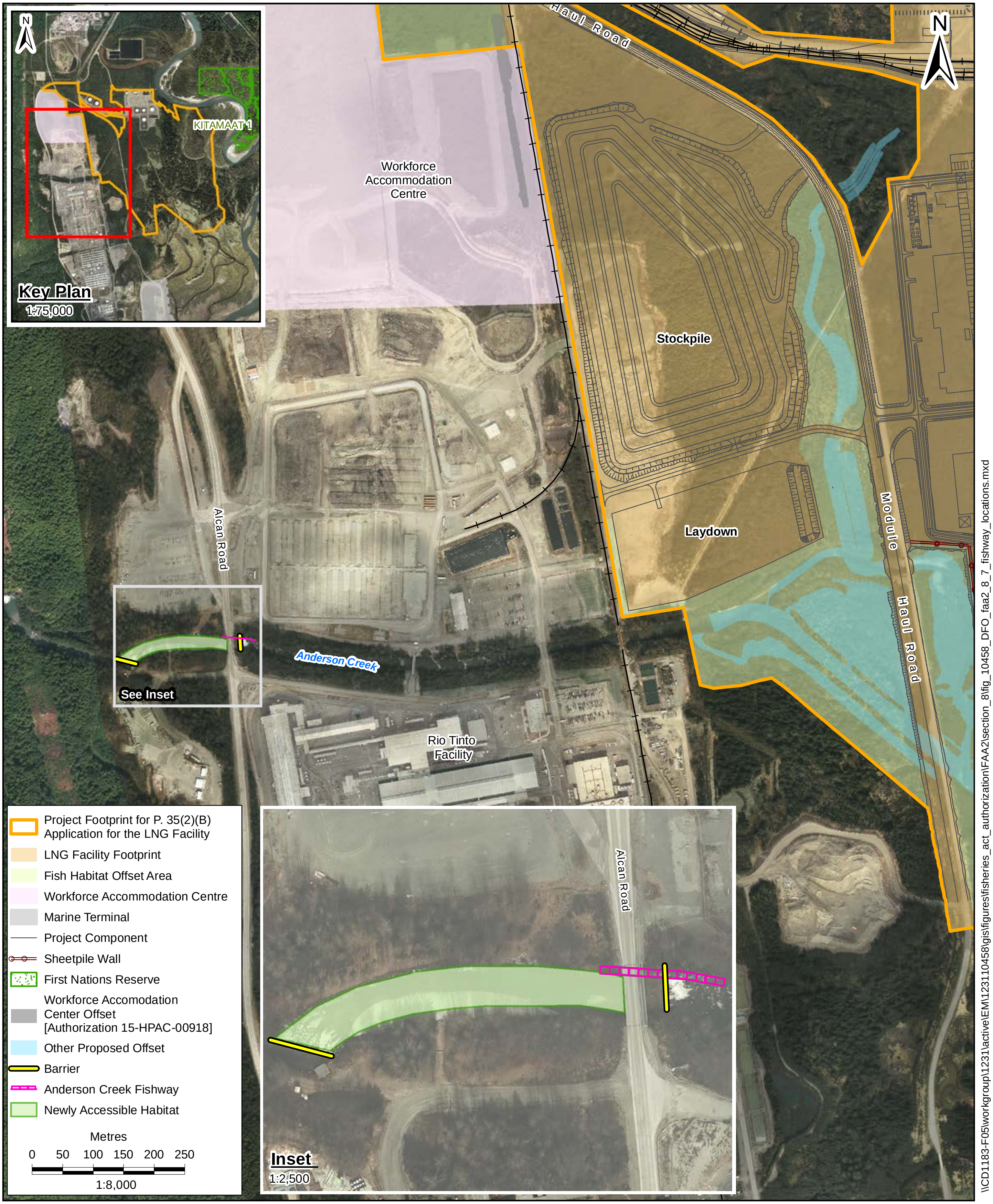
The accounting of spawning habitat areas uses a conservative (precautionary) approach. The offset spawning habitat area is calculated from low flow wetted habitat area, while the accounting of serious harm for existing spawning habitat is calculated using bankfull channel width.

As discussed in Section 5.4 (Anderson Creek), Anderson Creek supports runs of pink, coho, chum and sockeye salmon. Realignment of the creek will affect spawning habitats used by these populations; however, there will be spawning habitat created in the Anderson Creek realignment, the Anderson Creek side channel and the KRSC offset habitats. In addition, access to spawning areas upstream of Alcan Road is provided by the Anderson Creek fishway. See Section 9 (Habitat Balance) for a discussion of the availability of spawning habitat in the Anderson Creek system, including the realignment of Anderson Creek, and the creation of spawning areas by the various offset projects.

## 8.9. Anderson Creek Fishway

### 8.9.1. Background

There are three barriers to anadramous fish movement in upper Anderson Creek: the Alcan Road bridge, the Rio Tinto water intake weir, and natural falls at the base of the mountains. The offset plan includes a fishway on Anderson Creek at the Alcan Road bridge (and associated concrete apron under the bridge). The reach upstream of the Alcan Road consists of a low gradient riffle section with a few pools and substrates dominated by gravels that are consistent with those present downstream, between the haul road bridge and the Rio Tinto railway bridge, where coho and pink salmon spawning occurs. With passage for fish restored, adult salmon will be able to access approximately 175 m length of previously inaccessible habitats in Anderson Creek between the Alcan Road bridge and the Rio Tinto water intake weir (Figure 8-7).

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*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**PROPOSED ANDERSON CREEK FISHWAY LOCATION**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

| | |
|---|---|
| PROJECTION: UTM9 | DRAWN BY: SS |
| DATUM: NAD 83 | CHECKED BY: WP |
| DATE: 26-JUL-17 | FIGURE NO. 8-7 |

The FISS database indicates that coho salmon, as well as resident Dolly Varden and cutthroat trout, have historically been present in Anderson Creek upstream of the Alcan Road and water intake barriers (BC MOE 2017b); however, it is highly unlikely that coho salmon have been upstream of Alcan Road bridge since the concrete barrier was built. This is because the barrier is approximately 3 m high, and the plunge pool below the barrier is not deep enough for salmon to attain the swim speeds necessary to jump the barrier.

#### 8.9.2. Offset Design and Benefits to Fish

LNG Canada is proposing to construct a steep-pass Denil fishway built to allow coho and pink salmon to pass over the vertical concrete barrier and apron downstream of the Alcan Road bridge. Denil fishways have been constructed around the world, and their effectiveness has been extensively studied for use by salmonid (Laine et al. 1998 for example) and non-salmonid species (Bunt 1999; Bunt et al. 2001; Mallen-Copper and Stuart 2007). Salmonids as a group are strong swimmers, with generally above-average endurance. Coho salmon and pink salmon, the species most likely to use a fishway in Anderson Creek, are weaker swimmers than steelhead, chinook salmon and sockeye salmon, but are stronger swimmers than chum salmon and other species known to use Denil fishways (e.g., largemouth bass; Katapodis and Gervais 2016).

A Denhil fishway is proposed because the space available between Anderson Creek and the Rio Tinto facility on both sides of the stream channel is severely restricted. However, due to the relatively strong swimming ability of coho and pink salmon, and their strong instinct to move upstream to spawn, a Denil fishway is considered an appropriate fish passage technology for these species at the Alcan Road bridge.

The ability of Denil fishways to pass upstream migrants is dependent on attracting fish to their entrances, presenting water velocities in the fishway within the target species' swimming abilities, and providing adequate resting areas along the length of the fishway. Preliminary designs of the Alcan Road Fishway have been developed with these success criteria in mind, and by guidelines provided by DFO (Katapodis 1992).

This Denil fishway is in a preliminary design stage at present, but it is envisioned that the structure will consist of three Denil steep-pass fishways (Katopodis 1992). Each fishway will be 9 m long and 1.2 m wide (internal width 0.9 m, slot width 0.5 m) and will have 17% gradient, which is within the 15% to 25% gradient range appropriate for salmon (Katopodis 1992), for a total vertical rise of approximately 1.5 m. Resting pools, each 4 m long, 2 m wide, and 1 m deep, will separate the Denil fishways. These resting pools will be 9 m apart, which is within the 5 m to 10 m range appropriate for non-salmonid freshwater fish, and shorter than the 10 m to 15 m maximum range appropriate for adult salmon (Katopodis 1992).

A synthetic flow series for Anderson Creek was used to estimate the maximum flow through the structure, the number of Denil fishways required to achieve acceptable water depths and velocities, and the slope and width of the exit channel. Criteria used during the preliminary design included provision of effective fish passage during the 1-in-10 year 3-day delay flow between July 1 and December 15. Detailed design for the structure will include an assessment of hydraulics and hydrology in Anderson Creek to develop specific headwater and tailwater stage-discharge data and target velocities.

Attractant flow will be provided at the entrance to the fishway from the steep-pass fishway itself, as well as flow conveyed in a shallow notch cut into the north side of the existing concrete apron under the bridge. If additional attractant flows are required then an auxiliary attractant water system will be considered in the detailed design.

The north creek bank was chosen for the location of the fishway because this bank is the outside bend of the channel immediately upstream of the bridge. This is the preferable location for the fishway exit at the upstream end of the fishway due to higher expected flow velocities and increased scour potential, thereby reducing the likelihood of sediment deposition at the fishway exit. Small rock barbs may also be built on the south bank to help direct streamflow towards the fishway exit during lower flow conditions.

The upstream and downstream tie-ins will connect with pools in Anderson Creek. The approach channel connecting Anderson Creek to the Denil fishway will be approximately 0.6 m wide and 13 m long, and will pass under the Alcan Road bridge.

#### 8.9.2.1. Mitigation and Monitoring

Mitigation measures will be incorporated into the design and construction of the fishway. These will include: construction of anchor pads and bolts for the Denil fishways in isolation of flowing waters during the Anderson Creek reduced risk instream work window; and incorporating a grating cover over the Denil fishway channels and upstream pool to reduce the likelihood of predation of migrating salmon by bears and other mammals.

Routine maintenance will likely be required to preserve the functionality of the fishway. This maintenance will primarily consist of the removal of any accumulated sediment and debris from the fishway, its entrance, and exit. Inspection and maintenance is most likely to happen following large flow events when sediment and debris transport is most prevalent (Daniels et al. 2011).

### 8.9.3. Contribution to Habitat Balance

The proposed Anderson Creek fishway will provide access to currently inaccessible habitat upstream of the Alcan Road bridge to the Rio Tinto water intake waterfalls. This includes approximately 3,500 $m^2$ of habitat between the Alcan Road bridge and the water intake weir during high flow conditions and 1,590 m2 during low flow conditions (Table 8-7).

**Table 8-7 Areas of Existing Habitat Made Accessible by the Anderson Creek Fishway**

| Habitat Type | Habitat Value | Low Flow Area ($m^2$) | High Flow Area ($m^2$) |
|---|---|---|---|
| Mainstem: riffle-run sequence | • Spawning<br>• Rearing<br>• Overwintering | 1,590 | 3,500 |
| | **Totals** | **1,590** | **3,500** |

## 8.10. Anderson Creek Side Channel

### 8.10.1. Background

The Anderson Creek side channel is designed to divert the additional flows from Beaver Creek that have been introduced into the Anderson Creek realignment through the Beaver Creek realignment. The diversion of these flows will mitigate any potential scour and bank erosion that may result from increased flows downstream of the realignment works in the undisturbed reach of Anderson Creek, while creating a range of habitats for the same species that utilize habitats in Anderson Creek. Water from the proposed Anderson Creek side channel will flow into an estuarine channel downstream of the existing confluence with Beaver Creek (Figure 8-6).

The proposed Anderson Creek side channel and rearing ponds will be constructed south of the Anderson Creek mainstem and east of the module haul road. Engineered log jams will be installed to stabilize the channel inlet located at station 2 + 680 of the Anderson Creek realignment (Figure 8-6). The side channel will flow south then southeast for approximately 490 m, before connecting with an unnamed estuarine channel. Five rearing ponds are proposed in the riparian area adjacent to the side channel. The proposed side channel will provide overwintering, rearing, and spawning habitat (primarily for chum and pink salmon).

### 8.10.2. Offset Design and Benefits to Fish

The Anderson Creek side channel is intended to create spawning, rearing and overwintering habitats for the same species that utilize habitats in Anderson Creek. Flow from Anderson Creek will be directed into the side channel by the construction of an engineered log jam at the inlet. The engineered structure is designed to maintain the existing bankfull elevation along the banks of Anderson Creek. Maintaining this elevation will allow high flow events to continue to overtop the banks in the area of the diversion. This will simulate natural flooding processes, thereby maintaining the productivity of adjacent riparian areas, and reducing the risk of increased local scour in Anderson Creek. In-channel wood debris, cover logs and log sills have been incorporated into the design of the side channel to increase the habitat complexity. The main channel continues until it flows into the same estuarine side channel at station 30 + 505.

The proposed side channel will have an average bankfull width of 14 m and average bankfull depths of approximately 0.9 m at riffles and 1.1 m at pools. Because the channel was designed to accommodate the flows of Beaver Creek, channel dimensions surveyed in Beaver Creek were used as a reference (natural template) for the design. Habitat structures such as wood debris toe protection, LWD, and LWD constructed riffles will add cover and carbon to the channel. Habitat diversity will be enhanced by providing pools, riffles, runs, and glides.

The Anderson Creek side channel also includes five proposed off-channel rearing ponds. The first pond connects to the side channel at station 30 + 090 (inlet). The pond inlet will be protected by in-channel wood debris structures, and additional LWD structures in the pond for cover. The area of the proposed pond location encompasses existing wetted areas. An outlet for the channel has been designed to encourage flow through the pond, and is located at station 30 + 218. A second off-channel pond will be connected with an inlet at station 30 + 135 and outlet at 30 + 240.

Two additional off-channel rearing ponds will be connected along the right and left banks of the side channel at approximately 30 + 420 and 30 + 435, respectively. The left bank (north) pond inlet will feed into a larger rearing pond that will flow downstream into a smaller rearing pond, then into the unnamed estuarine side channel. A tidal connecting channel will provide access to a fifth rearing pond south of the main side channel.

The five proposed off-channel ponds will provide rearing and overwintering habitat. Overall pond habitat accounts for more than 8,800 $m^2$ of surface area under high flow conditions and more than 7,700 $m^2$ under low flow conditions. Maximum pond depths will be 1.5 m and average depths will be 1.1 m. Habitat structures, such as LWD and cover logs, have also been included in the proposed design.

The following specific design elements were used in development of the Anderson Creek side channel habitats:

- Spawning substrate will be incorporated into the channel mainstem, at the downstream end of the pool features, and throughout selected riffle sections.
- Most of the off-channel habitats have been provided with inlets and outlets to improve water circulation and reduce siltation.
- A low flow channel has been designed within the bankfull channel, which will consolidate flow to improve water depths during periods of low flow to permit fish passage. The low flow channel also helps to reduce siltation.

- A floodplain bench has been included in the design to accommodate overbank flows, and allow the additional stream energy from bankfull flows to be dissipated into the adjacent riparian area.
- Habitat complexity and diversity will be achieved through placement of root wads and other LWD structures. This will improve rearing habitat quality, invertebrate populations, and overall fish density.
- Wood debris toe protection has been incorporated into the outside of some meander bends. Wood debris toe protection will be used to stabilize streambanks and eliminate the need for armouring with rock, as well as enhance fish habitat, and maintain deep pools.
- Channel ponds are designed to remain wetted throughout the year.
- Constructed log riffles have been included to control grade and provide habitat diversity.

Design drawings, including plans, profiles, sections, and details for the Anderson Creek side channel are provided in Appendix 8.

#### 8.10.3. Contribution to Habitat Balance

The proposed Anderson Creek Side Channel will result in the creation of 15,600 $m^2$ of new habitat as summarized in Table 8-8. Table 8-8 also describes the areas of each habitat type created and their contribution to the offset program.

**Table 8-8 Areas of Habitat Created by the Anderson Creek Side Channel**

| Habitat Type | Habitat Value | Low Flow Area ($m^2$) | High Flow Area ($m^2$) |
|---|---|---|---|
| Mainstem: riffle-run-pool sequence | • Spawning<br>• Rearing<br>• Overwintering | 3,820 | 6,789 |
| Off-channel pond/wetland: perennial | • Rearing<br>• Overwintering | 7,728 | 8,811 |
| | **Totals** | **11,548** | **15,600** |

## 8.11. Moore Creek Dyke Breach

#### 8.11.1. Background

The Moore Creek dyke is located in the same estuarine channel fed by the proposed Anderson Creek side channel and off-channel habitats (Section 8.10 Anderson Creek Side Channel). The channel historically connected Moore Creek and Anderson Creek in a southwest to northeast direction; it is approximately 150 m east of where the estuarine channel has a confluence with Moore Creek, and 500 m south of where the estuarine channel has a confluence with Anderson Creek (Figure 8-6). On either side of the existing Moore Creek dyke, the estuarine channel is accessible to fish from either Moore Creek or Anderson Creek; however, migratory connectivity between the Moore and Anderson creek systems at the dyke location is limited to short periods at seasonally high tides. As discussed in Section 5.

The dyke is approximately 20 m wide and 1.5 m higher than the surrounding natural channel banks. The dyke is thought to have been installed in the 1950s to access the power transmission towers during the initial construction of the transmission line. Riparian vegetation throughout this area consists of estuarine grasses and shrubs. Channel width measurements within 75 m of the dyke ranged from 17 m to 29 m. Depths on both sides of the dyke, relative to the adjacent top of bank, range from approximately 0.5 m to 2.0 m, and vary with the tide. Substrate on both sides of the dyke consists of fine materials and organics. Fish cover adjacent to the dyke is limited, consisting of only occasional pools with a limited amount of LWD and overhanging vegetation.

Removal of this dyke was identified as Option 3 (Moore Creek blockage in Estuary #2) by the LKWPM (2013). Its removal also has been identified as a priority of Haisla Nation.

#### 8.11.2. Offset Design and Benefits to Fish

The proposed breach of the Moore Creek dyke will account for an area of 472 m² by improving fish access upstream of the dyke. Associated with the removal of the dyke, in-channel wood debris and cover logs will be installed over a 4,900 m² area of estuarine channel. Specific design components used in the development of the Moore Creek Dyke Breach habitats include the following:

- Channel side slopes in the dyke removal area will be contoured to match the existing channel slopes of about 4.5H:1V
- Habitat complexing will be achieved through placement of LWD and cover logs throughout the estuarine channel
- Design drawings, including plan, profiles, sections, and specifications for the Moore Creek dyke breach are provided in Appendix 8

The dyke breach will benefit fish species by improving connectivity within the estuarine channel. Fish sampling conducted in November 2015 set five over-night minnow traps on each side of the dyke. Traps on the Moore Creek side captured 81 coho salmon and one threespine stickleback, while traps on the Anderson Creek side captured seven coho salmon and two threespine stickleback. Trapping was also conducted in May and June 2012, approximately 200 m downstream of the dyke on the Anderson Creek side and yielded 148 threespine stickleback and one prickly sculpin. Based on these sampling results, removal of the dyke is expected to substantially increase the habitat use and productivity in habitats on the Anderson Creek side of the channel. In addition, habitat enhancements, via placement of in-channel wood debris structures and cover logs, will provide cover and more complex habitats for juvenile pink, chum and coho salmon from Moore and Anderson creeks.

#### 8.11.3. Contribution to Habitat Balance

The proposed Moore Creek Dyke Breach will result in creation of new habitat and enhancement of existing habitat. In calculating the total offset habitat gain, the habitat area gains associated with the enhancement of existing habitat has been claimed at a 75% ratio in the habitat balance (Section 8.17 Summary of Habitat Contributions from the Offset Projects and Section 9 Habitat Balance).

As discussed in Section 8.3.3 (Habitat Complexing), increasing the structure and available cover in rearing habitats can provide increases in juvenile coho salmon and juvenile steelhead densities of between 52% and 130% (Keeley et al. 1996). A 50% habitat credit has been applied to the enhanced estuarine channel area in recognition of this density increase.

In addition, the improved access between Anderson and Moore creeks and the proposed Anderson Creek off-channel resulting from removal of the Moore Creek dyke will improve fish mobility, as well as access to rearing habitats in the Kitimat estuary. In consideration of the minnow trapping results discussed above, an additional 25% habitat credit has been applied to the enhanced habitat area to recognize the productivity improvement from this improved migratory access; however, it has not been applied to the portion of the side channel that will not be enhanced.

Table 8-9 describes the areas of habitat created and their contribution to the offset program.

**Table 8-9 Areas of Habitat Created by the Moore Creek Dyke Breach**

| Habitat Type | Habitat Value | Low Flow Area ($m^2$) | High Flow Area ($m^2$) |
|---|---|---|---|
| Estuarine habitat | • Rearing | 472 | 472 |
| Estuarine habitat - enhancement | • Rearing | 3,683 | 4,910 |
| | **Totals** | **4,155** | **5,382** |

### 8.12. Kitimat River Side Channel Northern Realignment

#### 8.12.1. Background

The KRSC northern realignment will shift the existing KRSC east from its current alignment, which will be within the proposed LNGC facility footprint, while maintaining freshwater mainstem and off-channel habitats (Figure 8-8). The two primary objectives of this realignment are to:

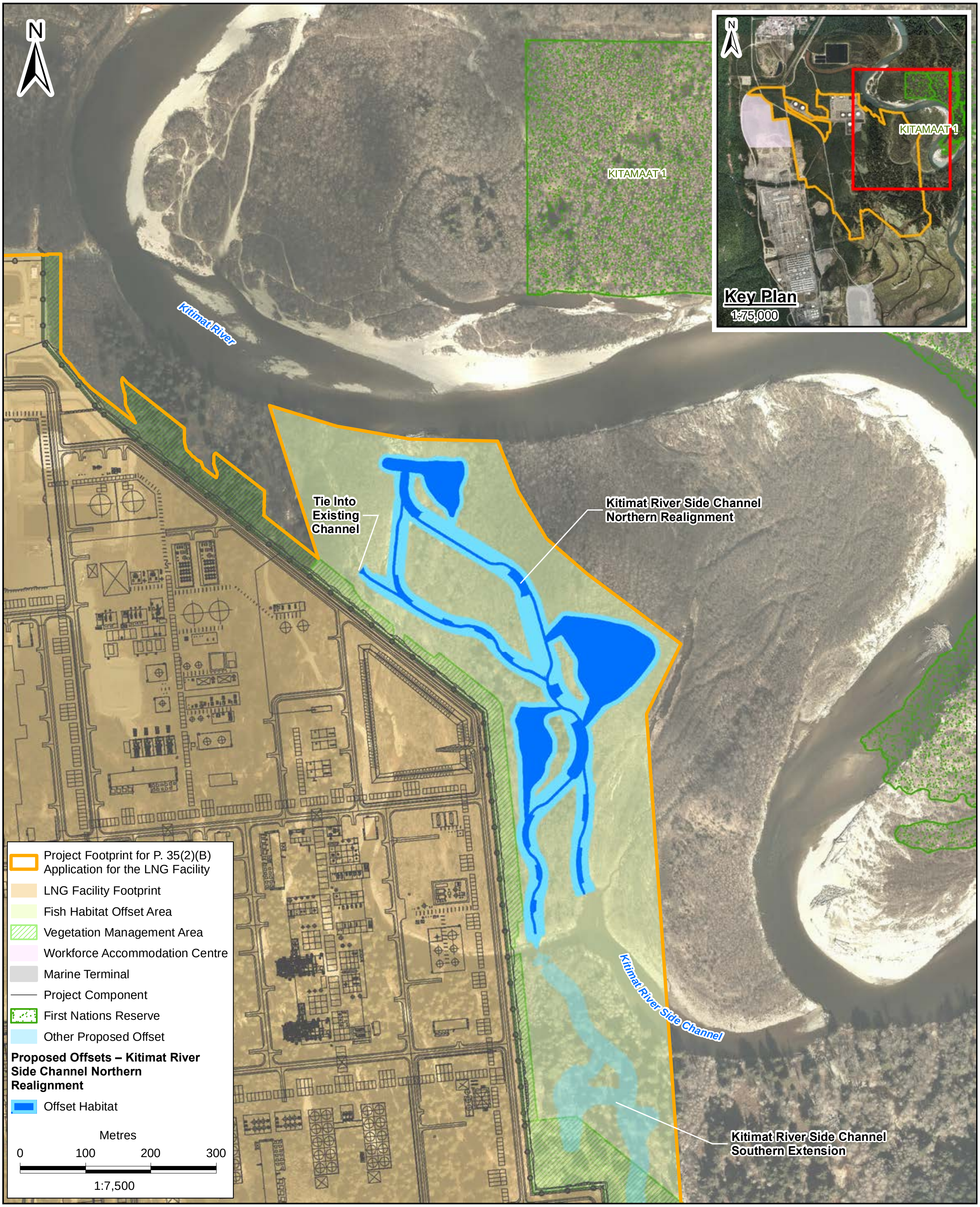
- Maintain spawning habitats for pink, chum, and coho salmon and potentially eulachon
- Create freshwater off-channel rearing habitats and refuge from high flows in the Kitimat River mainstem for juvenile salmon and eulachon

Approximately 280 m of the northern upstream limits of the existing KRSC west branch will be retained, while the east branch, which is only flooded when the Kitimat River is at higher flood stages, and lower portions of the KRSC will be realigned in a south-southeast direction around the eastern boundary of the LNG facility. The realigned KRSC will connect to an existing blind channel of the Kitimat River in two locations (Figure 8-8).

#### 8.12.2. Offset Design and Benefits to Fish

The basis for the KRSC northern realignment design is to establish a network of channels that will provide rearing habitat for juvenile salmon, with water flow and velocities generally higher than currently observed in the middle and lower sections of the existing KRSC during late summer/fall. The realignment design will also provide suitable spawning habitat for coho, chum, and pink salmon and potentially eulachon.

The northern realignment channel will be approximately 1,700 m long with three habitat ponds, including the inlet pond (Figure 8-8). It will have an average gradient of 0.1%, channel bottom widths will range from 8 m to 19 m, and bankfull widths will range from approximately 15 m to 25 m. Pools have been designed to have a residual pool depth of 1.0 m and a high flow depth (assumed to be the 1 in 1.5 year flow event) of 2.4 m. Off-channel ponds will have a maximum depth of 1.4 m.

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*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**PROPOSED KITIMAT RIVER SIDE CHANNEL NORTHERN REALIGNMENT OFFSET LOCATION**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

| PROJECTION | DRAWN BY |
|---|---|
| UTM9 | SS |
| DATUM | CHECKED BY |
| NAD 83 | WP |
| DATE | FIGURE NO. |
| 26-JUL-17 | **8-8** |

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Inlet flows will be provided through three structures that will be constructed through a riprap armoured berm on the Kitimat River bank in the vicinity of the existing side-channel inlet. The inlet structures will include culverts to provide flow into the new side channel. Flow volumes entering the side channel will be controlled by the culvert size (1.8 m diameter and 31 m long each) and invert elevations, relative to the Kitimat River. These structures will provide consistent flows from the Kitimat River into the KRSC, thereby providing benefits through more consistent water velocities and depths relative to current conditions. As a result, it will allow for a design that improves conditions for juvenile salmon rearing and adult salmon spawning.

All culverts associated with the KRSC inlet design will require routine maintenance and eventual decommissioning or replacement, as outlined in Section 4.4.4 (Other Maintenance and Monitoring). Additional maintenance will include annual inspection of the inlet berm to identify any deformation (slumping) and annual riprap inspection, as well as inspection following major flood events. Repairs will be completed by LNG Canada, as required.

The crest elevation of the berm will largely match the existing top of river bank elevation. Significant flood events in the river will overtop the inlet berm, flooding the side channel and adjacent land, as currently occurs in spring and fall and during large storm events, thereby allowing the natural flooding processes and maintaining riparian productivity.

Upstream passage of adult salmon through the inlet structure culverts will be possible in all but the most extreme high water events when adult fish are present in the Kitimat River. Culverts will be inspected monthly for accumulated debris and following flood events, with removal of debris as required and approved under regulation (Section 4.4.4 Other Maintenance and Monitoring). Average water velocities in the culverts were predicted using head loss calculation methods and the Kitimat River water surface elevations at the intake location (estimated from five years of data at the Water Survey of Canada stream gauge in the Kitimat River at Hirsch Creek). Average water velocities were predicted for:

- July and August, when chum and pink salmon are present in the river, water velocities are predicted to range between 0.48 m/s and 0.84 m/s
- September and October, when coho salmon are present in the river, water velocities are predicted to range between 0.49 m/s and 0.95 m/s

More than 50% of salmon 250 mm long are able to swim the necessary 31 m culvert lengths at water velocities up to 0.95 m/s without fatiguing (Katapodis and Gervais 2016). Adult salmon 500 mm long are able to swim this same distance at water velocities up to 1.2 m/s without fatiguing (Katapodis 1992).

Only salmon greater than 1,000 mm long (i.e., adult chinook and chum salmon) would be able to swim through the culverts at the maximum water velocities predicted between July and October (1.68 m/sec, 1.58 m/sec, 1.63 m/sec, and 1.78 m/sec in July, August, September, and October, respectively). However, these extreme events are infrequent and occur for only short durations, short enough that fish could hold in the side-channel until flows subsided. Downstream passage of fish through the culverts will be possible at any time of the year.

The KRSC design is based on hydraulic modelling that has been used to confirm suitable spawning flow conditions (velocity and depth) during spawning periods. Specific design criteria used to develop the KRSC northern realignment habitats include the following:

- Channel planform will exhibit a multi-threaded morphology with riffle, run, and pool habitats sized and spaced similarly to the existing side channel habitat
- A low flow channel has been included throughout the alignment to maintain flow connectivity (and wetted spawning gravels) during low flow periods
- Pools will be located on the outside of meanders as would occur in natural streams
- Rock weirs will be located at the upstream end of each pool to aid in gravel retention, and promote scour of potential sediment build-up downstream of the weir at the start of the pool
- Areas suitable for spawning habitat will be located directly downstream of riffles and in the tailouts of pools
- Cobbles and small boulders will be placed based on flow specifications in spawning areas to help retain finer gravels
- Discharges from the side channel will be split, with approximately 30% to 50% discharged from the smaller upstream outlet, to provide additional freshwater flow into an existing blind channel, and enhance the habitat quality for eulachon. The other 50% to 70% of the flow will remain in the side channel to discharge at the larger downstream outlet
- Habitat features, such as LWD and root wads, will be incorporated into the design to improve quality and carrying capacity of the habitats
- Cut slopes, where not armoured using riprap or other techniques, and riparian areas disturbed by construction will be re-vegetated through regrowth of intact root materials, as well as replanting using native plants according to the riparian plan described in Section 8.3.5 (Riparian Restoration)
- Riparian clearing during construction will be minimized to provide slope stability and maintain mature riparian function as much as possible

Native gravels near the upstream end of the KRSC will provide the gravel source needed to facilitate chum, coho, and pink salmon spawning habitat in the KRSC northern section. These gravels currently exist in a fan extending from both sides of the current side-channel inlet to a location approximately 200 m downslope. These gravels will be mobilized and carried naturally by water flow in the Kitimat River side channel into the newly created habitat. This is predicted due to the presence of a gravel fan at and below the location of the new inlet structure, combined with water velocities through the gravel fan area which will be higher when the Kitimat River is at bankfull discharge than currently occurs in the existing side-channels. This higher water velocity will allow the mobilization and carrying of the gravel to the newly created habitat. Therefore, it is expected that this native gravel source will preclude the need to divert bed-load from the Kitimat River through the intake structure culverts into the KRSC.

This KRSC northern realignment is consistent with DFO's offsetting objectives and principles; it represents the creation of productive in-kind habitat in the immediate vicinity of the affected habitats, supports fisheries management objectives, and enhances existing lower value habitats. This offset project will provide direct long-term benefits to affected pink, chum, and coho salmon. In addition, it is expected to provide rearing habitats for trout, char, and out-migrating juvenile chinook, and may be used by eulachon.

Design drawings and engineering specifications for the KRSC northern realignment are provided in Appendix 8.

#### 8.12.3. Contribution to Habitat Balance

The areas of habitat created by the KRSC northern realignment offset project are summarized in Table 8-10. The contribution of the new floodplain habitat along the KRSC northern realignment offset projects to the habitat balance was discounted by 25% (Section 8.17 Summary of Habitat Contributions from the Offset Projects and Section 9 Habitat Balance) to acknowledge the importance of refugia for juvenile salmonids during high flow periods while recognizing these areas are not perennially accessible. No other construction habitat was discounted.

**Table 8-10 Areas of Habitat Created by the Kitimat River Side Channel Northern Realignment**

| Habitat Type | Habitat Value | Low Flow Area ($m^2$) | High Flow Area ($m^2$) |
|---|---|---|---|
| Mainstem watercourse | • Spawning<br>• Rearing<br>• Overwintering | 11,000 | 31,094 |
| Mainstem watercourse: floodplain bench | • Refugia<br>• Rearing | 0 | 13,106 |
| Off-channel pond/wetland: perennial | • Rearing<br>• Overwintering | 24,208 | 32,340 |
| | **Totals** | **35,208** | **76,540** |

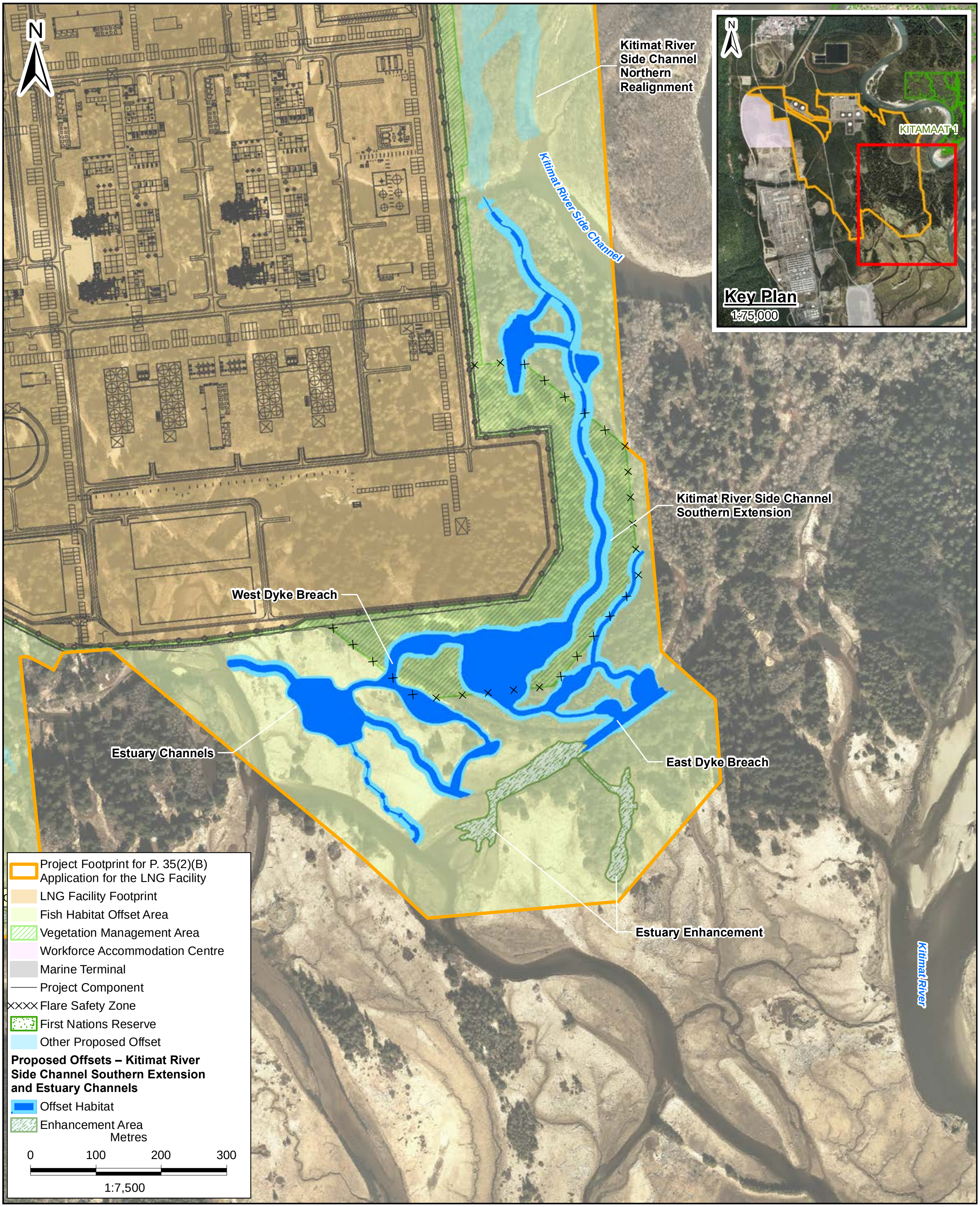
## 8.13. Kitimat River Side Channel Southern Extension

### 8.13.1. Background

The KRSC southern extension will continue the KRSC northern realignment south into the tidally influenced section of the Kitimat River and provide two new connects to the estuary (Figure 8-9). The three objectives of the KRSC southern extension are to:

- Re-establish connectivity between the Kitimat River and the lower energy habitats within Beaver, Anderson and Moore creeks, located along the west side of the Kitimat River estuary. As connectivity was lost when the Rio Tinto dyke was installed in the 1950s, re-establishing fish passage will increase availability of refuge habitat to juvenile fish in the lower Kitimat River.
- Create freshwater off-channel rearing habitats and refuge from high flows in the Kitimat River mainstem for juvenile (pink, chum and potentially coho) salmon.
- Provide potential spawning habitat for chum and pink salmon.

When constructed, the southern extension of the KRSC will discharge into a new wetland/pond complex that, in turn, will connect to a Kitimat River side channel to the east and the estuary to the south. The estuary connections will occur via through two breaches of the Rio Tinto dyke (the east dyke breach and the west dyke breach) (Figure 8-9).

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LNG CANADA
Opportunity for British Columbia. Energy for the world

*APPLICATION FOR A P.35(2)(B) FISHERIES ACT AUTHORIZATION FOR SERIOUS HARM TO FISH ASSOCIATED WITH THE LNG FACILITY*

**PROPOSED KITIMAT RIVER SIDE CHANNEL SOUTHERN EXTENSION AND ESTUARY CHANNELS OFFSET LOCATIONS**

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

| PROJECTION | DRAWN BY |
| --- | --- |
| UTM9 | SS |
| DATUM | CHECKED BY |
| NAD 83 | WP |
| DATE | FIGURE NO. |
| 26-JUL-17 | 8-9 |

### 8.13.2. Offset Design and Benefits to Fish

The design goal for the KRSC southern extension is to reconnect portions of the Kitimat estuary that have not been connected since the Rio Tinto dyke was constructed. The design will establish a connector channel that includes perennial pond/wetland complexes. Additionally, the channel will provide spawning habitat for chum and pink salmon. Rearing and overwintering habitat for juvenile pink, chum and coho salmon will be provided in the southern, tidally influenced, pond/wetland segments. When complete, the KRSC southern extension will be approximately 725 m long.

An engineered log jam inlet will be connected to a side channel of the Kitimat River (Appendix 8). The invert of the KRSC southern extension will be at the same elevation, and in line with, the downstream outlet of the KRSC northern realignment located on the opposite side of the Kitimat River side channel. This will allow the KRSC southern extension to collect freshwater discharges from the KRSC northern realignment, and convey freshwater flows to the downstream pond/wetland complex and, ultimately, the Kitimat River estuary.

A channel with riffles and pools is proposed for the KRSC southern extension. Habitat structures including in-channel LWD and cover logs have been included in the design to increase habitat diversity. The inlet of one of two online ponds in the upper channel is at station 0 + 160. Downstream of the outlet of the first pond, a second in-line pond will be located at station 0 + 280. Downstream of the second pond the channel continues as a gently meandering riffle-pool system until station 0 + 728, when it connects with a large pond/wetland complex.

The large pond downstream of the KRSC southern extension is designed with variable topography and habitat elements throughout. The perimeter of the pond will be wetland habitat. Two pond outlets have been designed to increase flow through the pond. The southeast outlet of the large pond is a connecting channel to a smaller pond. This smaller pond will also receive water from the north via an existing channel that will be enhanced as part of the offsetting program. The existing channel is a 2 m wide featureless channel; it will be widened and enhanced with LWD harvested from the adjacent riparian zone or the uplands areas during site clearing. The eastern outlet of the smaller pond flows to the north to connect to an existing side channel of the Kitimat River. It also has an outlet to the south to an existing pond that is currently disconnected from other waterbodies. The second outlet channel of the large pond flows through the west dyke breach. From the west dyke breach the channel flows into the Kitimat River estuary channels.

The east dyke breach will restore connectivity between the estuary and the existing side channel of the Kitimat River (Figure 8-9). Downstream of the east dyke breach, two existing pond features will be enhanced by the addition of large wood debris. Currently these natural features contain little cover for fish. Reconnecting these ponds with the