Figure 2.7 The Falls at the Mouth of Rattling Brook, June 22, 2006

Figure 2.8 Barrier to Upstream Fish Migration, 200 m Upstream of Concrete Weir, June 22, 2006

The Beak habitat classification quantifies the main stem as a total of 20.50 units of Type I (spawning), 313.73 units of Type II (rearing), 39.07 units of Type III and 225.58 units of Type IV (pool) habitat. The proposed DFO Classification System identifies 265.60 units of Riffle, 176.15 units of Pool/small pond, 17.25 units of Rapid, 86.62 units of Steady, 14.95 units of Cascade, 26.24 units of Falls and 12.06 units of Run habitat types.

This stream has also been subject to channelization and damming as part of past industrial use, namely:

- A wooden-creosote water pipeline between Rattling Brook Big Pond and the Long Harbour Industrial Park;
- A concrete weir in the brook approximately 400 m upstream from the mouth; and
- A rock-fill dyke on the outflow of Sam Howe's Pond (P14).

The pipeline is still in place, but does not present a major alteration of aquatic habitat and does not pose a barrier to migration. The concrete weir is approximately 4.5 m high with a vertical downstream face (Figure 2.9). The weir would be a complete obstruction to fish passage; however, the right-hand side has eroded, leaving a small side channel that, at certain flows, may provide passage. The rock-fill dyke, constructed to keep water levels high for water extraction by the phosphorus plant (Figure 2.10), is approximately two metres high with a downstream slope estimated at 60^{o}. The dyke is still in place but leaks, and during low to moderate flows, water exits the pond through the dyke itself with no clear channel for fish movement (i.e., the top of the dyke is dry). During high flows, the water crests the dyke and flows over its downstream face. This dyke is an obstruction to fish passage.

Stream channelizations have also occurred in at least two locations in the main stem. The first is just downstream of the upper bridge crossing when, large boulders have been removed and placed along the left-hand shore (Figure 2.11). The habitat is more uniform than most other locations. Gravels from the road and bridge have accumulated behind the downstream left-hand bridge abutment and at the downstream end of Reach 20, providing spawning habitat.

The second channelized section located at the outflow of a small pool/pond, is approximately 360 m long and is more uniform than most other locations (Figure 2.12). Substrates are primarily cobble and rubble over steep gradient. At the time of the survey, water velocities as high as 0.75 m/s were recorded.

Figure 2.9 Concrete Weir near the Mouth of Rattling Brook, June 22, 2006

Figure 2.10 Rock-fill Dyke at the Outflow of Sam Howe's Pond (P14) during High Flow, January 8, 2007

Figure 2.11 Rattling Brook Reach 21 Showing Channelized Habitat, June 22, 2006. Large Boulders were Removed and Placed Beyond the Left-hand Bank

Figure 2.12 Rattling Brook Reach 34 Showing Channelized Habitat, June 22, 2006. Large Boulders were Removed and Placed Beyond the Left-hand Bank.

Hydrology

The hydrology of the system has been established from past records as well as from a new water-level station installed in the main stem of Rattling Brook in the fall of 2006. Figure 2.13 presents the hydrographs for a typical, dry and wet year; Figure 2.14 presents the flow duration curve.

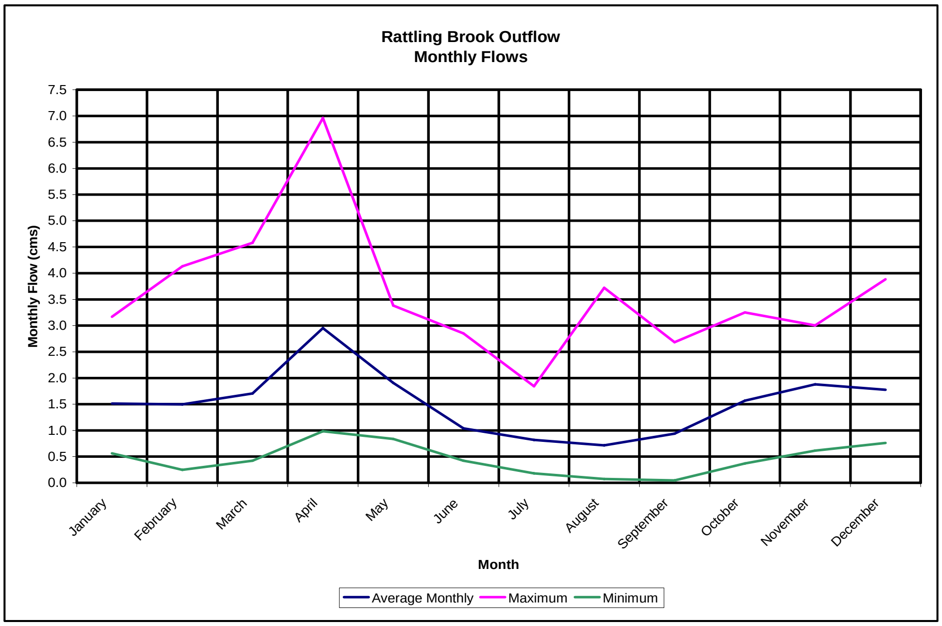

Figure 2.13 Hydrographs (typical, wet and dry year), Rattling Brook Outflow

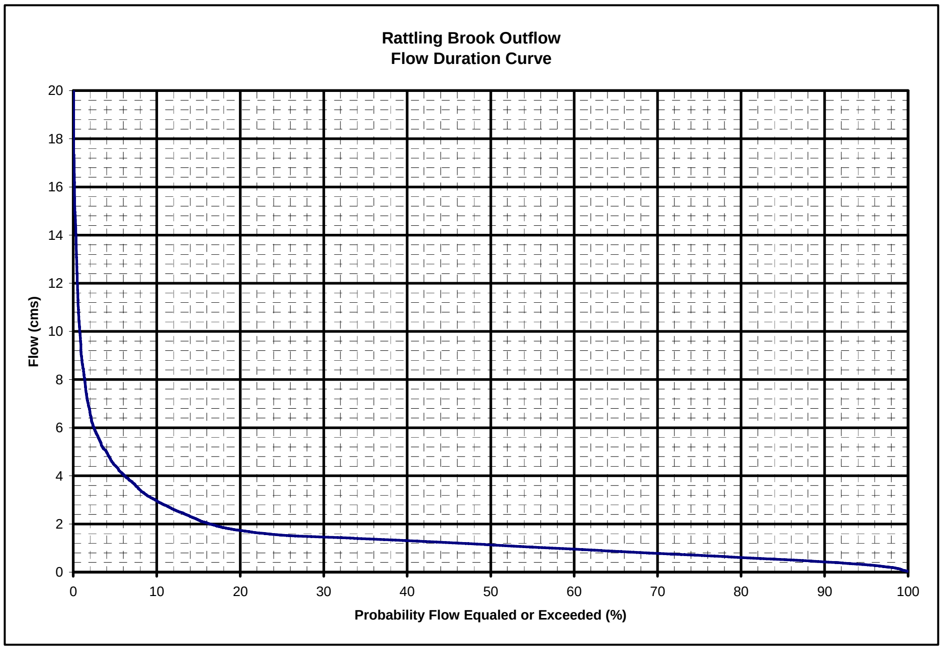

Figure 2.14 Flow Duration Curve, Rattling Brook Outflow

Beaver Brook Tributary

The plant site will be located within the watershed of this sub-tributary. Beaver Brook is a tributary to Rattling Brook, which joins the main stem at Reach 17 (see Figure 2.6). It has a total drainage basin of 2.1 km^2 and extends inland to the west from the main stem approximately 1.8 km. Its headwaters empty two small ponds (P24 and P25). An additional sub-tributary drains a second set of small ponds (P22 and P23) into Beaver Brook from the west.

Beaver Brook has approximately 2.33 km of fluvial habitat. The tributary is shown as intermittent on 1:50,000 topographic mapping. It has very heavy riparian vegetation with excessive large woody debris throughout the upper reaches. The slope of the tributary tends to increase upstream toward the ponds. At the time of the surveys, there were no barriers to migration. The substrate composition is primarily rubble and boulders with some bedrock; gravels are noticeably absent in the tributary (except for a single reach at the downstream end). The tributary begins with a culvert that crosses the access road to Rattling Brook Big Pond. It has a diameter of approximately 1.1 m with no evidence of excess erosion due to extreme flows.

The fish species in Beaver Brook is brook trout. The Beak habitat classification quantifies the tributary as a total of 0.28 units of Type I (spawning), 28.51 units of Type II (rearing), 8.22 units of Type III (migratory) and 55.9 units of Type IV (pool) habitat (excluding Ponds). The proposed DFO Classification System identifies a total of 28.47 units of Riffle, 38.45 units of Pool, 17.76 units of Steady and 8.11 units of Cascade habitat types.

The hydrology of the system has been pro-rated from past records as well as from the new water-level station installed in the main stem of Rattling Brook in fall 2006. Figure 2.15 presents the hydrographs for a typical, dry and wet year for the tributary while Figure 2.16 presents the flow duration curve.

Rattling Brook Lacustrine Habitat

Six ponds within the Rattling Brook watershed could potentially be affected by the Project. Each pond was sampled for a variety of parameters contained in baseline data reports and component studies (JWEL 1997, 1998, 2003; AMEC 2005, 2007a). A summary of the habitat within each is provided below.

Rattling Brook Big Pond (P8)

Rattling Brook Big Pond is situated at the headwater of Rattling Brook and is the largest of all waterbodies within the Project Area, with a total surface area of 189.29 ha. It lies at a general elevation of 105 m asl, in a bedrock-rimmed basin with ridges to the south rising 50 to 60 m above the existing pond. The pond axis lies in a general northeast-southwest direction.

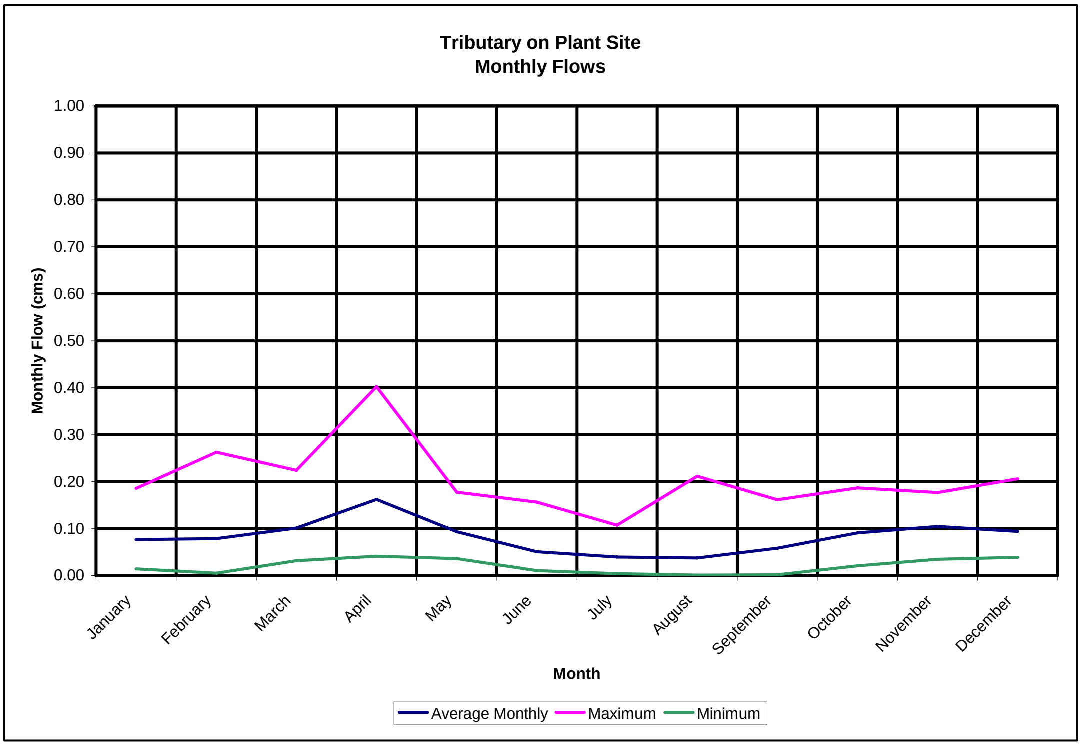

Figure 2.15 Hydrographs (Typical, Wet and Dry Year), Beaver Brook Outflow

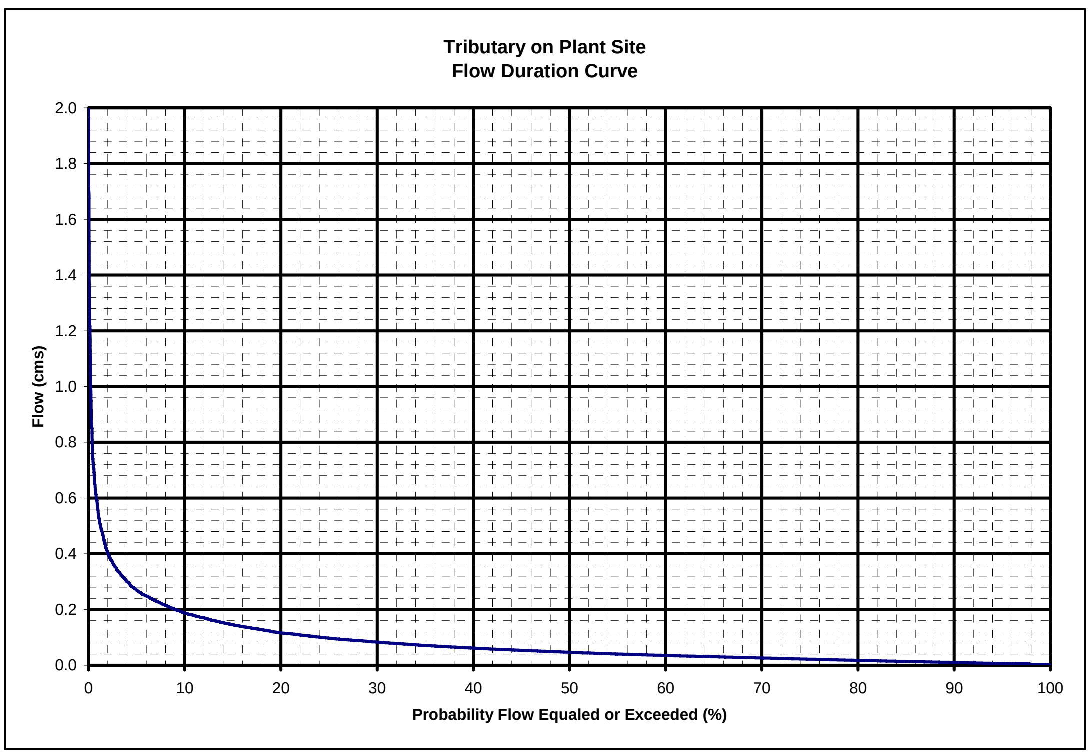

Figure 2.16 Flow Duration Curve, Beaver Brook Outflow

The pond has a drainage area of 23 km^2. The average depth of light penetration within the water column was determined to be 3.6 m with a maximum pond depth measurement of 36 m. The shoreline comprises boulder, bedrock and rubble with deeper zones comprised of fines (organics and detritus). Emergent vegetation is present/visible, primarily in a shallow area in the north-east end and near the outflow at the western end. Figure 2.17 presents the bathymetric contours.

The littoral and profundal zones were delineated using ArcGIS™ software and digital bathymetric mapping. The total littoral and profundal habitat surface areas are 83.10 and 106.19 ha respectively. Table 2.9 summarizes the fish habitat types within Rattling Brook Big Pond.

The shoreline is relatively pristine and undeveloped; however, several cabins are located along the shoreline of the small northern alcove and at the north-east end. Water extraction infrastructure still remains near the outflow. The original maintenance and access road still provides access to the pond from the Long Harbour Industrial Park and is used extensively by local anglers and hunters. Several boats are stored where the road meets the pond.

Pond P14 – Sam Howe's Pond

Sam Howe's Pond is located on the main stem of Rattling Brook just downstream of Rattling Brook Big Pond. It has a total surface area of 38.08 ha and lies at a general elevation of 90 m asl in a relatively low-lying valley with surrounding low hills. The pond lies in a general northeast direction, similar to Rattling Brook Big Pond.

The drainage area is 32.9 km^2, which includes the outflow from Rattling Brook Big Pond. The average depth of light penetration within the water column was determined to be 2.6 m with a maximum pond depth of 12.3 m. The shoreline comprising boulder and rubble with deeper zones comprised of fines (organics and detritus) with no aquatic vegetation. Figure 2.18 presents the bathymetric contour of Pond P14 as modeled from the data. The total littoral and profundal habitat surface areas are 8.89 and 3.19 ha respectively. Table 2.9 summarizes the fish habitat types within Sam Howe's Pond.

Ponds P22 and P23

Ponds P22 and P23 are small water bodies located at the headwater of Tributary T1-1-1 (Figure 2.6). They have total surface areas of 1.18 and 2.85 ha respectively. Both are in a high plateau with low ridges to the north, rising 20 m above the ponds.

Pond 22 extends at a general elevation of 135 m asl. The average depth of light penetration within the water column extends to the bottom of the pond (0.9 m depth). The pond is therefore comprised of littoral habitat only, with a substrate dominated by fines (organics and detritus) with gravel, cobble and boulders along the shoreline. The pond has emergent vegetation everywhere muck/detritus is present. Table 2.9 summarizes the fish habitat types within Pond P22.

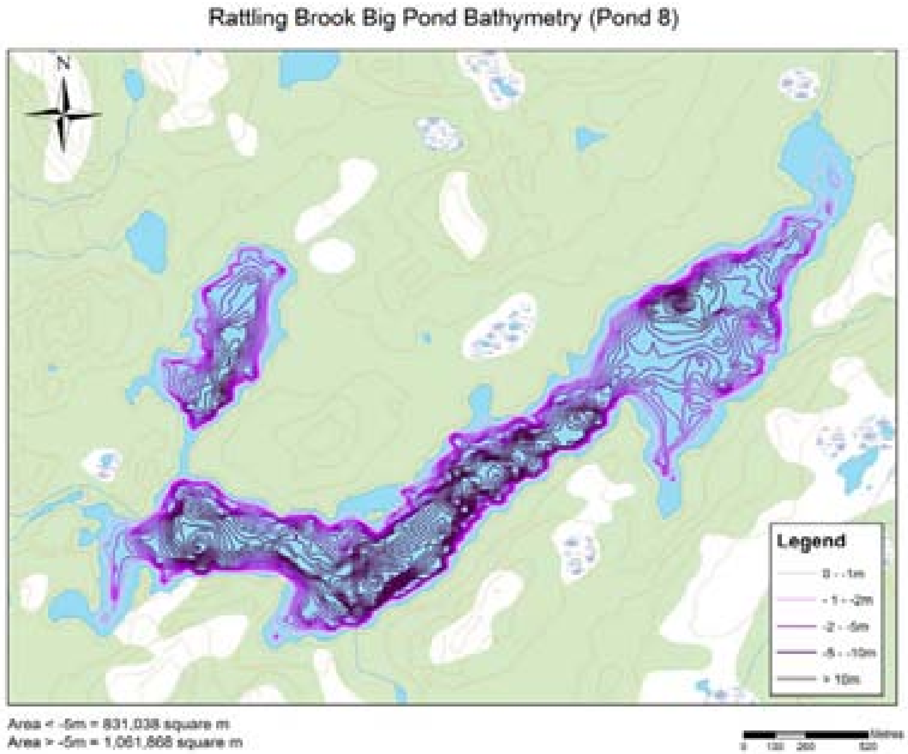

Figure 2.17 Rattling Brook Big Pond (P8) Bathymetric Contours, August 16, 2006

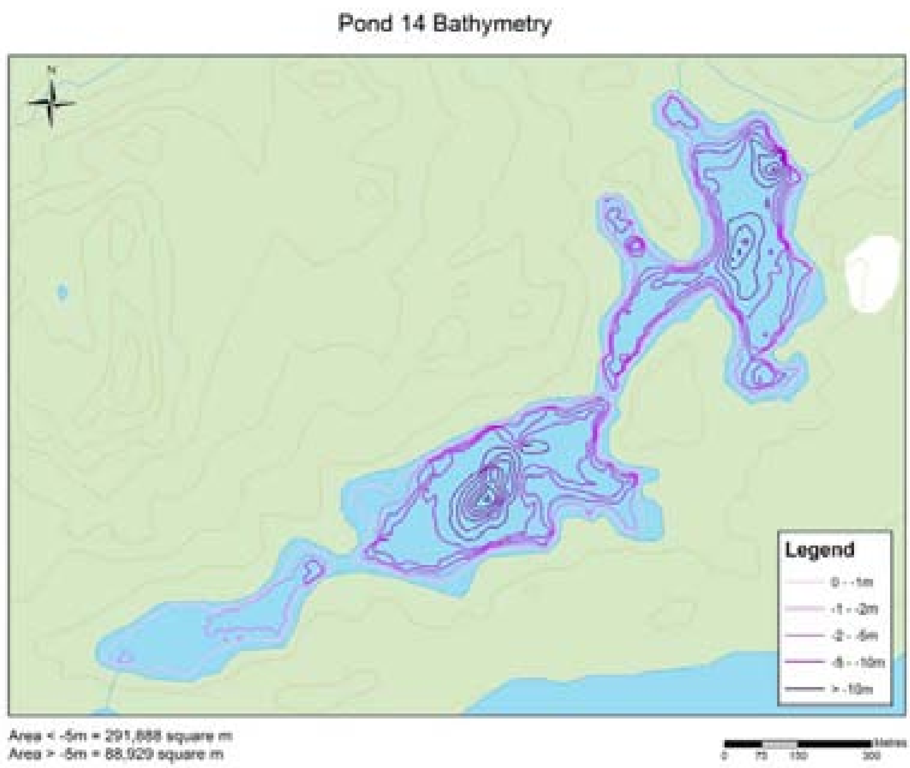

Figure 2.18 Sam Howe's Pond (P14) Bathymetric Contours, May 9, 2007

Table 2.9 Summary of Calculated Total Areas of Each Habitat Type within Ponds of Rattling Brook

HABITAT TYPE	Area (Hectares)						
	P8 (Rattling Brook Big Pond)	P14 (Sam Howe's Pond)	Pond P22	Pond P23	Pond P24	Pond P25	Pond P30
P - Profundal Zone	106.19	8.89	0.00	0.37	0.00	0.00	0.00
Lc - Littoral Zone - Coarse	32.02	9.72	0.14	0.87	0.09	0.22	0.46
Lm - Littoral Zone - Medium	8.40	12.46	0.46	0.84	0.04	0.03	0.74
Lf - Littoral Zone – Fine, no aquatic vegetation	39.64	7.01	0.03	0.17	0.00	0.55	0.00
Lf – Littoral Zone – Fine, with aquatic vegetation	3.05	0.00		0.60	1.21	0.27	3.02
Sub Total, Littoral Zone	83.10	29.19	0.55	2.48	1.34		4.22
Total Habitat	189.29	38.08	1.18	2.85	1.34	1.07	4.22

Key: Littoral Coarse (comprising a majority of bedrock, boulder)
Littoral Medium (comprising a majority of rubble, cobble and gravel)
Littoral Fine (comprising a majority of sand and organics/detritus)
Profundal (comprising a majority of organics/detritus)

Pond 23 is just downstream at a general elevation of 133 m asl. The average depth of light penetration was determined to be 1.05 m with a maximum pond depth of 3.4 m. The pond has a littoral zone comprising fines (organics and detritus) with some larger substrates around the shoreline. The profundal zone is entirely fines (organics and detritus). Emergent vegetation is present/visible throughout. Total littoral and profundal habitat surface areas are 2.48 and 0.37 ha respectively. Table 2.9 summarizes the fish habitat types within Pond P23.

Ponds P24 and P25

Ponds P24 and P25 are located on a high plateau at the headwaters of Beaver Brook (T1-1) (Figure 2.6). They have total surface areas of 1.34 and 1.07 ha respectively.

Pond P24 is at a general elevation of 105 m asl. The average depth of light penetration was to the bottom of the pond (1.0 m depth). The pond is therefore comprised of littoral habitat only with a substrate comprising a majority of fines (organics and detritus) with boulders present along the shoreline. It has emergent vegetation everywhere muck/detritus was present. Table 2.9 summarizes the fish habitat types within Pond P24.

Pond P25 is just downstream of Pond P24 at a general elevation of 100 m asl. The average depth of light penetration was 3.35 m with a maximum pond depth of 4.41 m. The pond is comprised of littoral habitat only, with substrate comprising a majority of fines (organics and detritus) and larger boulders around the shoreline. Emergent vegetation is present/visible throughout. Table 2.9 summarizes the fish habitat types within Pond P25.

Pond P30

Pond P30 is on the main stem of Rattling Brook just downstream from Sam Howe's Pond (P14) at a general elevation of 88 m asl. It has a total surface area of 4.22 ha.

The average depth of light penetration within the water column was 2.65 m, with a maximum pond depth measured at 3.9 m. As classified for DFO habitat quantification, the pond is comprised of littoral habitat only, with a substrate comprising a majority of fines (organics and detritus) with boulder, cobble and rubble along the shoreline. It has emergent vegetation everywhere muck/detritus was present. Table 2.9 summarizes the fish habitat types within Pond P30.

Water Resource Use

The watershed was used in the past as a fresh water source for the AWA plant. While exact volumes extracted are not readily available, several sources have identified water consumption for the plant.

Idler (1969), reported total effluent flows at 8,000 USGPM (0.505 m^3/s). ERCO (1967) indicated the total discharge from the boiler house was 7,000 USGPM (0.442 m^3/s). Seven thousand was selected as the most accurate value to represent past water extraction rates. The effects of this extraction rate on the natural hydrograph of Rattling Brook are shown in Figure 2.19. The resulting flow reduction would have reduced the available fish habitat within the watershed by restricting the amounts of suitable riverine habitat for most of the year, particularly in summer and mid-winter.

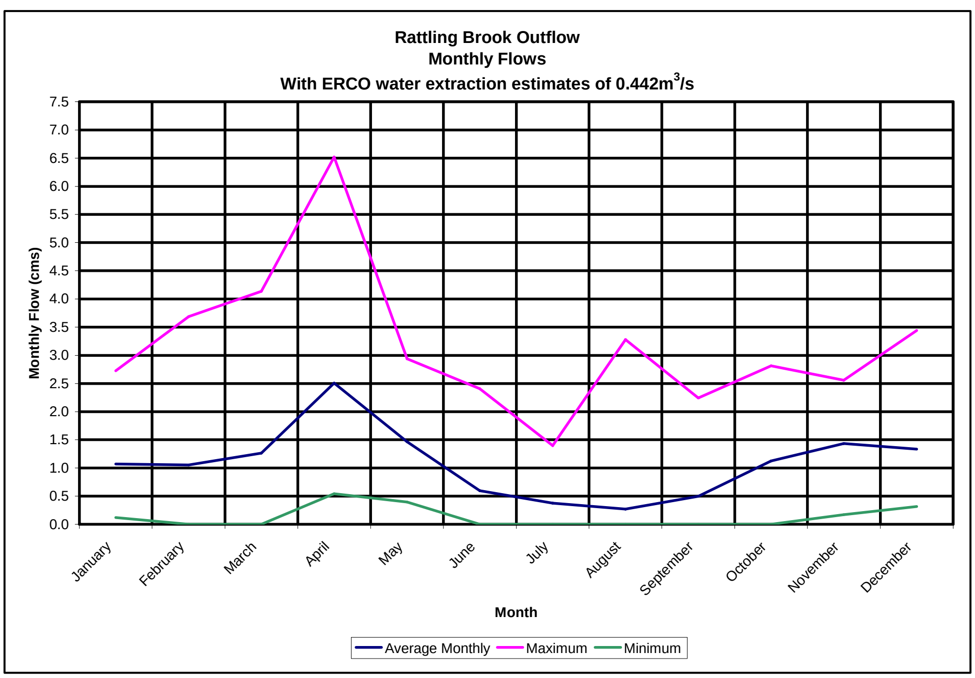

Figure 2.19 Hydrograph of Rattling Brook with Estimated Water Extraction for the Former Phosphorus Plant

2.3.4 Sandy Brook (S26)

Sandy Brook is located just east of Rattling Brook and also drains to the south side of Long Harbour. The watershed extends inland approximately 3.0 km and contains one large waterbody, Sandy Pond (P15), as well as two smaller ones (Ponds P26 and P27 – Figure 2.6). The drainage area of Sandy Brook is approximately 4.8 km^2 with approximately half of the drainage coming from the outflow of Sandy Pond (2.3 km^2). Figure 2.6 presents the Long Harbour area and the stream drainage basin boundaries of Sandy Pond. Species within the watershed are brook trout, rainbow smelt and American eel.

Main Stem

The main stem is 2.36 km between its mouth at Long Harbour and Sandy Pond. The brook is identified as intermittent on provincial 1:50,000 topographic mapping. The main stem has extensive riparian vegetation with large woody debris throughout the upper reaches. Two reaches were dry during the surveys and flow appeared to go underground. Five cascade sections form obstructions under most flows. The substrate composition is primarily boulders and rubble throughout, with limited gravels and sand in the lower reaches. Brook trout and American eel were captured in the stream.

The Beak habitat classification quantifies the brook as a total of 22.94 units of Type II (rearing), 28.18 units of Type III (migratory) and 26.5 units of Type IV (pool) habitat. The proposed DFO Classification System identifies a total of 26.28 units of Riffle, 16.63 units of Pool, 1.50 units of Rapid, 15.65 units of Steady, 20.98 units of Cascade, and 1.10 units of Run habitat types, with 4.28 units of unwetted streambed. Flows at the time of the survey were high due to heavy rains; as a result, the measured habitat units are overestimated.

Hydrology

The natural hydrology of Sandy Brook has been established by pro-rating past records of nearby gauging stations. Figure 2.20 presents the hydrographs for a typical, dry and wet year. Figure 2.21 presents the flow duration curve.

Tributary to Sandy Brook

There is a small intermittent sub-tributary that drains into the main stem of Sandy Brook approximately 1.5 km upstream from Long Harbour. The pro-rated hydrology of the brook presented below (Figure 2.22) shows its low flows; however, it provides about one-third the mean annual flow to Sandy Brook below its confluence.

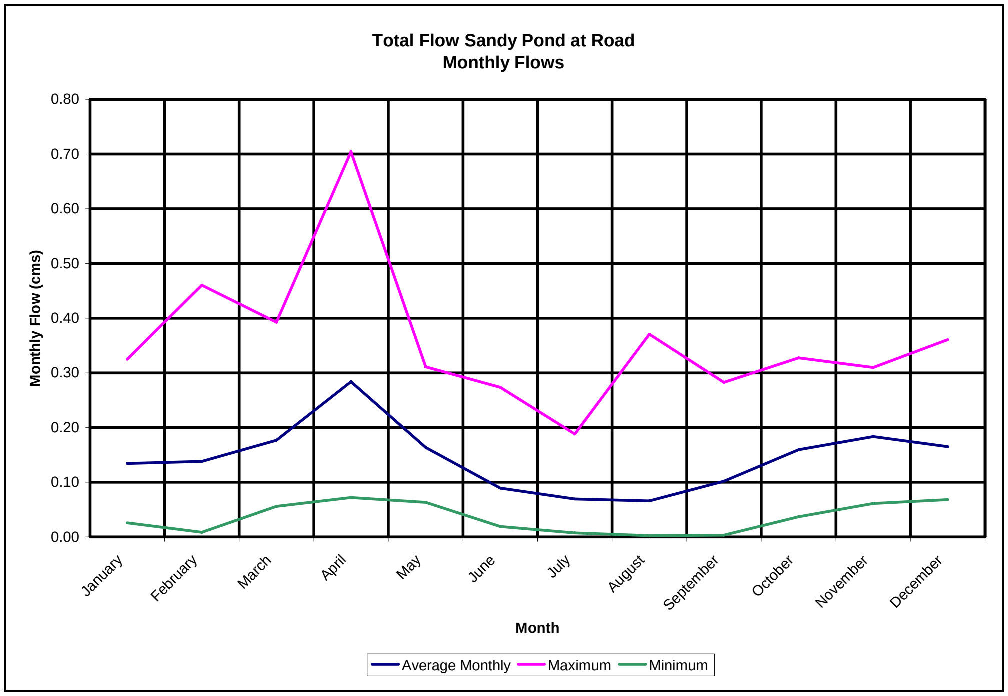

Figure 2.20 Hydrographs (Typical, Wet and Dry Year), Sandy Brook Outflow

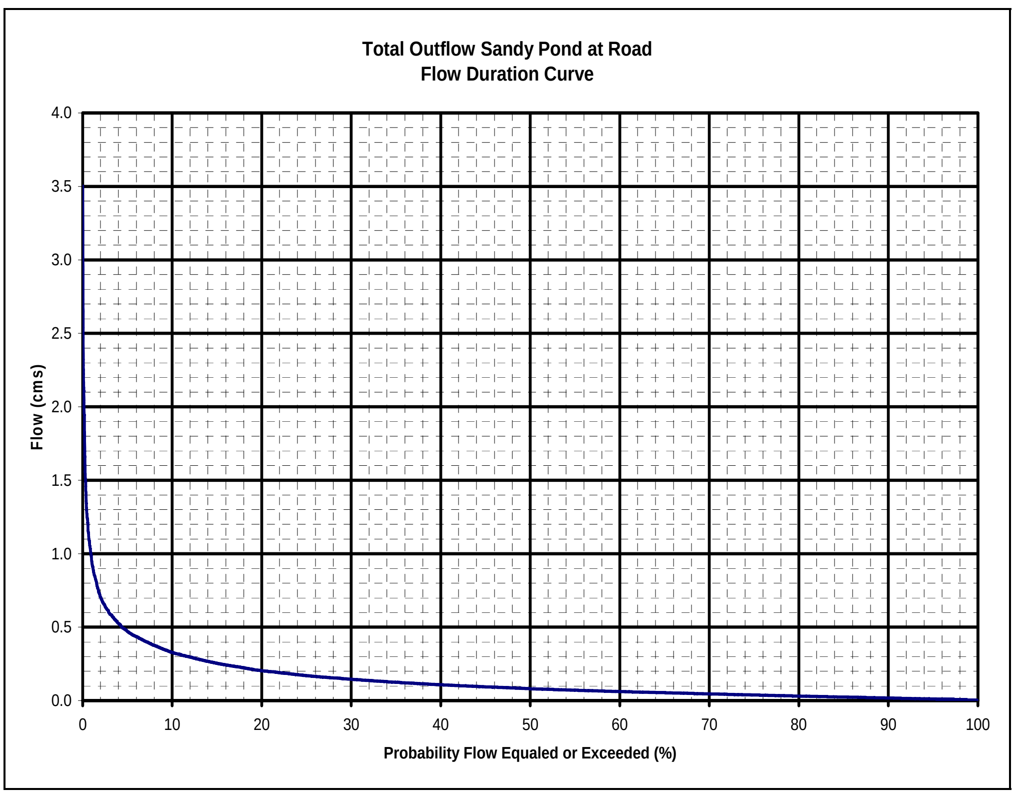

Figure 2.21 Flow Duration Curve, Sandy Brook Outflow

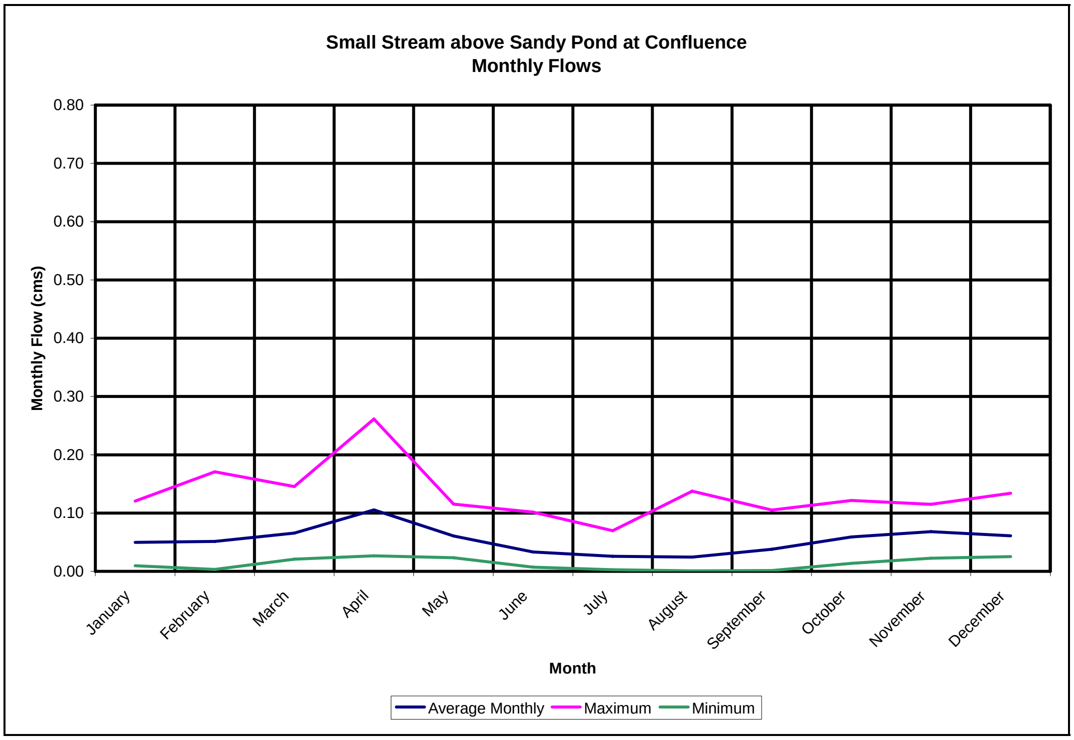

Figure 2.22 Hydrographs (Typical, Wet and Dry Year), Sandy Brook Tributary

Sandy Brook Lacustrine Habitat

Three waterbodies within Sandy Brook may be affected by the Project - Sandy Pond, Pond P26 (Moore's Pond) and Pond P27 (Figure 2.6). Summary habitat descriptions are provided below. Additional habitat quantification details are provided in the Freshwater Component Study (AMEC 2007a).

Sandy Pond (P15)

Sandy Pond (P15) has a total surface area of 37.83 ha. It is at a general elevation of 100 m asl in a forested valley with ridges surrounding the entire pond between 150 to 180 m asl. The average depth of light penetration was determined to be 2.9 m with a maximum pond depth of 16.5 m. The shoreline comprises a majority of boulders and rubble with the deeper zones comprised of fines (organics and detritus). The pond has emergent vegetation at the eastern end. Figure 2.23 presents the bathymetric contours of P15 as modelled from the data. The total littoral and profundal habitat surface areas are 13.91 and 23.92 ha respectively. Table 2.10 summarizes the fish habitat types.

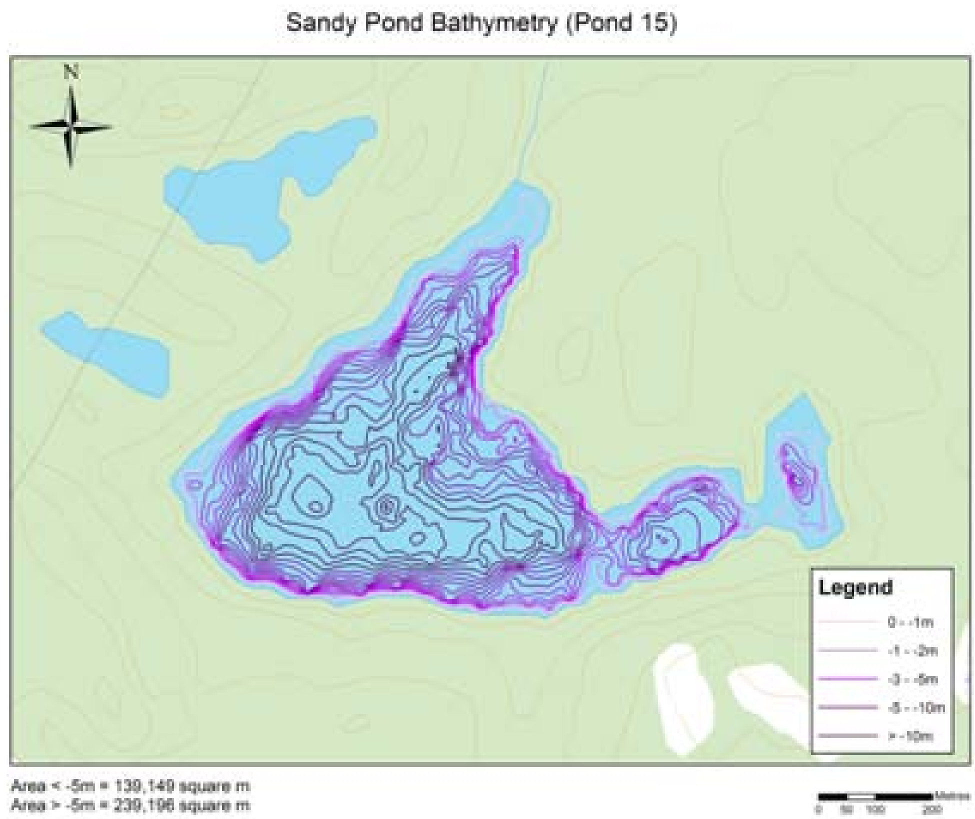

Figure 2.23 Sandy Pond (P15) Bathymetric Contours, August 17, 2006

Table 2.10 Summary of Calculated Total Areas of Each Habitat Type for Ponds in Sandy Brook Watershed

Habitat Type	Area (Hectares)	
	Sandy Pond	Pond P27
P - Profundal Zone	23.92	0.54
Lc - Littoral Zone – Coarse	3.35	0.48
Lm - Littoral Zone – Medium	1.90	0.18
Lf - Littoral Zone – Fine, no aquatic vegetation	8.44	0.41
Lf – Littoral Zone – Fine, with aquatic vegetation	0.22	0.01
Sub Total, Littoral Zone	13.91	1.08
Total Habitat	37.83	1.62
Key: Littoral Coarse (comprising a majority of bedrock, boulder) Littoral Medium (comprising a majority of rubble, cobble and gravel) Littoral Fine (comprising a majority of sand and organics/detritus) Profundal (comprising a majority of organics/detritus)		

Ponds P26 and P27

Two small water bodies lie at the headwater of Sandy Brook just to the northwest of Sandy Pond. Both are at a general elevation of 120 m asl, on an exposed bedrock plateau with some forested shoreline. The total surface areas of P26 and P27 are 4.10 and 1.62 ha respectively.

Pond 26 has an average depth of light penetration within the water column of 2.90 m with a maximum pond depth of 4.32 m. The pond has a shoreline of boulders, rubble, cobble and bedrock. Gravels are also present as well as muck/organics. Limited emergent vegetation is present/visible. Figure 2.24 presents the bathymetric contours of P26 as modelled from the data. No fish were captured, and therefore it is not considered fish habitat.

Pond 27 has an average depth of light penetration within the water column of 1.35 m with a maximum pond depth of 7.48 m. The shoreline is boulder-cobble. The deeper portion of the littoral zone and the profundal zone is composed primarily of organics and detritus, with limited emergent vegetation present/visible throughout. The total littoral and profundal habitat surface areas are 1.08 and 0.54 ha respectively. Figure 2.25 presents the bathymetric contours of P27 as modelled from the data. Table 2.10 summarizes the fish habitat types within the pond. Brook trout were the only species captured.

The two small water bodies, P26 and P27 which lie at the headwater of Sandy Pond, are not expected to be significantly impacted by the modifications to Sandy Pond. The smaller Pond 27 has a water level of 147.7 m asl and is elevated above Sandy Pond with a maximum depth of 7.48 m therefore it is unlikely to be affected by any change in groundwater movements.

Pond 26 is located at a level of 132.3 m asl, has a maximum depth of 4.32 m and is connected to Sandy Pond by a small creek. A dam structure will be installed (Dam 1) which will isolate this pond from the Sandy Pond. The operating water level for Sandy Pond will be in the range 136 – 137.5 m asl but the dam structure will prevent any surface generated back flow to this pond.

Sandy Pond Water Resource Use

The Sandy Pond watershed is undeveloped with no cabins or roads. It is, however, a local destination for brook trout fishing, and discussions with local residents and anglers indicate that fish can be larger than those typically found in the surrounding ponds. This may be due to the presence of rainbow smelt as a food source. An existing trail from Highway 101 to Sandy Pond is used by anglers to access the pond, mostly during winter, as it is easier to access. While sought for angling, the fish are not preferred for eating since their flesh is pale and of poor quality and taste.

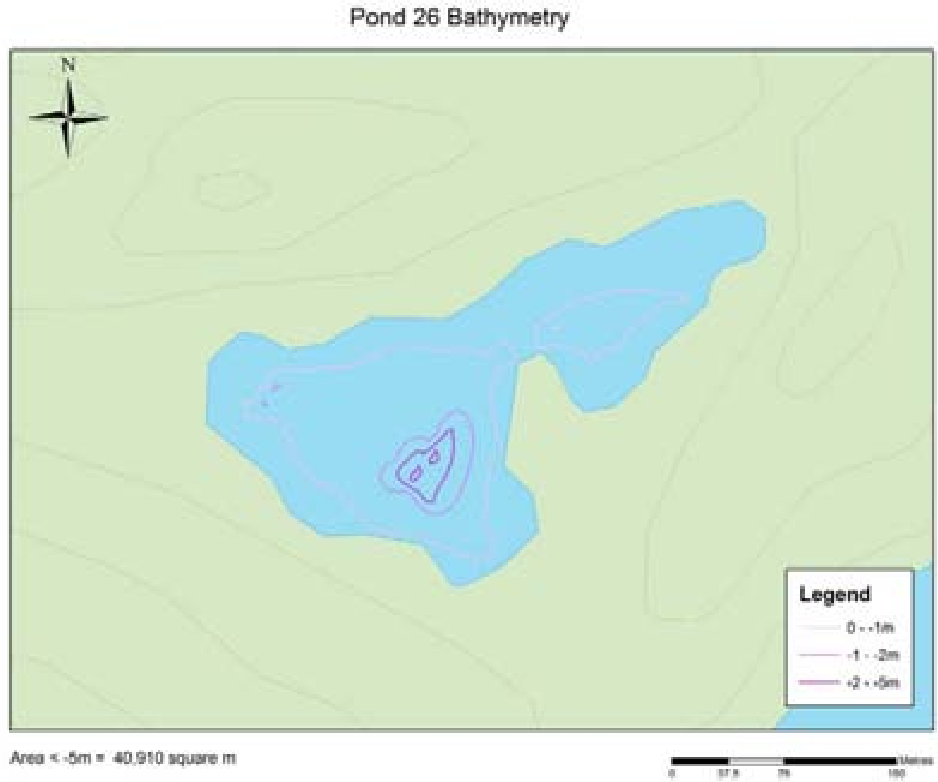

Figure 2.24 Pond P26 Bathymetric Contours, July 2, 2006

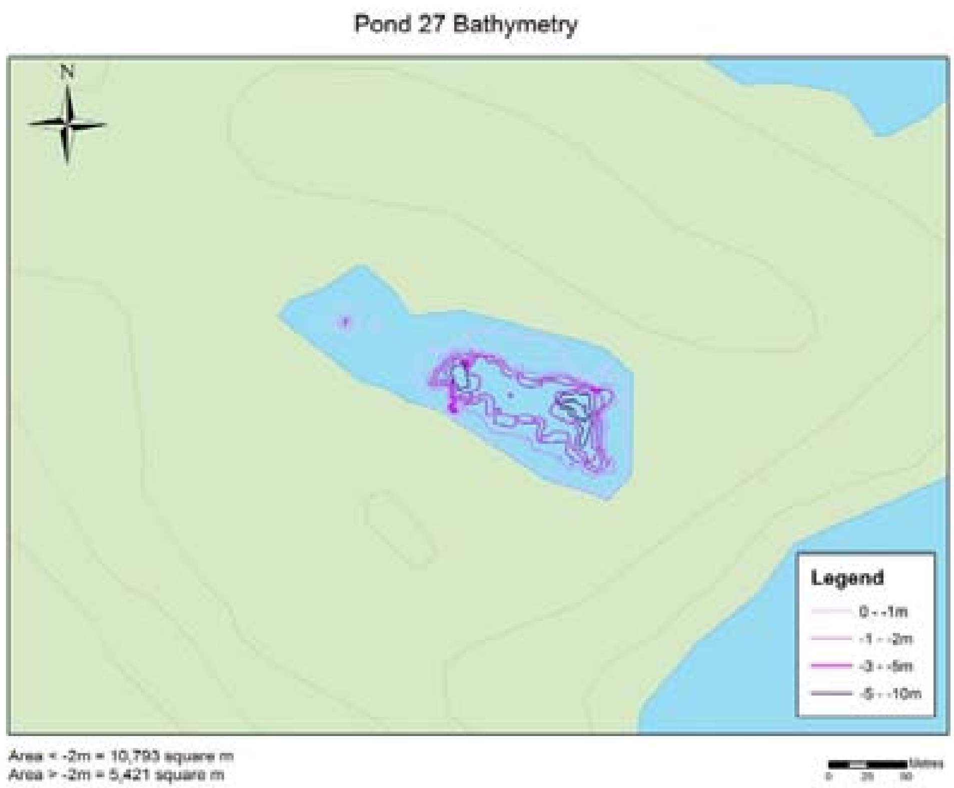

Figure 2.25 Pond P27 Bathymetric Contours, June 30, 2006

2.3.5 Little Rattling Brook (S33)

Little Rattling Brook (T3) is located west of Rattling Brook and drains to Ship Harbour (Figure 2.6). This small watershed (approximately 8.55 km^2) is identified as intermittent on available 1:50,000 topographic maps. The brook is approximately 1.6 km long and has a complete obstruction approximately 500 m upstream from Ship Harbour (Porter et al. 1974). The pro-rated hydrology presented below (Figure 2.26) shows its intermittent nature in summer low flow periods.

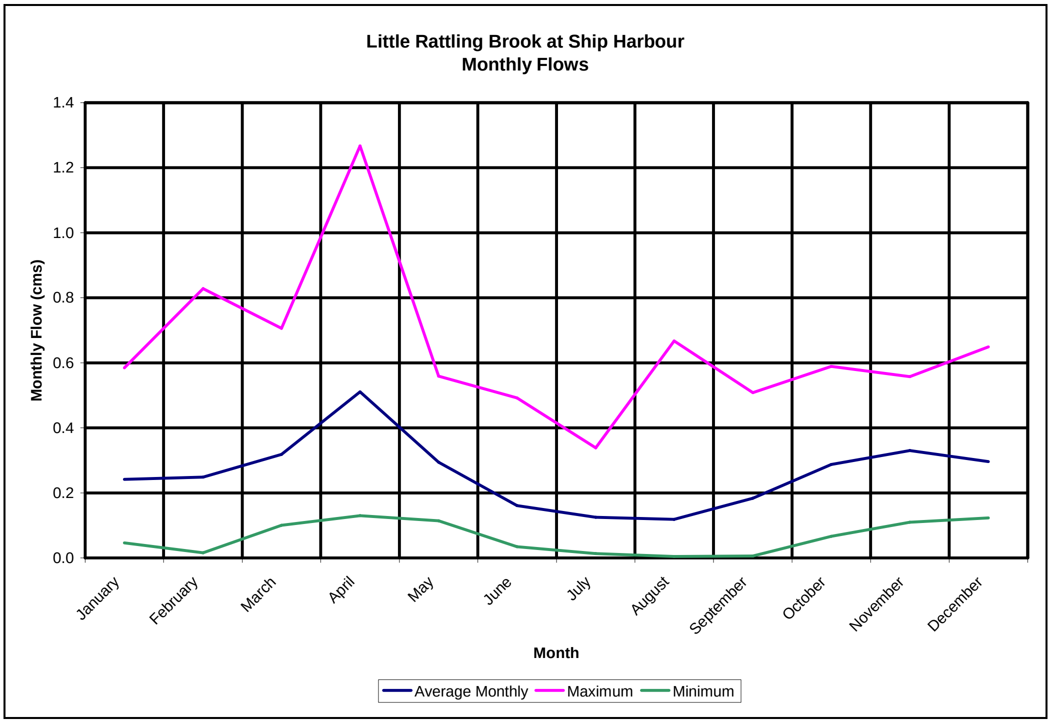

Figure 2.26 Hydrographs (Typical, Wet and Dry Year), Little Rattling Brook Outflow

2.3.6 Freshwater Fish

The following sections are based on a review of information and field surveys conducted by AMEC (2007a) and describe the freshwater fish (including anadromous and catadromous species) present in watersheds of the Project site.

Fish species recorded during the VBNC studies in the proposed Project Area include brook trout (*Salvelinus fontinalis*), Arctic char (*Salvelinus alpinus*), rainbow smelt (*Osmerus mordax*) and American eel (*Anguilla rostrata*). Several DFO documents summarize the general biology of each species for use in habitat quantification (see Bradbury et al. 1999; Grant and Lee 2004). Each species is listed below with a brief life history description from these documents. It is interesting to note that no stickleback species were captured within the Study Area.

Brook Trout

Brook trout are widely distributed throughout Newfoundland and Labrador and are thought to exist in all Newfoundland freshwater ecosystems, where they have been reported to make extensive use of lake habitats. They can be either landlocked or anadromous, spending one or two months feeding at sea in relatively shallow water close to their natal stream. There is also evidence to suggest that two forms of brook trout may coexist in some Newfoundland lakes: a primarily benthic feeding population that is relatively slow growing and short-lived, and a larger-bodied, piscivorous population that is faster growing and longer-lived. Optimal riverine habitat is characterized as clear, cold spring-fed water with silt-free rocky substrate in riffle-run areas; well vegetated stream banks; an approximate 1:1 pool-riffle ratio with areas of slow, deep water; abundant instream cover; and relatively stable water flow, temperature regimes, and stream banks.

Spawning normally occurs between late September and early November in shallow, gravel-bottomed streams and occasionally in lakes at depths less than two metres. Although growth rates are variable, brook trout usually mature at two to four years of age. Although they seldom live longer than five or six years, they have been reported from several Newfoundland lakes up to eight years of age.

Brook trout often seek refuge among rocks, aquatic vegetation, woody debris, overhanging logs and undercut banks. They are common in the Project Area and environs and are the target of recreational fishing.

Arctic Char

The Arctic char has the most northerly distribution of any freshwater fish and is distributed throughout Newfoundland and the entire Labrador coast, and may be classified as either anadromous or resident freshwater populations. They are common in certain areas of the province and may be the dominant species in some lakes.

In Newfoundland, landlocked Arctic char may spawn in streams or lakes from early October to mid-November. Preferred habitat is usually gravel/cobble substrate at depths of one to five m, which are sufficient to keep eggs safe from winter ice.

In Newfoundland lakes, Arctic char (age 4+ to 9+) have been found predominantly in the pelagic zone during June and July, while occupying mainly benthic habitat during other times of the year. Within lakes, some part of the adult population usually performs a seasonal movement from the benthic to the pelagic zone in response to improved food abundance during late summer in the form of high crustacean zooplankton density.

Arctic char are scarce in the Study Area and were only found in Rattling Brook Big Pond.

Rainbow Smelt

Rainbow smelt may occur in both anadromous and landlocked forms. Landlocked populations may exist as either normal or dwarf-sized forms, and have been reported throughout many parts of insular Newfoundland. It has been assumed that both have similar habitat requirements.

On the Avalon Peninsula, landlocked rainbow smelt have been observed spawning in lakes before ice-out in early to mid-April, while spawning in tributary streams did not occur until early to mid-May, after ice had moved out. Eggs are released indiscriminately over a wide variety of substrates including mud, clay, sand, gravel, cobble, rubble, boulders and aquatic vegetation at depths ranging from 0.1 to five metres. Rainbow smelt mature at one to two years.

The only pond in the Study Area found to contain smelt was Sandy Pond. Local fishers believe that trout in this pond are relatively large due to their diet of smelt; however, catches are not often eaten because of the poor taste and flesh colour.

American Eel

The American eel is distributed from the southern tip of Greenland, southward along the Atlantic coast and the Gulf of Mexico to the northern portion of the east coast of South America. They have been reported throughout Newfoundland and the southeastern coast of Labrador as far north as Hamilton Inlet. The American eel is catadromous spending most of its life in freshwater and estuaries but migrating to sea to spawn. Eels typically begin their spawning migration in late summer and fall throughout much of eastern Canada, although migration from lakes that are far inland may begin earlier. Peak migratory activity often occurs in September-October during the last quarter of the moon, and is enhanced by dark, stormy nights and rising water levels.

Eels spawn in the Sargasso Sea, with peak spawning occurring in between January and March, but sometimes extending to May or June. Although spawning depth is not known, evidence suggests it is in the upper few hundred metres of the water column. Adult eels presumably die after spawning.

During the freshwater phase of their life history, eels move into streams, rivers, and muddy or silt-bottomed lakes, generally following the bank of the river in very shallow water. They can be very mobile and may gain access to ponds and lakes that appear unavailable to them by using very small watercourses or by moving overland through wet grass. Being nocturnal, they usually spend the day hiding under rocks and logs or buried in the mud. Investigations on diet composition of juvenile eels suggest that they rely heavily on benthic organisms and demersal fishes as food sources. Eels migrate to sea after spending 12 to 13 years in fresh water. However, there are indications that a proportion of the population may remain in brackish estuaries and not enter fresh water at all.

Fish Species in Rattling Brook

Fish species recorded in the Rattling Brook watershed during 2005-06 investigations include brook trout, Arctic char and American eel (AMEC 2007a). This composition is supported by past reports (Albright and Wilson 1992), which confirm that the primary fish species in the surrounding watersheds is brook trout. Atlantic salmon do not the use watersheds near the Project site, and there are no reports of ouananiche (landlocked salmon) presence in the ponds. Arctic char have been occasionally taken from Rattling Brook Big Pond and were determined by DFO to be resident (Albright and Wilson 1992). Brook trout are the primary fish species, occurring as resident populations throughout the ponds and streams within the watershed.

Brook trout numbers are relatively high with population estimates ranging between 9.98 and 48.68 individuals per unit (one unit =100 m^2). Biomass was also high (345.6 – 883.9 g/unit).

American eel were captured in low numbers (3) and only near the mouth of the main stem.

A single Arctic char was captured in Rattling Brook Big Pond. Resident Arctic char were previously identified (Albright and Wilson 1992).

Fish Species in Sandy Brook

Fish species recorded in the Sandy Pond watershed during 2005-06 investigations included brook trout, American eel and rainbow smelt, a species composition supported by past reports (Albright and Wilson 1992).

Brook trout were found in Sandy Pond (P15), Pond P27 and at stream electrofishing stations within the watershed. Numbers were relatively high with estimates ranging between 53.14 and 124.23 individuals per unit (one unit = 100 m^2). Biomass was also relatively high (427.5 – 1,999.8 grams/unit).

American eels were captured in Sandy Brook and Sandy Pond, but not in Ponds P26 or P27. Rainbow smelt captured in Sandy Pond as well as a sub-sample of brook trout were submitted for stable isotope analysis. The results indicate that both populations are resident and non-anadromous.

2.3.7 Freshwater Fish Species at Risk

Recent concern regarding population decreases in the Great Lakes has prompted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to list the American eel as a *species of concern* in 2006 (COSEWIC 2006b). This designation is defined as a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats. The reason for the designation has been that indicators of the status of the total Canadian component of this species are not available. Indices of abundance in the Upper St. Lawrence River and Lake Ontario have declined by approximately 99 per cent since the 1970s. The only other data series of comparable length (no long-term indices are available for Scotia/Fundy or Newfoundland and Labrador) are from the lower St. Lawrence River and Gulf of St. Lawrence, where four out of five time series declined. Because the eel is panmictic (i.e., all spawners form a single breeding unit), recruitment of eels to Canadian waters would be affected by the status of the species in the United States as well as Canada. Prior to their decline, eels reared in Canada comprised a substantial portion of the breeding population of the species. The collapse of the Lake Ontario-Upper St. Lawrence component may have significantly affected total reproductive output, but time series of elver abundance, although relatively short, do not show evidence of an ongoing decline. Recent data suggest that decline may have ceased in some areas; however, numbers in Lake Ontario and the Upper St. Lawrence remain drastically lower than former levels, and the positive trends in some indicators for the Gulf of St. Lawrence are too short to provide strong evidence that this component is increasing. Possible causes of the observed decline, including habitat alteration, dams, fishery harvest, oscillations in ocean conditions, acid rain, and contaminants, may continue to impede recovery. The designation as a *species of concern* does not engage any additional conservation measures outside those within the *Fisheries Act*. American eel has been found at several locations in the Study Area.

2.4 Marine Environment

This section concerns water and sediment chemistry, marine fish and fish habitat, marine-related avifauna including Bald Eagle, and marine-associated mammals including river otter. The related components, commercial fisheries and aquaculture, are contained in Volume 3 Effects Assessment-Socio-economic Environment.

2.4.1 Marine Ecosystem

Marine habitat can be defined as a set of physical, chemical and biological conditions that support the survival of a population of organisms. The organisms use that particular marine space for all or part of their life history for feeding, migration, refuge, and reproduction (Vandermeulen 2005).

According to the *Fisheries Act*, “fish habitat” means spawning and nursery grounds, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes.

There are a variety of fish habitat types in Placentia Bay. A relatively recent biological and geomorphological classification of Placentia Bay (Catto et al. 1999) identified five regional subdivisions of shoreline biological communities:

1. Cape Shore (Cape St. Mary’s to northern tip of the Argentia Peninsula);
2. Northeast Placentia Bay (northern tip of Argentia Peninsula to North Harbour);
3. the Swift Current Estuarine Region (North Harbour to Prowsetown, including Sound Island, Woody Island, and Bar Haven Island);

4. Northwest Placentia Bay (Merasheen Island, Long Island, the Ragged Islands archipelago, Isle Valen, Presque Harbour, Paradise Sound, and the adjacent mainland shores of Newfoundland); and
5. Burin Peninsula.

The Project Area occurs in the subdivision of Northeast Placentia Bay. Biota along the shores are affected by the same north-flowing currents that influence the Cape Shore subdivision, but the shores of Northeast Placentia Bay are relatively more protected from surf and ice erosion by the highly convoluted and indented nature of the coast. Pack ice that enters the outer part of Placentia Bay rarely occurs north of the Argentia Peninsula (Catto et al. 1999).

Catto et al. (1999) also identified 11 biological shoreline units as components of the five regional subdivisions:

1. Saltmarsh;
2. Eelgrass;
3. *Fucus anceps* Surf Zone;
4. Seabird-Dominated Shores;
5. *Ascophyllum* Rockweed Shores;
6. Capelin Spawning Beaches;
7. Temporary Intertidal Communities;
8. Barachois Estuaries;
9. Vertical Biological Zones;
10. Rockweed Platforms; and
11. Periwinkle Shores.

Many of these biological shoreline units are discussed in more detail in this section in relation to fish and invertebrate habitat components (e.g., water and sediment quality, plankton, benthos) and important macroinvertebrates and fish.

Offshore habitat in Placentia Bay is less diverse than the nearshore habitat. Maximum water depth exceeds 250 m and bottom substrate varies from fine (mud/silt) to coarse (boulder/bedrock).

Marine Water Quality

Water quality relates to the composition of water as affected by natural processes and human activities. It includes not only chemical composition, but also biological and physical characteristics. The quality of water is also related to specific use, and is usually measured in terms of constituent concentrations. The primary role of seawater being considered here is its importance as a component of fish habitat.

Placentia Bay

This section discusses the chemical aspect of seawater quality as it pertains to Placentia Bay. The biological aspect will be discussed in subsequent sections.

Surface seawater samples were collected at 16 stations in the water column surrounding the Argentia Peninsula within the past 10 years (JWEL 1997; LGL 1998).

Long Harbour

Between October 2005 and October 2006, bottom and surface seawater samples were collected on four occasions at six locations within Long Harbour, and three times at a reference location (Little Seal Cove) immediately south of the harbour mouth (see Marine Component Study by LGL 2007). Sampling stations provided coverage from the head of the harbour (Sandy Point) to the mouth (Shag Rocks). Water depths at the bottom sampling stations ranged from seven to 18 m (LGL 2007). Parameters measured in the sea water samples included pH, total suspended solids (TSS), benzene, toluene, ethylbenzene, xylene/total petrogenic hydrocarbons, mercury, and metals.

Concentrations of copper, iron, manganese and zinc were generally higher in surface and bottom sea water samples at stations in the inner part of Long Harbour (Sandy Point, Maturin Point, and The Key) than in those collected at outer harbour stations (Tim Barrett Cove, Crawley Island, and Shag Rocks) (Table 2.11). The concentration of lead in bottom water was also higher at some of the inner Long Harbour stations compared to the outer stations and reference station (Table 2.11). The TSS, arsenic, chromium, copper, iron manganese, and zinc concentrations were consistently higher in Long Harbour than at Little Seal Cove.

Table 2.11 Comparison of Seawater Metal Concentration Ranges (µg/L) at Inner and Outer Long Harbour Sampling Stations

Sampling Depth/Metal	Inner Long Harbour			Outer Long Harbour		
	Sandy Point	Maturin Point	The Key	Tim Barrett Cove	Crawley Island	Shag Rocks
Surface						
Copper	0.2-1.5	0.3-0.6	0.4-3.8	0.2-0.9	0.2-0.5	0.3-0.5
Iron	<1-137	<1-34	<1-7	<1-10	<1-9	<1-9
Manganese	2-12	1-6	<1-2	<1	<1-2	<1-2
Zinc	<1-3	<1-2	<1-2	<1-1	<1	<1
Bottom						
Copper	0.3-0.6	0.2-2.7	0.1-2.4	0.1-0.3	0.1-0.4	0.1-0.3
Iron	<1-21	<1-6	<1-8	<1-6	<1-7	<1-7
Lead	0.1-0.4	<0.1-5.2	<0.1-25.7	<0.1-0.2	<0.1-0.3	<0.1-0.1
Manganese	1-5	<1-1	<1-1	<1	<1-1	<1
Zinc	<1-4	<1-5	<1-19	<1-1	<1	<1

Surface seawater data were also collected at two stations in Rattling Brook Cove in December 2002 (JWEL 2003). Analytical results for samples collected by LGL (2007) between October 2005 and October 2006 at the stations nearest to Rattling Brook Cove (i.e., Maturin Point and The Key) were similar to the 2002 results. Notable differences included maximum concentrations of arsenic and copper that were noticeably higher in 2005-06 compared to 2002 results, and maximum concentrations of iron and manganese that were noticeably lower in 2005-06 compared to 2002 (LGL 2007).

Marine Sediment Quality

Marine sediments provide habitat for many benthic infauna and epibenthic organisms, which in turn interact with non-benthic marine organisms. Sediments also influence the environmental fate of many chemical substances in marine ecosystems by acting as both sinks and sources of substances that enter the marine environment.

Placentia Bay

Surficial sediments sampled at four locations in the inner part of Placentia Bay (Come By Chance Refinery, Woody Island/Sound Island, Red Island, and Long Island) were analyzed for aromatic hydrocarbons (Kiceniuk 1992). Overall, the highest levels of bioavailable aromatic hydrocarbons were found in sediment collected at Woody Island/Sound Island and Port Royal Arm on the west side of Long Island.

Ramey and Snelgrove (2003) also collected surficial sediments in Placentia Bay: six stations in the inner part of the bay (H, C, W1, W2, E1, and E2) and one in the middle of outer Placentia Bay (O). Specifics of these samples are contained in Figure 2.27 and Table 2.12.

These data provide an indication of the difference between inner Placentia Bay deep surficial sediments and those in the outer bay. Sediments sampled at the inner Placentia Bay locations were characterized by higher proportions of clay, carbon and nitrogen.

Surficial sediment quality was also examined at five stations during a survey of benthic conditions at Whiffen Head in the 1990s (JWEL 1996b). Approximate water depths ranged from five to <20 m. No detailed particle size analysis results were presented in the report. One station was in sand/cobble habitat and the other four were in cobble/boulder habitat. Analyses were conducted for 22 inorganic analytes. The mean levels of four inorganic analytes (arsenic, copper, nickel, and vanadium) exceeded either the respective guideline values for Ocean Dumping or threshold effect level (TEL) established by Environment Canada at one station (10 to 20 m depth; cobble/boulder habitat). None exceeded the respective probable effect level (PEL) established by Environment Canada, the concentration at which adverse effects on aquatic life are occasionally expected to occur.

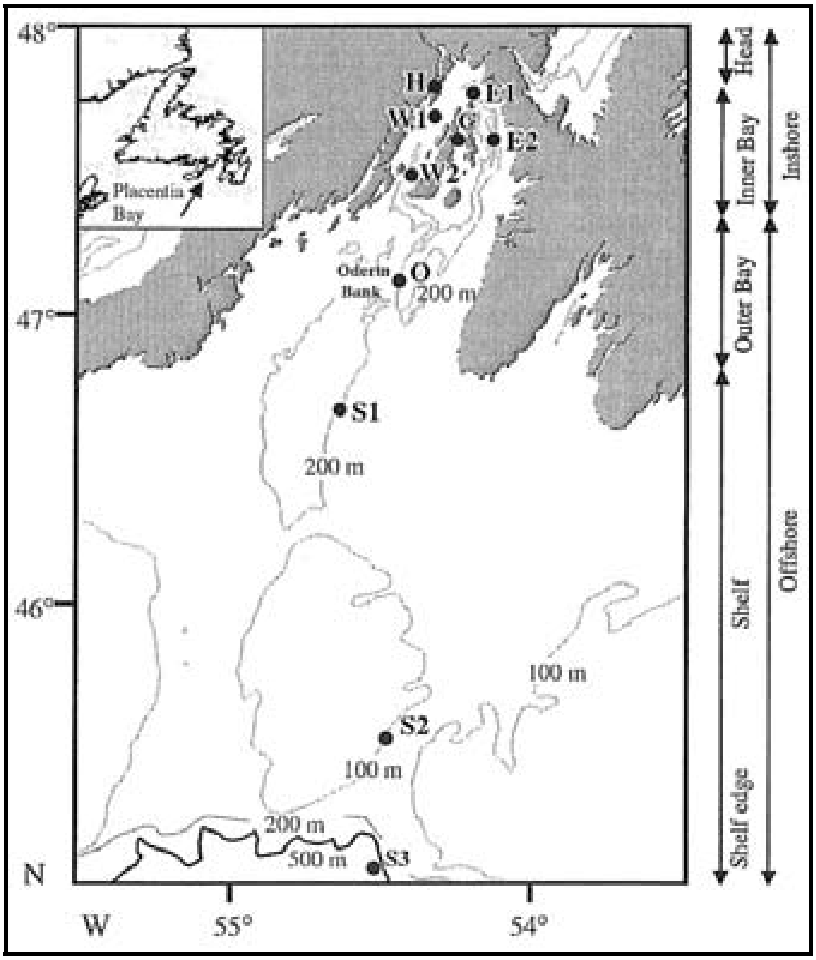

Figure 2.27 Locations of Sampling in Placentia Bay by Ramey and Snelgrove (2003)

Source: Ramey and Snelgrove (2003).

Table 2.12 Surficial Sediment Analyses (mean±sd) in Placentia Bay, 2003

Site	Depth (m)	n (grain size)	% Clay	% Fine/medium Silt	% Coarse Silt	% Very fine Sand	% Fine Sand	% Medium Sand	n (C, N)	% C	% N	C/N
H	67±3.7	6	36.0±5.6	45.0±8.9	11.0±1.2	3.9±2.3	3.9±4.8	0.24±0.5	3	8.07±0.61	0.33±0.2	8.51±0.2
C	210±5.1	6	38.4±9.0	48.3±9.0	10.4±6.3	1.6±0.5	1.0±0.2	0.16±0.2	3	6.57±0.30	0.91±0.1	9.11±0.1
W1	214±2.1	6	55.0±16.8	41.6±6.8	0.50±0.4	1.3±1.2	1.2±0.9	0.27±0.5	3	7.82±0.1	1.15±0.1	8.79±0.1
W2	283±11.7	5	41.0±7.6	47.4±7.6	8.2±2.9	2.6±1.0	0.86±0.7	0.0±0.0	3	5.31±0.3	0.64±0.1	9.05±0.2
E1	225±6.7	5	33.8±16.6	60.4±13.9	3.3±3.8	1.3±1.0	0.91±0.9	0.0±0.0	3	6.15±0.2	0.77±0.1	8.60±0.2
E2	217±6.5	5	45.2±4.6	46.7±4.2	5.4±1.1	1.6±1.2	1.1±1.9	0.0±0.0	3	4.83±0.4	0.61±0.1	9.23±0.4
O	230±0.0	3	11.6±2.7	23.5±3.5	43.3±5.7	21.1±2.7	0.42±0.2	0.00±0.1	3	1.26±0.23	0.15±0.04	8.26±0.57

Source: Ramey and Snelgrove (2003).

Long Harbour

Surficial marine sediment samples were collected on four occasions at six locations within Long Harbour, and three times at a reference location immediately south of the harbour mouth between October 2005 and October 2006 as part of the Marine Component Study (LGL 2007). A single sediment sample was also collected at a location between Shag Rocks and Crawley Island at a depth of 69.5 m. Sampling stations within Long Harbour provided coverage from the head of the harbour (Sandy Point) to the mouth (Shag Rocks). Water depths ranged from 7.5 to 70 m. Surficial sediments with high proportions of fines were targeted (LGL 2007).

Parameters measured in the surficial marine sediment samples included particle size, total inorganic carbon/total inorganic carbon, extractable hydrocarbons ($>C_{10}$-C_{32}), sulphate, mercury, and available metals.

Similar to the water analyses, stations in the inner part of Long Harbour, particularly at Sandy Point and Maturin Point, generally exhibited higher concentrations of some parameters than the outer stations. These parameters include extractable hydrocarbons, sulphate, mercury, arsenic, boron, cadmium, copper, iron, lead, molybdenum, phosphorus, uranium, vanadium, and zinc (Table 2.13). Concentrations at the stations within Long Harbour were consistently higher than those at the reference station at Little Seal Cove. Exceptions to this included C_{10}-C_{21} hydrocarbons, strontium, and thallium (LGL 2007).

None of the surficial sediment samples collected between October 2005 and October 2006 exceeded any of the available PEL (probable effects level) guidelines. All exceedances were related to *Interim Sediment Quality Guidelines* (ISQG), which are more conservative than the PEL guidelines and do not have as strong a biological basis (LGL 2007).

Marine sediment data were collected at two stations in Rattling Brook Cove in December 2002 during a previous baseline investigation for VBNC (JWEL 2003). Recent surficial sediment sampling was also conducted in the vicinity of the wharf in Long Harbour (JWEL 2003; AMEC 2006).

The surficial sediments collected at the two 2005-06 stations nearest to Rattling Brook Cove (i.e., Maturin Point and The Key) had higher maximum levels of many parameters compared to sediments collected in 2002. These parameters included sulphate, mercury, C_{21}-C_{32} TPHs, arsenic, barium, chromium, copper, iron, nickel, and vanadium. Marine sediments collected in December 2002 were much coarser than those collected at the Maturin Point and The Key stations during the 2005-06 baseline study. The 2002 marine sediment samples were primarily composed of gravel and sand and the fines component never constituted more than four per cent. The higher proportion of fines in the 2005-06 samples likely contributed to the higher levels of some metals and hydrocarbons in surficial sediments compared to the earlier results.

Table 2.13 Comparison of Surficial Sediment Chemistry Concentration Ranges (mg/kg) at Inner and Outer Long Harbour Sampling Stations

Sampling Depth/Chemical Parameter	Inner Long Harbour			Outer Long Harbour		
	Sandy Point	Maturin Point	The Key	Tim Barrett Cove	Crawley Island	Shag Rocks
$>C_{10}$-C_{21}	15.0-31.0	3.5-17.0	4.9-8.0	2.0-6.6	4.0-8.2	5.3-11.0
$>C_{21}$-C_{32}	41.0-96.0	9.2-60.0	13.0-25.0	5.9-18.0	8.6-23.0	2.6-22.0
Sulphate	7,400-11,000	4,200-4,700	3,400-4,400	730-8,500	2,300-7,500	1,400-4,900
Mercury	0.06-0.12	0.02-0.05	0.03-0.04	0.02-0.03	0.02-0.03	0.02-0.03
Arsenic	14-19	10-13	10-13	4-8	7-9	6-9
Boron	110-250	52-62	39-60	9-44	24-51	16-51
Cadmium	2.1-2.5	0.6-1.1	0.4-0.8	0.3-0.4	0.3-0.4	<0.3
Copper	21-28	18-22	16-21	6-20	12-21	10-21
Iron	17,000-18,000	17,000-24,000	19,000-20,000	16,000-21,000	16,000-19,000	17,000-18,000
Lead	18-54	12-23	15-20	6-18	12-19	11-19
Molybdenum	10-22	4-5	2-3	3-4	<2	2
Phosphorus	3,300-10,000	3,200-9,000	2,300-3,400	980-1,600	1,700	920-1,500
Uranium	9.1-23.0	2.6-12.0	2.9-4.2	0.7-2.1	1.7-1.8	0.9-1.3
Vanadium	41-52	38-40	33-40	20-34	27-36	24-34
Zinc	59-88	63-71	59-65	50-63	55-63	57-59

Four marine surficial sediment samples were collected along the edges of the wharf in Long Harbour in July 2006 (AMEC 2006). Generally, levels of many parameters were higher in the sediments collected at the wharf than in those collected at the Maturin Point and The Key stations. Parameters with noticeably higher maximum concentrations in the wharf sediments include C_{21}-C_{32} TPH, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, nickel, and zinc. The maximum available phosphorus concentration found in sediments from Maturin Point and The Key stations was 9,000 mg/kg. The total phosphorus found in the wharf sediments ranged between 18,100 and 86,200 mg/kg.

Plankton in Placentia Bay

Chorophyll a, a measure of phytoplankton standing crop, was measured in water samples collected at seven locations in Placentia Bay in June and August 1998 (Ramey and Snelgrove 2003). Samples were collected at five m depth in six locations in the inner part of the bay and one in the central part of the outer bay. In both June and August, *chlorophyll a* concentrations were generally higher in inner Placentia Bay than at the outer location, and the innermost stations had the highest concentrations. Ramey and Snelgrove (2003) indicated that these trends were consistent with those indicated by the Sea-Viewing, Wide-Field-of-View Sensor Spacecraft (SeaWiFS) in April, July and September of that same year. Overall, *chlorophyll a* concentration was highest in April.

DFO Newfoundland Region has conducted zooplankton sampling (including icthyoplankton) in Placentia Bay. Fish stomach analysis also provides information on zooplankton. The diet of capelin captured within Placentia Bay in January and May-June 1999 was investigated by O'Driscoll et al.

(2001). Sampling sites were located in inner and outer areas of the bay during both sampling times. *Temora* spp. and *Metridia* spp. were the most abundant copepods in diet of capelin collected in January. The proportion of *Calanus* spp. in the diet increased in the spring (May-June). Large capelin caught in Placentia Bay in spring fed mainly on *hyperiid* amphipods.

The seasonal diet of Atlantic cod in Placentia Bay was investigated during the 1997 to 2000 period. Planktonic invertebrates identified in the cod stomachs included various amphipods, cnidarians and copepods (Mello and Rose 2005a).

Ichthyoplankton is defined as the free floating stages of certain species of fish eggs and larvae. Distribution information on the pelagic eggs of American plaice, Atlantic cod, and cunner (*Tautogolabrus adspersus*) has been compiled by Bradbury et al. (2003). Plaice and cod eggs were found in highest abundance on the west side of Placentia Bay, particularly in the vicinity of Bar Haven Island and off the southern Burin Peninsula. A notable abundance of Stage II eggs of both American plaice and cod was also found immediately southwest of Merasheen Island. Cunner eggs were distributed more widely, occurring primarily in waters proximate to Marystown, between Marystown and Paradise Sound, off Cape Shore, offshore of Paradise Sound, and extensively throughout the large islands of inner Placentia Bay.

Bradbury et al. (2003) also provide distributional information on the larvae of Atlantic cod, cunner, capelin, and sand lance (*Ammodytes* sp.) based on field sampling in June and August 1998. Cod larvae were most abundant in western waters off the Burin Peninsula, cunner larvae in the inner part and off the southern Burin Peninsula, Capelin larvae in western waters off the southern Burin Peninsula and in the waters around southern Merasheen Island and Red Island. Sandlance larvae were most abundant in waters off the Cape Shore, in the central part of outer Placentia Bay, and off the southern Burin Peninsula. Cod larvae were the least abundant of the four species. Patchiness in distribution generally increased during development of all three species with pelagic eggs (Atlantic cod, American plaice, and cunner). Larval patchiness was initially high at hatch, decreased strongly post-hatch, and subsequently rose sharply. The range of estimated patchiness during development was highest for pelagic schooling species with demersal eggs (capelin, sandlance) (Bradbury et al. 2003).

Spatial distribution patterns during the egg and early larval period of cod, American plaice, and cunner were consistent with passive transport out of the western side of the bay following spawning near the head. Bradbury et al. (2003) hypothesized that observed spatial patterns in older larvae, seasonal size increases in larvae from demersal eggs, and ontogenetic changes in patchiness reflect active processes; in other words, larger larvae may actively contribute to changes in their spatial distribution. The authors concluded that swimming ability and behaviour become increasingly important in determining spatial distribution patterns as pelagic larvae develop.

Ichthyoplankton surveys during the spawning and postspawning seasons of 1997 and 1998 indicated that Atlantic cod egg densities were highest during early spring of both years, subsequently decreasing during spring and summer (Bradbury et al. 2000). The distributions of different egg development stages and larvae of varying size suggested that the eggs and larvae were released from spawning locations and developed as they were transported in cyclonic flow from the southeast and around the bay towards the southwest. This is in agreement with the results of the VBNC oceanographic studies and others that suggest that the water currents generally flow counter-clockwise in Placentia Bay. During the two years of study, Stage I cod eggs were concentrated in three areas: Perch Rock, southeast outer bay; Bar Haven, northwest inner bay; and Oderin Bank, western outer bay. The data indicated that substantial inshore cod spawning occurs at spatially consistent sites in Placentia Bay. The reasons for this are still unclear, although algal biomass is typically highest at the head and western side of the bay, thereby perhaps providing greater food resources for hatching larvae.

Bradbury et al. (2001b) suggested that the effects of predation on cod egg mortality are small relative to the advective effects within the Placentia Bay system, and that the interaction between advection and temperature-dependent vital rates of eggs may have dramatic consequences for coastal retention of eggs and larvae produced within the bay.

Marine Benthos in Placentia Bay

The term "benthos" refers to those plants and animals that live on or in the seabed. The community is composed of many of taxonomic groups, from algae to flounder, that use a wide variety of feeding modes. A study conducted in the 1970s identified 84 gammaridean and two caprelliad amphipod species in Placentia Bay (Fenwick and Steele 1983).

The first major study on sedentary macrofauna in muddy substrates in Placentia Bay was conducted in 1998 (Ramey and Snelgrove 2003). Benthic macrofauna was sampled at seven locations within Placentia Bay, six at depths within a 210 to 230 m range, and the other at 67 m (Ramey and Snelgrove 2003) (Figure 2.27)**.** Six of the sampling stations were located in the inner part of Placentia Bay north of latitude 47º25'N (shallowest one at the head of Placentia Bay inside of Bar Haven Island [H], two in the Western Channel between mainland and Merasheen Island [W1 and W2], two in the Eastern Channel between mainland and Long Island [E1 and E2], one in Central Channel between Merasheen Island and Long Island [C]), and one was near Oderin Bank [O] (latitude 47º11'N). The six inner sampling stations were located from 0.6 to 4.0 km from the shoreline. The single outer station was located 23 km from the Cape Shore shoreline. E1 and E2 occur in Northeast Placentia Bay subdivision, H occurs in Swift Current Estuarine Region subdivision, and W1, W2, and C occur in the Northwest Placentia Bay subdivision.

Based on various statistical analyses, distinct infaunal communities occurred at H, C + W1 (most northerly), E1 + E2 +W2, and O. Highest macrofaunal density was found at O and the lowest densities at H and C + W1. Vertical distribution of macrofauna in samples collected at O was more extensive than that in samples collected in the inner part of Placentia Bay. In all cases, macrofaunal density was highest in the upper three cm fraction of sediment compared to the three to10 cm fraction (Ramey and Snelgrove 2003).

In terms of species richness (i.e., number of species per station), all of the inner stations were less than the outer station. Within the inner stations, species richness was highest at the shallowest station (H) and least at the northernmost Western Channel station (W1). Shannon diversity H' was highest at H, O and C + W1, and lowest at E1 + E2 + W2 (Ramey and Snelgrove 2003).

The dominant taxa at the seven sampling stations included numerous polychaete species, the bivalve *Thyasira* sp. and various ribbon worm species (Nemertea). The amphipod *Byblis gaimardi* was found at the outer Placentia Bay station but not at the inner stations. The single most abundant polychaete species was *Cossura longocirrata*. The polychaete *Pectinaria granulata* was abundant at the shallow station H but was either rare or absent at all of the other stations. *Thyasira* sp. was most abundant at O, C and W2 (Ramey and Snelgrove 2003).

Ramey and Snelgrove (2003) suggested that broad-scale changes in sedimentary macrofaunal communities in Placentia Bay may be related to surface water characteristics such as *chlorophyll a* levels. Within the inshore stations, high levels of organic carbon influenced macrofaunal assemblages that were similar to those characteristic of organic-rich areas. Surface *chlorophyll a* concentration was positively correlated with sedimentary organic carbon, which was the most important predictor of infaunal abundance.

Marine benthic habitats in the vicinity of the Newfoundland Transshipment Terminal at Whiffen Head were assessed in 1996 (JWEL 1996b). The survey was conducted within an area of approximately two km^2 (~ 1.5 km shoreline x 1.25 km offshore) in shallow subtidal areas off six beaches and several deeper subtidal areas (10 m to >20 m). Subtidal substrates were categorized by particle size, and characteristic macrobenthos were identified for each substrate category. Three substrates and their respective characteristic macrobenthos were identified:

1. Sand/Cobble – sea urchins, sand dollars, scallops;
2. Cobble/Boulder – sourweed (*Desmarestia* spp.), coralline algae, sea anemones, mussels, sea urchins; and
3. Boulder/Bedrock - rockweed (*Fucus* spp.), sea anemones, mussels, sea urchins, cunners.

The shallow subtidal areas were predominantly boulder/bedrock and cobble/boulder habitats. The sand/cobble habitat was located primarily in areas where depth exceeded 10 m. The coarser substrate habitats were also common in the deeper subtidal area (JWEL 1996b). Other biota noted during the habitat survey at Whiffen Head included cord weed (*Chorda filum),* sea colander kelp (*Agarum cribrosum*), sea stars, winter flounder, yellowtail flounder, ocean pout, lumpfish, and Atlantic cod (JWEL 1996b).

Subtidal marine sediment samples were collected at two locations near the Come By Chance refinery site in 1990 (Fox Head and Come By Chance Point within five km of the refinery site), at Bread Island (approximately 10 km from the refinery site), and at Bar Haven Island (approximately 15 to 20 km from the refinery site) (LFA 1991). Samples were collected at six and 12 m depths at each of the four locations. Average abundance of benthic fauna was higher in the deeper sediments. Polychaetes were the most abundant benthic invertebrate group in the shallow sediments, followed by molluscs, crustaceans, and echinoderms. The most abundant species in each of these four groups were capitellid thread worms (polychaetes), chitons and limpets (molluscs), amphipods (crustaceans), and sea urchins (echinoderms) (LFA 1991). Crustaceans were the most abundant benthic invertebrate group in the deep sediments, followed by molluscs, echinoderms, and polychaetes. The most abundant species in each of these four groups were amphipods and copepods (crustaceans), chitons (molluscs), brittle stars (echinoderms), and clam worms and terebellid worms (polychaetes) (LFA 1991).

The seasonal diet of Atlantic cod in Placentia Bay was investigated during the 1997 to 2000 period. Many benthic invertebrates were identified in the cod stomachs, including various echinoderms, amphipods, molluscs, polychaetes, and decapods (Mello and Rose 2005a).

As mentioned in the section on marine sediment quality, the physical characteristics of surficial marine sediments in Long Harbour are diverse. Associated with this physical diversity is biological diversity. Although surficial marine sediment samples collected in Long Harbour between October 2005 and October 2006 were not analyzed in terms of infauna, Remotely Operated Vehicle (ROV) surveys in the area indicated a diversity of both infauna and epifauna. Soft-substrate areas surveyed were often characterized by burrowing molluscs and polychaetes, small shrimp-like crustaceans and flatfish (winter flounder, American plaice). Areas with harder substrates were characterized by kelp and filamentous algae, coralline algae, epibenthic bivalves (e.g., scallops, mussels), echinoderms (e.g., sea stars, sea urchins), anemones, and demersal fish (e.g., cod, cunner) (LGL 2007).

2.4.2 Long Harbour Benthic Habitat

In October 2006, ROV surveys were conducted to assess fish habitat at three areas within Long Harbour: deep water area (60 to 74 m) between Shag Rocks and Crawley Island; the shallow water area (eight to 15 m) immediately adjacent to the north side of the former ERCO wharf; and a shallow water area (one to 10 m) of Rattling Brook Cove on the south side of the wharf (LGL 2007). The following sections describe the results of these surveys.

Deep Water Area between Shag Rocks and Crawley Island

The dominant substrate type on transects surveyed in this area consisted of soft, silty sediment that readily re-suspends in the water column when disturbed. Water depths in this area ranged from 60 to 74 m. Fauna observed in the soft sediment regions of the candidate outfall area included winter flounder, American plaice, eelpouts (Zoarcidae), bivalves, seastars, brittlestars and small crustaceans (likely amphipods). Occasional boulder clusters were also observed. Biota associated with these clusters included sea anemones, sea urchins and sea stars. A rocky hump that tops off at about 60 m and is completely surrounded by the deeper soft sediment habitat appeared to be a productive area relative to the surrounding area, and biota included echinoderms (seastars, sunstars, and sea urchins), corals, sea anemones, crabs, and cod (LGL 2007).

North Side of Wharf

The predominant type of substrate indicated by transects surveyed on the north side of the former ERCO wharf consisted of hard sediments such as sand, gravel, cobble, and small boulder. Water depth of the surveyed area ranged from 8.5 to 14.5 m. Biota observed during the survey included clumps of kelp, areas of low-lying filamentous algae (red, brown, and green algae), cunner, winter flounder, sea stars, sand dollars, mussels, and amphipods. There also appeared to be considerable decomposition (probably kelp) occurring in this area. Close to the wharf, at the start of each transect, metal scraps and other industrial waste was abundant (LGL 2007).

Rattling Brook Cove

The dominant substrate type indicated by transects surveyed in Rattling Brook Cove consisted of hard sediments such as sand, gravel and cobble. Water depth of the surveyed area ranged from 0.2 to 9.1 m. Biota observed during the survey includes low-lying filamentous algae (red, brown, and green algae), coralline algae, eelgrass, and Irish moss in the shallower areas, along with periwinkles, hermit crabs, rock crabs, scallops, sea stars, and sand dollars. No fish were encountered during the survey within Rattling Brook Cove (LGL 2007).

2.4.3 Macroinvertebrate and Fish Species

This section focuses on species with the highest profiles from both ecological and commercial perspectives. Invertebrates include snow crab (*Chionoecetes opilio*), American lobster (*Homarus americanus*), sea scallop (*Placopecten magellanicus*), Iceland scallop (*Chlamys islandica*), and blue mussel (*Mytilus edulis*). Finfish discussed include Atlantic cod (*Gadus morhua*), capelin (*Mallotus villosus*), Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), lumpfish (*Cyclopterus lumpus*), American plaice (*Hippoglossoides platessoides*), and winter flounder (*Pseudopleuronectes americanus*).

Snow Crab

Snow crab in Newfoundland waters typically occurs at depths ranging between 60 and 400 m on mud/gravel bottom. The commercial fishery for snow crab has generally been very lucrative since the groundfish moratorium in 1992, but recent years have seen a downward turn in the stock (DFO 2006a).

Spawning by snow crab typically occurs in spring and early summer. The eggs are carried by the females until larval hatch during the summer months when water temperatures are appropriate for development. The larvae are pelagic and may remain in the water column for months. Eventually, the final larval stage drops to the bottom and continues development to maturity in the benthic habitat (DFO 2006a). After assuming the benthic habitat, snow crab feed on benthic organisms including polychaetes, echinoderms, and molluscs (DFO 2006a).

American Lobster

The American lobster has a continuous distribution around the island of Newfoundland, occupying a relatively narrow band of rocky habitat over an approximate depth range of two to 40 m (Ennis 1984). The inshore lobster fishery is primarily conducted in areas with water depths of 15 to 20 m during spring and early summer and remains important for many fishers (DFO 2006b). Lobster mating typically occurs during the summer months, immediately after the female moults. Egg fertilization might not occur until late summer/fall, when the female carries the developing eggs on the underside of her abdomen. Hatching occurs the following summer, and the resultant larvae assume a pelagic existence. The planktonic larvae undergo four moults before leaving the upper water column and adopting a benthic habitat. Development to the adult stage occurs on the ocean bottom (DFO 2006b). The American lobster is an opportunistic feeder and is known to consume a variety of food including crustaceans, echinoderms, molluscs, fish, and polychaetes (DFO 2006b).

Sea Scallop

Sea scallops are generally distributed throughout the shallow (<20 m) coastal region, occurring primarily on sand/gravel or gravel/pebble substrates. They are most abundant in shallow sheltered sandy locations, such as western Placentia Bay. Commercial and recreational harvesting of sea scallops occurs in areas around Newfoundland, including Fortune Bay, Placentia Bay, and St. Mary’s Bay.

Spawning typically occurs in September and October. Both the eggs and larvae are planktonic, the latter for about four weeks. The larva develops a “foot” that allows it to attach to an appropriate substrate and, once attached, it develops into the juvenile stage. After a period of growth, the juveniles lose their byssal attachments and lie freely on the ocean bottom for development to the adult stage (Black et al. 1993). Larval sea scallops feed on phytoplankton, while the larger juveniles and adults typically feed on plankton and detritus (Black et al. 1993).

Iceland Scallop

An exploratory scallop survey conducted by DFO in 1990 identified an Iceland scallop bed in the Perch Rock area located 15 to 20 km off St. Brides, southeastern Placentia Bay (Dooley 1991). Depth of scallop catches ranged from 55 m to 110 m. The best catches at the Perch Rock area in a subsequent DFO investigation occurred at a depth range of 77 m to 90 m (Naidu and Seward 1992).

Atlantic Cod

Atlantic cod has historically been one of the leading food fishes in the world, and until recent years was Newfoundland and Labrador’s single most important commercial species. The various Atlantic cod populations have decreased precipitously during the past couple of decades, to the point where inshore Atlantic cod appear to be more abundant than those in the offshore areas (DFO 2006c).

Inshore cod spawning occurs in several bays in Newfoundland, including Placentia Bay. During 1997 to 1998, three cod spawning grounds were identified at Bar Haven, Perch Rock near Cape St. Mary's, and Oderin Bank in Placentia Bay (Lawson and Rose 2000a). Spawning occurs during the March to August period.

Juvenile cod remain pelagic during early growth and then become associated with the seabed. First-year demersal juvenile cod have been found in shallow nearshore waters (<8 m depth) during autumn. First-year juvenile cod have been caught over a variety of substrate types in nearshore waters, including mud, sand, gravel, and cobble. It appears that the preferred inshore habitat for juvenile cod is characterized by dense beds of eelgrass in sheltered coves, although high numbers also occur in areas without eelgrass, both sheltered and exposed. Juvenile cod in inshore waters move from shallow to deep water as they mature to age three, but do not appear to mix with adult cod until they reach about age three to four (DFO 2006c).

Atlantic cod larvae and pelagic juveniles feed mainly on zooplankton. Early demersal stage juveniles in inshore areas continue to feed on zooplankton but then switch to benthic and epibenthic invertebrates (Scott and Scott 1988).

There is evidence that capelin are necessary for the optimal growth, condition, and reproductive potential of northern cod (Rose and O'Driscoll 2002). Between 1996 and 2001, cod were sampled in three areas off Newfoundland and Labrador, including Placentia Bay. During January and June sampling, capelin were found in 9.5 per cent of the cod taken in Placentia Bay and constituted 22 per cent of the diet in terms of weight. During both January and June sampling, stomach content weights were highest in Placentia Bay cod compared to cod from Trinity Bay and Hawke Channel. The condition of Placentia Bay cod was usually higher than the condition of cod sampled further north at Hawke Channel, possibly because potential contact between cod and capelin was higher in the southern areas.

All four indices of the 3Ps cod population are below their long-term averages. The two offshore indices (trawl) have been declining, whereas the two inshore indices (fixed gear) have been somewhat stable in recent years (Brattey et al. 2005; Maddock Parsons and Stead 2005; DFO 2006c).

Juvenile Fish

From September to December, 1997 to 1999, age 0 cod were surveyed at numerous shallow shoreline sites throughout Placentia Bay (Robichaud and Rose 2006). Sites included a variety of habitat types, although most of them had eelgrass. Generally, catches of age 0 cod were higher at sites in the northern part. Highest overall catches were made at Great Brule and Bar Haven North in the inner bay. This study also indicated a density-dependent range expansion for age 0 juvenile cod - that is, as cod abundance increased, the number of occupied sites also increased. These juvenile cod were most likely found at sites with eelgrass, but with increasing abundance came increased occurrence at sites without eelgrass. Sites such as Great Brule and Bar Haven North may represent critical habitat since these two sites consistently had the highest abundances of these fish regardless of overall annual abundance.

Habitat preferences and use of cover of one to four year-old juvenile cod in the inshore waters were investigated with the use of deep sea submersibles (Gregory and Anderson 1997) in areas ranging from 18 to 150 m. Age 2 to 4 juvenile cod were most often associated with areas of coarse substrate and high bathymetric relief (i.e., submarine cliffs). Age 1 juveniles were most often associated with areas of gravel substrate and low relief. Juvenile cod did not exhibit selection for substrates with macroalgae cover.

Placentia Sound has also been identified as a nursery ground for winter flounder (Khan 2003b). Sediment of this inshore habitat was described as muddy (Khan 2003b).

Adult Fish

The cod stock in Placentia Bay exhibits marked variations in abundance and composition over the course of an annual cycle. Based on data collected in 1999 (Mello and Rose 2005b), a patchy distribution comprised mostly of spawning, old (ages 7 to 9), large (>60 cm) cod were present in the inner part of Placentia Bay in April/May. The outer part of Placentia Bay had widely scattered and low fish density in April/May except for a high density aggregation near Cape St. Mary’s in May. By July, cod were more dispersed throughout Placentia Bay in small dense aggregations and abundance had increased four-fold. The cod found in Placentia Bay in July and early October were predominantly younger (ages 4 to 6) and smaller than those observed in April/May. The October distribution pattern was similar to that in July although fewer fish were located over the banks in the outer part of Placentia Bay. By November, most cod were located at the head of the bay in moderate to high-density aggregations. The November cod abundance had again decreased to levels similar to those observed in April/May and older, larger fish predominated. The variation in age and size of cod coincided with the expected influx of the non-resident young, small fish into Placentia Bay during the post-spawning period and their subsequent departure in the fall. In summary, Mello and Rose (2005b) showed that the cod stock in Placentia Bay experiences marked variations in abundance and composition over the annual cycle. The variations appear to be related to movement and mixing of fish from different populations.

Acoustic surveys in the bay in 1997 and 1998 identified three primary cod spawning grounds: Bar Haven, Oderin Bank, and Perch Rock (Lawson and Rose 2000a). Ground use and spawning times differed between years. Mean spawning female densities were highest at Perch Rock in 1997 and at Oderin Bank in 1998. Peak spawning in 1997 occurred in April but not until June/July in 1998. In both years, cod spawned at sub- or near-zero temperatures.

Robichaud and Rose (2001) provided the first direct evidence through a telemetry study that cod undertaking long-distance feeding migrations may home to a specific spawning ground in consecutive years. Approximately 67 per cent of the fish tagged at the Bar Haven spawning ground in April 1998 were relocated during the two years following spawning. All cod relocated during the 1999 and 2000 spawning seasons were within 10 km of the tagging location at Bar Haven. Several of the fish relocated outside of spawning season in 1999 and 2000 were as far as 110 km from the tagging location. Multiyear homing (1999 and 2000) was observed in 26 per cent of the cod tagged at Bar Haven. Windle and Rose (2005) suggested that spatial familiarity may be a key factor in cod homing, reinforced through multiyear migrations. Relocation rates on the spawning ground were higher for male fish in all years, suggesting that female cod move in and out of male-dominated spawning aggregations (Robichaud and Rose 2003).

Different spawning aggregation structures have also been observed with the application of active acoustics (Rose 1993). The pelagic behaviour of an aggregation of cod was observed in deep water areas (>300 m) and spawning columns were observed in shallow water areas (~50 m). Some of these spawning columns extended as high as 20 m off the ocean floor.

Acoustic surveys and mark-recapture experiments conducted in the late 1990s investigated the seasonal movements and distribution of coastal cod in Placentia Bay (Lawson and Rose 1998, 2000b). Spawning cod tagged in the inner part of the bay in spring moved outwards along both the east and west sides of Placentia Bay during spring and summer, further on the east side, sometimes leaving Placentia Bay entirely. Lawson and Rose (2000b) estimated that 10 to 30 per cent of the Placentia Bay cod may move in spring and summer into the adjacent stock area, 3L. The majority of tagged cod recaptured in spring the next year following tagging were taken in the bay, perhaps suggesting a return migration. Smaller cod (<50 cm) tended to remain resident in the inner bay and did not migrate as far as larger fish. The degree of aggregation was highest in spring and fall, and lowest in the summer. Cod moved to shallower water after spawning and occupied an increasingly narrow range of depths from spring to fall. Results presented by Lawson and Rose (2000b) were evidence of repeat spawning, year-round residence, and return migrations, suggesting the existence of a Placentia Bay coastal cod stock.

A mark-recapture study of Atlantic cod in NAFO Subdivision 3Ps was initiated in 1997 (Brattey and Healey 2006). Between 1997 and 2006, more than 66,000 cod were tagged at locations in inner and outer Placentia Bay, but primarily the former. Results of the study indicate that most of the recaptures of cod tagged within Placentia Bay occurred in Placentia Bay. Some of the cod tagged in Placentia Bay have been recaptured in other inshore areas within 3Ps, inshore areas outside of 3Ps (Cape St. Mary's to White Bay), and offshore areas within 3Ps.

Atlantic Herring

There are five coastal herring stocks in east and southeast Newfoundland, one of which is the St. Mary's Bay-Placentia Bay (SMB-PB) stock (Wheeler et al. 2004; DFO 2006d). Although there are fall spawning herring, spring spawners appear to dominate most stocks. Atlantic herring generally spawn during May and June. These demersal spawners deposit adhesive eggs on stable bottom substrates, typically in shallow (<20 m depth) coastal waters, primarily on gravel or rocky bottom where there is an abundance of seaweed. Other documented spawning substrates include sand and bare rock. Eelgrass has been associated with herring spawning in some locations (Scott and Scott 1988; DFO 2006d,e).

The larvae that hatch from the demersal herring eggs are pelagic. The pelagic larvae and the juveniles that develop from them are known to make diel (night-to-day) vertical migrations. The juveniles and adults tend to avoid the surface waters during daylight hours, likely a strategy for avoiding avian predators. These pelagic schooling fish do not appear to have any substrate preference during juvenile and adult phases. Atlantic herring are visual feeders, consuming primarily plankton during daylight hours (Scott and Scott 1988).

Spring-spawned herring accounted for 70 per cent of the commercial fishery landings in SMB-PB in 2005, up seven per cent from 2004. Commercial landings in this area in 2005 were up two to three per cent from 2004 (DFO 2006d).

In the research gill net program, catch rates in SMB-PB were stable from 2004 to 2006 but remained below the historical mean. Gill net fishers indicated that herring abundance was higher in 2006 than in 2004 but still below average. Purse seine fishers indicated that herring abundance was similar in 2006 to 2004 and above average. A joint industry/DFO acoustic survey in Placentia Bay and St. Mary's Bay in February 2005 indicated substantial stock decline since the 2000 survey, and that spawning intensity was also lower in 2004 than in 2002 (DFO 2006e).

Mean weight (ages 4 to 10) has a decreased since the early 1980s. The mean weight in 2003 was 89 per cent of the long-term mean weight. This could potentially lead to an increase in fishing mortality per tonne of fish caught. Overall, the status of the SMB-PB herring stock has deteriorated since 2002 (DFO 2006d,e; Wheeler et al. 2004).

Sjare et al. (2003) identified areas of herring aggregation in all five regional subdivisions of shoreline biological communities based on local ecological knowledge (Catto et al.1999). The primary areas indicated include coastal waters between Lamaline and St. Lawrence on the southern part of the Burin Peninsula, around Boat Harbour/Brookside/Little Harbour West on the west side of Placentia Bay, at the head of Placentia Bay, and around the islands of inner Placentia Bay (Merasheen Island/Long Island).

Lumpfish

Lumpfish are semi-pelagic, spending much of their time far from the coast. Adult lumpfish exhibit seasonal migrations in Newfoundland waters, moving into shallow coastal waters to spawn in spring and early summer, and then returning to deeper offshore waters in late summer and early fall. Mature female lumpfish are commercially fished for their roe during the inshore spring-summer spawning season (DFO 2002a).

Lumpfish eggs adhere to the nest substrate, which is most often rock. Larval hatch typically occurs during May-June and the larvae attach to macroalgae and hard substrate by means of an adhesive disc. They swim freely and feed four to seven days after hatching, but may also feed from the attached position. Juvenile lumpfish appear to remain in the coastal area up to age 1. They then adopt the semipelagic lifestyle characteristic of adult lumpfish and distribute themselves offshore (Scott and Scott 1988; DFO 2002a).

Free-swimming larvae and first-year juveniles feed on zooplankton. After adopting the semipelagic lifestyle, lumpfish switch to a variety of benthic and pelagic food items including ctenophores, amphipods, polychaetes, molluscs, fish and ichthyoplankton (Scott and Scott 1988).

Capelin

These pelagic fish exhibit inshore-offshore migrations associated with spawning. Capelin typically overwinter in offshore waters, move shoreward in early spring to spawn on appropriate beaches in spring/summer, and return to offshore waters in autumn. Exact timing of spawning appears to be highly dependent on water temperature. Juvenile capelin are found in Newfoundland bays but capelin larvae appear to be rapidly carried out of the bays and inshore areas by surface currents (DFO 2001).

Five stock complexes of capelin have been recognized in the Newfoundland region based on spawning and overwintering locations, including the Saint-Pierre Bank stock that spawns on the south coast of Newfoundland (Carscadden et al. 1989).

Beach suitability for spawning is primarily dependent on substrate type, with capelin showing a preference for gravel. Suitable beaches are found in exposed, moderately exposed and sheltered locations. Beach spawning by capelin is demersal with the eggs typically being deposited in the intertidal zone, although capelin are also known to deposit eggs in the subtidal zone in depths ranging up to 37 m (Carscadden et al. 1989).

Capelin larvae remain on the gravel, upon hatching, until they are flushed by wave action. Once flushed from the spawning sediments, the capelin larvae are pelagic and rapidly advected from embayments into open bays and eventually into the offshore. Adult capelin exhibit diel (night-to-day) vertical migrations in that they occupy the lower water column during the day and move upwards at night. During autumn, the diel vertical migration shows a reverse pattern (Scott and Scott 1988; Carscadden et al. 1989). Capelin feed on various plankton, including copepods and amphipods, mainly during non-spawning times. (Scott and Scott 1988).

The abundance and distribution of capelin in Placentia Bay were assessed using acoustic surveys in January, March, and June 1998, and in January 1999 (O'Driscoll and Rose 1999). Capelin biomass was highest in June 1998, estimated at 132,000 t in the outer bay. Estimated biomasses were much lower during the other three surveys, ranging from 390 t in January 1999 to 13,000 t in January 1998. In addition to these seasonal differences in spatial distribution, seasonal differences in vertical distribution were also observed. Capelin occurred near the surface at night and near the bottom during the day in June 1998. No diurnal vertical migration was evident during the other three survey times. Capelin tended to remain near the bottom during January and March. Most of the capelin observed during the four surveys were immature, approximately 75 per cent measuring less than 130 mm.

The highest capelin densities observed during January 1998 occurred on the eastern side of outer Placentia Bay, and immediately to the south of Merasheen Island and Red Island (O'Driscoll and Rose 1999). In March 1998 the highest densities had shifted towards the western side of outer Placentia Bay and throughout more of the inner bay. June 1998 densities were distributed relatively evenly throughout outer Placentia Bay. The survey in January 1999 found the highest densities in Paradise Sound and towards the head of the bay.

Sjare et al. (2003) identified areas with capelin spawning beaches and offshore spawning areas based on local ecological knowledge. Capelin spawning beaches occur in all five of the regional subdivisions of shoreline biological communities described by Catto et al. (1999). Areas with offshore capelin spawning were identified in four of the five regional subdivisions; the exception was the Swift Current Estuarine Region. The most extensive area of offshore spawning activity was identified off the south coast of the Burin Peninsula.

Atlantic Mackerel

This pelagic fish undertakes long annual migrations, often travelling in dense schools in spring and fall. Most mackerel spawning occurs in the southern Gulf of St. Lawrence in June and July. Recent changes in mackerel migration routes are responsible for a marked increase of landings on the east coast of Newfoundland in 2004 and 2005, and an accompanying drop in catches in the southern Gulf of St. Lawrence. Recent unusual oceanographic conditions in the southern Gulf of St. Lawrence could be the reason for this change in migration. Spring migration of mackerel may be delayed or occur elsewhere in order to avoid cold water in the Gulf of St. Lawrence (DFO 2006f).

American Plaice

American plaice occur both inshore and offshore in the Newfoundland region, typically in depths of 90 to 2,500 m (Pitt 1989). The fishery for this species was once the largest flatfish fishery in the Newfoundland region; declining stocks resulted in a fishing moratorium in 1993 (DFO 2005a; Morgan et al. 2005).

Spawning typically occurs between March and September, with peak activity in April and May. The northeastern and eastern slopes of the Grand Bank are probably the most important offshore spawning areas in eastern Newfoundland waters. American plaice also spawn in inshore waters. Eggs and larvae of this flatfish are pelagic, with larval hatch typically occurring within two weeks of spawning. Past surveys in August and September have indicated the presence of pelagic juvenile plaice in inshore waters. Once the pelagic juveniles switch to demersal habitat and develop into adults, the typical depth range is 55 to 130 m, although they occur in much shallower or deeper waters (DFO 2005a; Morgan et al. 2005). Larval and pelagic juvenile plaice feed on small phytoplankton and zooplankton. When they settle to the ocean bottom, the diet switches to larger food items, including echinoderms and sand lance (Scott and Scott 1988).

Winter Flounder

This species occurs in the western North Atlantic Ocean from southern Labrador, to the coast of Georgia, USA. It is a coastal flatfish that inhabits depths ranging from five to 100 m, typically less than 40 m. Winter flounder are most often associated with soft or moderately hard bottoms. This flounder is primarily a daytime feeder, preying on benthic organisms including algae, polychaetes, crabs, amphipods, shrimps, sea urchins, molluscs and fish eggs (Scott and Scott 1988; DFO 2005b; Fish Base 2007).

The winter flounder typically spawns in late winter/spring in Newfoundland waters. The female releases eggs that settle to the bottom and adhere to rocks and vegetation. Hatching occurs two to three weeks after fertilization and the larvae drift in surface waters for two to three months before the onset of metamorphosis and settlement to the bottom (Scott and Scott 1988; DFO 2005b).

The winter flounder is fished commercially in some areas of eastern Canada (e.g., NAFO Division 4T in the Gulf of St. Lawrence) for bait and limited food markets (DFO 2005b).

2.4.4 Bioindicators

Cultured blue mussels have been employed by VBNC (LGL) as bioindicators since October 2005, at six locations within Long Harbour. A reference station using blue mussels was set up in May 2006. Stations within Long Harbour provide coverage from the head of the harbour (Sandy Point) to the mouth of the harbour (Shag Rocks). Water depths of the deployed mussels range from six to 17 m (LGL 2007).

The general trend associated with soft tissue chemical loading is for higher concentrations in mussels exposed to the environment in the inner part of Long Harbour than those in the outer harbour. Growth rate and condition index have been highest in the outer Long Harbour mussels. Analyses have been conducted for varying lengths of time (LGL 2007).

As part of the VBNC baseline program, winter flounder were collected at a location between Shag Rocks and Crawley Island in September 2006, and at the reference station located south of the harbour mouth. Winter flounder were used because of their direct contact with the surficial sediment in the benthic habitat. Chemical analyses were conducted on skeletal muscle, liver tissue and kidney tissue, and generally, chemical concentrations were higher in tissues of fish collected within Long Harbour than in those collected at the reference station (LGL 2007).

2.4.5 Fish Species at Risk

The provincial legislation that concerns Species at Risk is the *Endangered Species Act*. Their listing as of October 6, 2006, included no marine fish species. The relevant federal *Species at Risk Act* (*SARA*) Schedule 1 listing includes three wolffish species: *Anarhichas denticulatus, Anarhichas minor* and *Anarhichas lupus*.

Wolffish

While the three wolffish species may occasionally occur in or near the Project Area, they are usually distributed in much deeper water. Northern wolffish and spotted wolffish are listed as *threatened* in Schedule 1 of *SARA*, and the Atlantic wolffish is listed as a species of *special concern*. Of the three species, northern wolffish is the deepest residing species and Atlantic wolffish is the shallowest. Based on DFO trawl surveys in Newfoundland and Labrador waters between 1971 and 2003 (Kulka et al. 2004), northern wolffish were most concentrated during December to May in areas where depths ranged from 500 to 1,000 m, shifting to slightly shallower areas from June to November. Spotted wolffish concentrations were highest in areas with water depths ranging from 200 to 750 m at all times of the year, peaking in 300 m areas from June to November. They were most concentrated in areas with depths approximating 250 m at all times of the year.

Tagging studies have shown that northern wolffish do not migrate long distances and do not form large schools. It is a benthic and bathypelagic predator, preying upon jellyfish, comb jellies, crabs, brittle stars, seastars and sea urchins. Its predators include redfish and Atlantic cod (Scott and Scott 1988).

Tagging studies have shown that spotted wolffish only migrate locally, and do not form schools (DFO 2002b). Spatial analysis of DFO research vessel catch data indicate that abundance declined from the late 1980s to the mid-1990s, with an increase in abundance during two survey seasons since the mid-1990s (Kulka et al. 2003). Its prey includes hard-shelled invertebrates such as crustaceans and molluscs, echinoderms and fish (primarily those discarded by trawlers). The species has few predators, although remains have been found in the stomachs of Atlantic cod, pollock and Greenland shark (Scott and Scott 1988).

There is no evidence that Atlantic wolffish migrate long distances or form schools in Newfoundland waters (DFO 2002b). In the northwest Atlantic, they feed primarily on benthic invertebrates such as echinoderms, molluscs and crustaceans, as well as small amounts of fish. No predators of adult Atlantic wolffish have been identified, but juveniles have been found in the stomachs of Atlantic cod (Scott and Scott 1988).

It is not known with certainty if any of these three wolffish species spawn in the Placentia Bay area, although it is probable given the limited migration of the species. During late fall fertilized eggs are deposited on either a hard bottom or underwater ledge (Scott and Scott 1988), producing larvae that are large (two cm long upon hatching) and semi-pelagic (DFO 2002b).

Both northern and spotted wolffish are incidentally captured in fisheries directed at other commercial species. Incidental capture in the commercial fishery is considered the dominant source of human-induced mortality. Permits, education on live release, and gear modification have been identified as the key issues in ensuring the survival of these fish (DFO 2004).

COSEWIC Listings

It is considered advisable to address the COSEWIC listing as some of these species may attain (or change) the federal and/or provincial legal listings during the life of the Project. An analysis of the COSEWIC listings (August 2006) concluded that relevant changes to *SARA* could include potential inclusion of porbeagle shark (*Lamma nasus*) as endangered, shortfin mako shark (*Isurus oxyrinchus*) as threatened, and American eel (*Anguilla rostrata*) as a special concern.

For legal purposes, the *SARA* establishes Schedule 1 endangered and threatened species as the official list of wildlife species at risk. Species that were designated at risk by COSEWIC prior to October 1999 must be reassessed using revised criteria before they can be considered for addition to Schedule 1 of *SARA*.

Porbeagle Shark

The porbeagle shark was designated as endangered by COSEWIC in May 2004 (COSEWIC 2004). This large cold-temperate coastal and oceanic shark is distributed across the North Atlantic and is known to occur in southern Newfoundland waters during spring and summer (Scott and Scott 1988). The porbeagle shark is typically most common on continental shelves but is also found far from land in ocean basins and occasionally close to shore. It mates within NAFO Subdivision 3Ps during late summer/fall, followed by the release of live young (pups) the following winter (Campana et al. 2001). The pupping occurs outside of Placentia Bay.

Porbeagle sharks are predators of various fish species and cephalopods (Campana et al. 2001). Pelagic species are the primary prey during the spring and summer, followed by a shift to groundfish species in the winter. This prey shift reflects the seasonal change of distribution of porbeagle (i.e., migration to deeper areas in fall and winter) (Campana et al. 2001).

Between March and July 2005, three DFO meetings were held to assess the recovery potential of NAFO Subarea 3-6 porbeagle shark (O'Boyle 2005). DFO (2005c) indicates that porbeagle in the northwest Atlantic can recover if human-induced mortality is sufficiently low. The only sources of human-induced mortality identified in DFO (2005d) are fisheries that capture this shark as bycatch.

Shortfin Mako Shark

The shortfin mako shark was designated as *threatened* by COSEWIC in April 2006. Shortfin makos are distributed circumglobally in all tropical and temperate seas. In Canadian Atlantic waters, it is typically associated with warm water in and near the Gulf Stream. There are no reliable population-level stock assessments available in the northwest Atlantic. Trend information based on declines in bycatch rates in the entire northwest Atlantic suggests that shortfin mako populations may have decreased in the past 15 to 30 years (COSEWIC 2006a).

This is a highly migratory seasonal visitor (late summer and fall) to Canada's Atlantic coast, typically occurring anywhere from surface waters to depths of about 500 m. The life cycle of the shortfin mako is not completely understood. It is ovoviviparous (internal hatching) and likely breeds outside of Canadian waters. Few mature makos have been caught in Canadian waters (COSEWIC 2006a).

American Eel

The status of American eel is discussed in Freshwater Fish, Section 2.3.6.

2.4.6 Marine-related Avifauna

Marine-related birds considered here include raptors, shorebirds, and waterfowl that feed in the tidal zone, as well as birds that live on the ocean. Species known to occur in Placentia Bay are listed in Table 2.14.

Placentia Bay is one of the richest bays in Newfoundland for seabirds. Four seabird colonies are designated as Important Bird Areas (Figure 2.28; Table 2.15). This includes Cape St. Mary's, which supports the largest of three Northern Gannet colonies in Newfoundland and nearly 20 per cent of the Atlantic Canada breeding population. Middle Lawn Island, Burin Peninsula, supports the only known sustainable breeding colony of Manx Shearwaters in North America. Large numbers of Greater and Sooty Shearwaters that breed in the Southern Hemisphere during winter spend part of the summer in Placentia Bay feeding on capelin and other fish while moulting flight feathers. Concentrations of summering shearwaters in eastern Placentia serve as the basis for a 1,675 km^2 area on the east side of Placentia Bay being designated an Important Bird Area (IBA) (www.ibacanada.com). In the winter large aggregations of sea ducks such as Common Eiders, the most northerly wintering distribution of Black Scoters, and the eastern Harlequin Duck are found in parts of Placentia Bay. The eastern population of Harlequin Duck is listed as a species of s*pecial concern* by COSEWIC and *vulnerable* under the *ESA* of Newfoundland and Labrador. There are over 365 islands in Placentia Bay, many of which support small colonies of terns, gulls and Black Guillemots.

Waterfowl

The Canada Goose breeds on open bogs and wetlands throughout much of Newfoundland. During migration, they often stage in shallow tidal areas, and small concentrations probably occur during migration on coastal Placentia Bay. No areas with large (e.g., 100 individuals) concentrations are known for the area. Dabbling ducks (those that tip into the water to feed as opposed to those that dive) that occur in Placentia Bay are similar to the species found throughout Newfoundland. American Black Duck is the most common, a freshwater species that regularly feeds in the tidal zone. During the non-breeding season small numbers are widespread in Placentia Bay where there are sheltered or even

Table 2.14 Seasonal Occurrence of Sea-associated Birds in Placentia Bay

Relative Abundance[1]	Species	Scientific Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Common	Canada Goose	*Branta canadensis*			■	■	■	■	■	■	■	■	■	■
Rare	Gadwall	*Anas strepera*	■	■	■						■	■	■	■
Scarce	American Wigeon	*Anas americana*				■	■				■	■	■	
Common	American Black Duck	*Anas rubripes*	■	■	■	■	■	■	■	■	■	■	■	■
Scarce	Mallard	*Anas platyrhynchos*	■	■	■	■	■				■	■	■	■
Scarce	Blue-winged Teal	*Anas discors*				■	■			■	■	■		
Uncommon	Northern Pintail	*Anas acuta*				■	■	■	■	■	■	■	■	
Common	Green-winged Teal	*Anas crecca*				■	■	■	■	■	■	■	■	■
Uncommon	Ring-necked Duck	*Aythya collaris*				■	■	■	■	■	■	■		
Uncommon	Greater Scaup	*Aythya marila*	■	■	■	■	■					■	■	■
Scarce	Lesser Scaup	*Aythya affinis*				■	■				■	■	■	■
Scarce	King Eider	*Somateria spectabilis*	■	■	■	■	■					■	■	■
Common	Common Eider	*Somateria mollissima*	■	■	■	■	■				■	■	■	■
Scarce	Harlequin Duck	*Histrionicus histrionicus*	■	■	■	■					■	■	■	■
Uncommon	Surf Scoter	*Melanitta perspicillata*	■	■	■	■	■	■	■	■	■	■	■	■
Uncommon	White-winged Scoter	*Melanitta fusca*	■	■	■	■	■	■	■	■	■	■	■	■
Uncommon	Black Scoter	*Melanitta nigra*	■	■	■	■					■	■	■	■
Common	Long-tailed Duck	*Clangula hyemalis*	■	■	■	■						■	■	■
Scarce	Bufflehead	*Bucephala albeola*	■	■	■	■						■	■	■
Uncommon	Common Goldeneye	*Bucephala clangula*	■	■	■	■	■	■	■	■	■	■	■	■
Rare	Barrow's Goldeneye	*Bucephala islandica*											■	■
Rare	Hooded Merganser	*Lophodytes cucullatus*										■	■	■
Uncommon	Common Merganser	*Mergus merganser*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Red-breasted Merganser	*Mergus serrator*	■	■	■	■	■	■	■	■	■	■	■	■
Uncommon	Red-throated Loon	*Gavia stellata*									■	■	■	■
Common	Common Loon	*Gavia immer*	■	■	■	■	■	■	■	■	■	■	■	■
Scarce	Horned Grebe	*Podiceps auritus*	■	■	■							■	■	■
Uncommon	Red-necked Grebe	*Podiceps grisegena*	■	■	■	■						■	■	■
Common	Northern Fulmar	*Fulmarus glacialis*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Greater Shearwater	*Puffinus gravis*					■	■	■	■	■	■		
Common	Sooty Shearwater	*Puffinus griseus*					■	■	■	■	■	■		
Uncommon	Manx Shearwater	*Puffinus puffinus*					■	■	■	■	■	■		
Scarce	Wilson's Storm-Petrel	*Oceanites oceanicus*						■	■	■	■			

Relative Abundance[1]	Species	Scientific Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Common	Leach's Storm-Petrel	*Oceanodroma leucorhoa*												
Common	Northern Gannet	*Morus bassanus*												
Common	Double-crested Cormorant	*Phalacrocorax auritus*												
Common	Great Cormorant	*Phalacrocorax carbo*												
Uncommon	American Bittern	*Botaurus lentiginosus*												
Rare	Great Blue Heron	*Ardea herodias*												
Common	Osprey	*Pandion haliaetus*												
Common	Bald Eagle	*Haliaeetus leucocephalus*												
Uncommon	Black-bellied Plover	*Pluvialis squatarola*												
Uncommon	American Golden-Plover	*Pluvialis dominica*												
Common	Semipalmated Plover	*Charadrius semipalmatus*												
Common	Spotted Sandpiper	*Actitis macularius*												
Scarce	Solitary Sandpiper	*Tringa solitaria*												
Common	Greater Yellowlegs	*Tringa melanoleuca*												
Scarce	Lesser Yellowlegs	*Tringa flavipes*												
Common	Whimbrel	*Numenius phaeopus*												
Scarce	Hudsonian Godwit	*Limosa haemastica*												
Common	Ruddy Turnstone	*Arenaria interpres*												
Scarce	Red Knot	*Calidris canutus*												
Uncommon	Sanderling	*Calidris alba*												
Common	Semipalmated Sandpiper	*Calidris pusilla*												
Common	Least Sandpiper	*Calidris minutilla*												
Common	White-rumped Sandpiper	*Calidris fuscicollis*												
Rare	Baird's Sandpiper	*Calidris bairdii*												
Uncommon	Pectoral Sandpiper	*Calidris melanotos*												
Common	Purple Sandpiper	*Calidris maritima*												
Uncommon	Dunlin	*Calidris alpina*												
Uncommon	Short-billed Dowitcher	*Limnodromus griseus*												
Common	Wilson's Snipe	*Gallinago delicata*												
Uncommon	Red-necked Phalarope	*Phalaropus lobatus*												
Uncommon	Red Phalarope	*Phalaropus fulicarius*												
Uncommon	Black-headed Gull	*Larus ridibundus*												
Scarce	Bonaparte's Gull	*Larus philadelphia*												
Rare	Mew Gull	*Larus canus*												
Common	Ring-billed Gull	*Larus delawarensis*												

Relative Abundance[1]	Species	Scientific Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Common	Herring Gull	*Larus argentatus*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Iceland Gull	*Larus glaucoides*	■	■	■	■	■					■	■	■
Scarce	Lesser Black-backed Gull	*Larus fuscus*	■	■	■	■					■	■	■	■
Uncommon	Glaucous Gull	*Larus hyperboreus*	■	■	■	■						■	■	■
Common	Great Black-backed Gull	*Larus marinus*	■	■	■	■	■	■	■	■	■	■	■	■
Rare	Sabine's Gull	*Xema sabini*							■	■	■			
Common	Black-legged Kittiwake	*Rissa tridactyla*	■	■	■	■	■	■	■	■	■	■	■	■
Rare	Caspian Tern	*Hydroprogne caspia*				■	■			■	■			
Common	Common Tern	*Sterna hirundo*					■	■	■	■	■			
Common	Arctic Tern	*Sterna paradisaea*					■	■	■	■	■			
Scarce	Great Skua	*Stercorarius skua*					■	■	■	■	■	■		
Scarce	South Polar Skua	*Stercorarius maccormicki*					■	■	■	■	■	■		
Uncommon	Pomarine Jaeger	*Stercorarius pomarinus*					■	■	■	■	■	■		
Uncommon	Parasitic Jaeger	*Stercorarius parasiticus*					■	■	■	■	■	■		
Scarce	Long-tailed Jaeger	*Stercorarius longicaudus*					■	■	■	■	■			
Common	Dovekie	*Alle alle*	■	■	■	■						■	■	■
Common	Common Murre	*Uria aalge*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Thick-billed Murre	*Uria lomvia*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Razorbill	*Alca torda*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Black Guillemot	*Cepphus grylle*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Atlantic Puffin	*Fratercula arctica*	■	■	■	■	■	■	■	■	■	■	■	■
Uncommon	Belted Kingfisher	*Megaceryle alcyon*	■	■	■	■	■	■	■	■	■	■	■	■
Common	American Crow	*Corvus brachyrhynchos*	■	■	■	■	■	■	■	■	■	■	■	■
Common	Common Raven	*Corvus corax*	■	■	■	■	■	■	■	■	■	■	■	■

Notes: The shaded areas indicate months of occurrence in Placentia Bay.
[1]Relative Abundance derived from various sources published and unpublished. The status given is only an indication of relative abundance and can not be used quantitatively. The abundance code refers to some or all of the shaded months but may be less numerous in some months and may occasionally occur in the non-shaded months. Common: usually present in moderate to high numbers in appropriate habitat. Uncommon: present regularly in small numbers. Scarce: present irregularly in small numbers. Rare: occasionally present, may be absent.

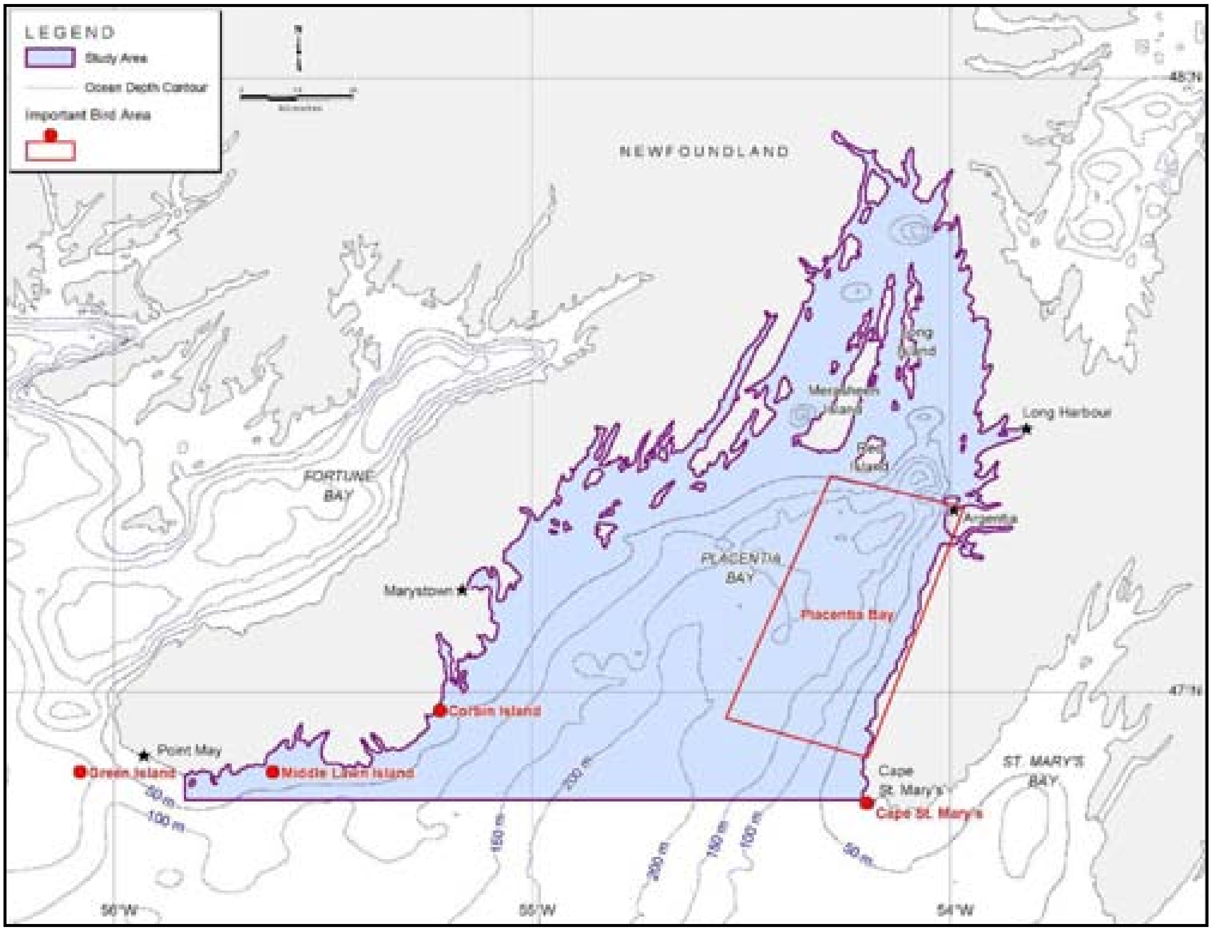

Figure 2.28 Important Bird Areas of Placentia Bay

Table 2.15 Colonies and Populations Designated as Important Bird Areas in Placentia Bay

Species	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island
Northern Fulmar	12[a]	-	-	-
Manx Shearwater	-	11[b]	-	-
Leach's Storm-Petrel	-	13,879[b]	100,000[b]	65,280[d]
Northern Gannet	12,156[c]	-	-	-
Herring Gull	Present[b]	20[b]	5,000[b]	-
Great Black-backed Gull	Present[b]	6[b]	25[b]	-
Black-legged Kittiwake	10,000[b]	-	50[b]	-
Common Murre	10,000[b]	-	-	
Thick-billed Murre	1,000[b]	-	-	-
Razorbill	100[b]	-	-	-
Black Guillemot	Present[b]	-	-	-
TOTALS	**33,268**	**13,916**	**105,075**	**65,280**

Sources:
[a] Stenhouse and Montevecchi (1999).
[b] Cairns et al. (1989).
[c] Chardine (2000).
[d] Robertson et al. (2002).

semi-sheltered tidal coves. Concentrations of more than 50 are known to occur on Harbour Island at the entrance to Long Harbour during fall migration (A. Murphy, pers. comm.). The largest concentration occurs at Arnold's Cove. Since protection from hunting was enforced in the late 1980s, concentrations have peaked at 300+ individuals in fall and winter. There were just two observations of American Black Ducks, three individuals each, from inner Long Harbour during the 2006 marine surveys (LGL 2007). However, a group of 24 to 26 was observed in March 2006 by the terrestrial survey crew. [A follow-up survey for waterfowl broods by VBNC on August 1, 2007, failed to find any in the Project Area.] Small numbers of Mallard, Northern Pintail, and Green-winged Teal are also found in tidal flats around Placentia Bay in season. A Gadwall observed on Harbour Island at the mouth of Long Harbour on June 13 was a rare sighting for the province.

Common Eider is the most abundant diving duck in Placentia Bay. Two subspecies occur in Atlantic Canada. The northern subspecies *Somateria mollissima borealis* breeds in the eastern Arctic south to the mid-Labrador coast and winters south to Newfoundland and the Gulf of St. Lawrence (Goudie et al. 2000). The southern subspecies *S. m. dresseri* breeds from the mid-Labrador coast south to Massachusetts, wintering in Newfoundland and the Gulf of St. Lawrence south to Massachusetts (Goudie et al. 2000). Common Eider is mainly a wintering species in Placentia Bay, occurring October to May with peak numbers from November to April. Large numbers winter at Cape St. Mary's, where a winter study of sea ducks in 1978-79 showed a peak mean of 4,593 during the period January 4-24 (Goudie 1981). Christmas bird count totals for the period 1997 to 2006 ranged from 1,999 to 3,198 with an average of 2,613 (http://www.audubon.org/bird/cbc/hr/). One to two thousand individuals winter by the Virgin Rocks and along a 10-km stretch of the east coast of Placentia Bay from Great Barasway to Gooseberry Cove. A winter eider survey of eastern North America, conducted in 2006 by the Sea Duck Joint Venture under the North American Waterfowl Management Plan, and summarized by one-half-degree blocks of longitude and latitude, show 530 to 1,140 males per block off St. Mary's Bay and 1,140 to 2,500 males per block around Saint-Pierre et Miquelon (S. Gilliland, CWS, unpubl.). Blocks within Placentia Bay ranged between 0 to 90 and 90 to 530 males per block. The block with the highest concentration of eiders within Placentia Bay was mid-way along the Burin Peninsula in the vicinity of Oderin, Flat and Jude islands, where flocks of up to 500 are known to occur (S. Gilliland, pers. comm.).

The Harlequin Duck is considered *special concern* under the *SARA*. All three species of scoter (White-winged, Surf, and Black Scoter) migrate through Placentia Bay and winter in small numbers. Cape St. Mary's harbours the largest known wintering flock of Black Scoters in Newfoundland, with Christmas Bird Count totals in the ten-year period 1997 to 2006 ranging from 25 to 112 individuals, with an average of 61 (http://www.audubon.org/bird/cbc/hr/). The Long-tailed Duck is a ubiquitous winter sea duck in ice-free coastal waters of Newfoundland. The Cape St. Mary's Christmas Bird Count totals in the same ten-year period (1997 to 2006) ranged from 116 to 365 individuals, with an average of 227 (http://www.audubon.org/bird/cbc/hr/). Long-tailed Ducks probably winter throughout coastal Placentia Bay, typically in flocks of five to 50+ birds.

The Ring-necked Duck is a common Newfoundland breeding species with a preference for fresh water. Small numbers probably occur in Placentia Bay in shallow protected coves during spring and fall migration. Greater Scaup is an uncommon Newfoundland breeding species but occurs more commonly as a migrant and winterer, freely using both salt water and fresh water. Traditional wintering flocks in Newfoundland tend to be local. At present, no wintering flocks are known from Placentia Bay, but the potential for their occurrence is high. Small numbers are expected to be encountered during migration and in winter in Placentia Bay.

Common Goldeneye is a widespread locally common resident duck in Newfoundland, nesting on lakes and rivers, wintering mainly in tidal estuaries and shallow bays. Goldeneyes are known to winter in the brackish water at Swift Current and likely winter regularly where other larger rivers empty into the ocean. Barrow's Goldeneye is considered a species of *special concern* under the *SARA*. It is rarely observed in Placentia Bay. The only known observation of the species is an adult male and female at Arnold's Cove estuary November 30, 1993 (B. Mactavish, LGL, pers. comm.). Bufflehead is a scarce migrant and wintering bird in Newfoundland. It often associates with the Common Goldeneye in the non-breeding season and probably occurs in very small numbers with wintering Common Goldeneye in Placentia Bay.

Common Merganser is a year-round resident in Newfoundland, breeding on rivers and large lakes and wintering where fast-moving fresh water does not freeze or in brackish water estuaries where larger rivers enter the ocean; it is probably regular in small numbers in Placentia Bay. Red-breasted Merganser breeds on large lakes, rivers and tidal estuaries in Newfoundland, wintering on salt water close to shore, usually in broad shallow coves and tidal estuaries. The Cape St. Mary's Christmas Bird Count totals in the ten-year period 1997 to 2006 ranged from 27 to 67 individuals, with an average of 49 (http://www.audubon.org/bird/cbc/hr/). Red-breasted Merganser is fairly common during the winter in suitable habitat in Placentia Bay.

Loons, Grebes, and Cormorants

The Red-throated and Common Loons are the two typical loon species in Newfoundland waters. Red-throated Loon is an uncommon spring and fall migrant, and a scarce wintering bird in coastal waters. Small numbers can be expected in Placentia Bay, mainly during the fall migration, September to November. Small numbers winter on the south coast of Newfoundland; Cape St. Mary's Christmas bird counts from 1996 to 2005 recorded Red-throated Loon in four years, with a maximum of three in 1997. The Common Loon is a widespread breeder in Newfoundland and is common in ice-free coastal waters throughout the year. Sub-adults remain in salt water throughout the year. In summer the adults breed on lakes within commuting distance of the coastal areas for feeding. Cape St. Mary's Christmas bird counts from 1996 to 2005 recorded an average of 16.3 per year and a maximum of 42 in 2002. The Common Loon is expected to be relatively common in coastal Placentia Bay year-round.

Grebes occur in smaller numbers than loons. In Canada, Horned Grebe and Red-necked Grebe breed in a variety of wetland habitats from British Columbia east to Ontario. Both species winter largely on salt water. Horned Grebe is rare in Newfoundland, with at least one recorded at Cape St. Mary's in December 1998. Red-necked Grebe occurs in small numbers during the non-breeding season, October to April, in ice-free bays and inlets. Christmas bird counts at Cape St. Mary's from 1996 to 2005 recorded one to 11 individuals per year and an average of 2.3.

Both Great and Double-crested Cormorants breed in Newfoundland. Great Cormorant is a year-round resident and the Double-crested is present from late April to October. Both species nest in Placentia Bay. The population of breeding cormorants in Newfoundland is poorly known. The number of breeding pairs of Great Cormorant prior to 1989 was 160 pairs (Cairns et al. 1989). Only 19 pairs were known to nest in Placentia Bay, in the Cape St. Mary's Ecological Reserve; however, it is thought that breeding numbers have increased on the east side of the bay. Great Cormorants winter in Placentia Bay. At least 261 pairs of Double-crested Cormorants breed in Newfoundland; this number is based on an incomplete tally of breeding colonies (Cairns et al. 1989). A colony north of Grand Barasway contained 29 pairs in 1988 (Cairns et al. 1989). Populations have probably grown in eastern Newfoundland in recent years. During an aerial survey for colonial nesting birds (mainly terns and gulls) conducted in Placentia Bay June 25-27, 2005, CWS found seven Double-crested Cormorant colonies; five colonies ranged in size from 11 to 100 individuals and two colonies from 101 to 500 (P. Thomas, CWS, pers. comm.). An aerial survey for nesting Bald Eagles on the east coast of Placentia Bay on June 7, 2006, conducted by LGL recorded incidental sightings of colonial species. Five cormorant breeding colonies and a cormorant roost site were recorded (Table 2.16).

Table 2.16 Possible Cormorant Nesting Colonies Observed during Aerial Surveys for Bald Eagle June 7, 2006

Location	Coordinates	Cormorant Sightings
Freshwater Cove, Jerseyside	N47 15.015 W53 59.622	25+ cormorants, probably roost site
2.0 km north of Little Barasway	N47 11.807 W54 02.491	30-50+ cormorants at breeding colony
2.5 km north of Great Barasway	N47 08.893 W54 03.895	20+ cormorants at breeding colony
0.5 km north of Angels Cove	N47 08.893 W54 03.895	100+ cormorants (some or all Great Cormorants) breeding colony
1.0 km north of Cuslett	N46 58.252 W54 10.121	25+ Great Cormorants breeding colony

Fulmar, Shearwaters, Storm-Petrels, and Gannets

The Northern Fulmar has a circumpolar distribution, breeding in the north Pacific, Arctic and the North Atlantic oceans. The centre of breeding abundance in the North Atlantic is the Canadian Arctic, Greenland, Iceland, and northeast Europe and Scandinavia. It is a common year-round resident in eastern Newfoundland waters south of the pack ice. Only about 100 pairs breed in eastern Newfoundland (Lock et al. 1994; Stenhouse and Montevecchi 1999). Twelve pairs held nest sites at Cape St. Mary's in 1999 (Stenhouse and Montevecchi 1999). The summer populations off eastern Newfoundland are thought to be composed of sub-adults from northern breeding colonies. Banding records show that Northern Fulmars from breeding colonies in the Canadian Arctic, Greenland and the British Isles regularly occur in Newfoundland waters (Brown 1986; Lock et al. 1994), although it is probably scarce to common in the outer reaches of Placentia Bay throughout the year. Winter storms are known to shift hundreds of individuals temporarily into Placentia Bay. Counts of 1,619 and 330 were observed flying south past Cross Point, St. Bride's, the morning after southeast gales during annual Christmas bird counts in December 1999 and 2006 (http://www.audubon.org/bird/cbc/hr/). The birds were thought to have been displaced by the southeast winds overnight and during the first light of day corrected their position by flying back out to the open ocean (B. Mactavish, LGL, pers. comm.).

Greater Shearwaters nest on the island of Tristan de Cunha in the South Atlantic from November to March. Most of the world population of five to ten million summer in the North Atlantic (Lock et al. 1994). The Grand Banks are thought to be the main summering area for a significant portion of the population (Lock et al. 1994). The Sooty Shearwater also breeds in the Southern Hemisphere from November to March. A large percentage of the population migrates to the Northern Hemisphere and is present from April to October. It is a common bird during the summer months off Atlantic Canada north to Labrador but is usually outnumbered by the Greater Shearwater, with which it often associates. Concentrations of 100,000, mostly Greater with some Sooty Shearwaters, have been observed on the east side of Placentia Bay in June. Such observations are the basis for an area on the east side of Placentia Bay being designated an IBA (Figure 2.28). Shearwaters moult their flight feathers in June and July, when they spend considerable time in flocks resting on the water. Their diet is small fish and crustaceans. Large numbers of shearwaters are attracted to the southern Avalon Peninsula during the capelin spawning season. The numbers using Placentia Bay during the summer are not known, but are probably in the hundreds of thousands, with the largest numbers occurring during the capelin spawning season, mid-June to end of July.

The Manx Shearwater is the smallest regularly occurring shearwater species in Newfoundland. Most of the world population breeds on islands in northwest Europe (Iceland, Scotland, Ireland, England and France), the Azores and the Canary Islands. It winters in the southwest Atlantic off eastern South America (Lee and Haney 1996). It is an uncommon species in Atlantic Canada from April to October, with most of the birds thought to be sub-adults from European breeding colonies. The only known established breeding colony in the northwest Atlantic is at Middle Lawn Island on the Burin Peninsula. Breeding was first confirmed in 1977. The breeding population has been estimated as high as 100 pairs, based on the number of burrows and adults present; however, it was later determined that most of the birds appeared to be prospecting nesting sites without actually laying eggs. In 1981, 13 burrows contained eggs with an estimated 360 birds attending the colony (Storey and Lien 1985 *in* Robertson 2002). The low rate of breeding indicates the colony was in the early stages of development. In 2000, a thorough survey of nesting revealed only two burrows with an egg plus nine other burrows that were deemed active (Robertson 2002). In 2001, an estimated 100 Manx Shearwaters were present at Middle Lawn Island (Robertson 2002). That the breeding colony is struggling to maintain an existence is indicated by the consistent low rate of breeding relative to the number of birds in attendance from 1981 to 2001, the decline in numbers of eggs in burrows from 1981 to 2000, and fewer birds.

Wilson's Storm-Petrel breeds on islands in the South Atlantic Ocean, including the Antarctic and Subantarctic, from December to March. In the non-breeding season, they migrate to the Northern Hemisphere. The northern limit of their range is Nova Scotia and southern Newfoundland (Brown

1986; Godfrey 1986). They are generally considered scarce in Newfoundland waters. Small numbers probably occur annually in the outer reaches of Placentia Bay.

Leach's Storm-Petrel is a widespread and abundant species occurring in both the Atlantic and Pacific oceans. In the Atlantic it breeds in northwest Europe (Iceland, Scotland, and Norway) and in North America from southeast Labrador to Massachusetts (Huntington et al. 1996). The centre of breeding abundance in the North Atlantic is Newfoundland. There are several large colonies on the east coast, including the largest colony in the world at Baccalieu Island (3.3 million pairs). Three significant breeding colonies are located on the southern Burin Peninsula: Middle Lawn Island with 26, 313 pairs, Corbin Island with 100,000 pairs and Green Island with 72,000 pairs (Cairns et al. 1989). Leach's Storm-Petrels are common and widespread at sea. They visit nesting colonies at night to avoid predators, mainly gulls, and do not normally occur within sight of land during daylight hours. They are probably regular in moderate numbers in the outer parts of Placentia Bay from April to early November.

The Northern Gannet breeds in the North Atlantic in eastern Canada, Iceland, The Faeroe Islands, and The British Isles, and it winters along the coast from New Jersey to Florida and The British Isles to the Azores. Three of the five major colonies in North America are located at Cape St. Mary's, Baccalieu Island, and Funk Island. In 1999, there were 12,156 pairs of adults at Cape St. Mary's (Chardine 2000), representing 51.3 per cent of the Newfoundland breeding population, 19.9 per cent of the Canadian breeding population (Chardine 2000) and 3.1 per cent of the world population. Gannets feed by plunge-diving from the air. Their food is mainly small to medium-size fish and squid over shelf waters; they usually avoid deep water beyond the continental slope. They feed extensively in Placentia Bay and follow spawning herring and capelin schools to the head of the bay at Arnold's Cove and the entrance to Long Harbour. They are common in the bay from late March to mid-November, with a few individuals remaining until early December.

Shorebirds

Many species of shorebird occur in Placentia Bay, most of them Arctic or sub-Arctic breeders that migrate through Placentia Bay in the fall. Spring migration routes are mainly west of Newfoundland. Shallow tidal flats, estuaries and kelp piles on beaches offer the best feeding opportunities for shorebirds. Newfoundland breeding species, including Spotted Sandpiper, Greater Yellowlegs, and Least Sandpiper, occur commonly during spring and fall migration but only the Spotted Sandpiper breeds in coastal terrain, e.g., grassy areas above highest tide line. The most numerous species of migrant shorebirds in Placentia Bay are Black-bellied Plover, Semipalmated Plover, Greater Yellowlegs, Ruddy Turnstone, Sanderling, Semipalmated Sandpiper, Least Sandpiper, White-rumped Sandpiper, Pectoral Sandpiper, and Short-billed Dowitcher. There are no outstanding locations for migrant shorebirds in Placentia Bay. Arnold's Cove contains tidal flats that attract up to 100 individuals during peak days in August and September, with Greater Yellowlegs, Semipalmated Plovers, Semipalmated Sandpipers and White-rumped Sandpipers being the dominant species.

The Purple Sandpiper is the only shorebird species to overwinter in Placentia Bay. Another Arctic breeder, the species lives along rocky shorelines of high energy such as points, islands, and rocky islets. The number that winters in Placentia Bay is unknown. The Purple Sandpiper was recorded for nine of ten Cape St. Mary's Christmas bird counts, 1996 to 2005. Numbers ranged from two to 61, with an average of 27.3 per year.

Both Red and Red-necked Phalaropes migrate through Newfoundland offshore waters en route between their wintering area in the south Atlantic and their Arctic and sub-Arctic breeding grounds. Phalaropes are known to congregate in areas of upwelling and convergence, particularly along the continental slope. Both species have been recorded in Placentia Bay, but there are few data on their abundance. In fall, the Red-necked Phalarope generally migrates earlier than Red Phalarope, with peak fall migration in August and September, while Red Phalarope migrations extend into October.

Gulls, Terns, Skuas, and Jaegers

At least eleven species of gulls are likely to occur annually in Placentia Bay. Black-headed, Mew and Lesser Black-backed are European species that regularly migrate in small numbers to Atlantic Canada in the non-breeding season. The Black-headed is the most numerous of these European species; groups of up to 50 occur on the tidal flats at Arnolds Cove in fall, winter, and spring, and small numbers occur in harbours and estuaries throughout eastern Newfoundland, including Placentia Bay, from October to April. Iceland and Glaucous Gulls breed in the sub-Arctic and Arctic, and winter in eastern Canada including Newfoundland. The Iceland Gull is more numerous than the Glaucous, but both species can be expected anywhere in the bay from October to April. The Ring-billed Gull is a common breeder in Atlantic Canada with large breeding colonies on Crawley Island in Long Harbour and on Goose Island, two kilometres southeast of Arnold's Cove. The Crawley Island colony contained 992 active nests in 2005 (G. Robertson, CWS, pers. comm.). In 2006, this colony was disrupted by an unknown predator during egg-laying period in late May, but the colony relocated farther into Long Harbour and successfully produced many fledglings (LGL 2007). Goose Island contained 304 active nests in 2005 (G. Robertson, CWS, pers. comm.). Other colonies are known from the Burin Peninsula, including 518 pairs at Woody Island, and 800 pairs at Spanish Room Point. (Cairns et al. 1989). Ring-billed Gulls are present in Placentia Bay from April to October. Herring and Great Black-backed Gulls are common year-round residents south of the pack ice in Atlantic Canada. In Placentia Bay, they are both common year-round, breeding in many locations throughout the bay. The VBNC survey for breeding birds on islands at the entrance to Long Harbour on June 13, 2006, found Herring and Great Black-backed Gulls breeding on Harbour Island, North Green Island, and Hole-in-the-Wall Island. Harbour Island held the largest number of breeding gulls, with a minimum of 215 Herring Gull Nests and 11 Great Black-backed Gull nests (LGL 2007). Aerial surveys of colonial nesting birds in Placentia Bay by CWS in 2005 resulted in the location of 51 Herring Gull and 38 Great Black-backed Gull nesting colonies (P. Thomas, CWS, pers. comm.). Herring Gull colony sizes ranged from one to 500+ individuals, with 20 colonies falling in the range of 11 to 100 individuals and 15 in the range of 101 to 500. For Great Black-backed Gull, colony size ranged from one to 500, with seventeen colonies in the range of one to 10 individuals, 18 in the range of 11 to 100 individuals and two in the 101 to 500 range. Both Herring and Great Black-backed Gulls are common through the winter season in Placentia Bay.

The Black-legged Kittiwake is a true sea gull in that it spends all its life at sea, coming to land only to nest. An abundant breeding species in eastern Newfoundland and the Canadian Arctic, they nest in colonies on sea cliffs and rocky islands. Approximately 10,000 pairs nest at Cape St. Mary's (Cairns et al. 1989), accounting for 12 per cent of the total Newfoundland breeding population. An isolated breeding colony at Goose Island, two km southeast of Arnold's Cove, contained 788 nests in 2005 (G. Robertson, CWS, pers. comm.). The Black-legged Kittiwake is present in Newfoundland waters south of the pack ice throughout the year. In the non-breeding season it is probably regular in the outer reaches of Placentia Bay.

Common and Arctic Terns are the only species of tern that occur regularly in Placentia Bay. Common Terns breed throughout Atlantic Canada and north to mid-Labrador, inland as well as in coastal areas, and winter in the southern United States and southward. The Arctic Tern is more coastal and breeds farther north (to the high Arctic), wintering at sea south to the Antarctic. Both species are present in Newfoundland waters from late May to early September, often nest in mixed colonies. A June 13, 2006, survey for breeding birds on islands in the outer reaches of Long Harbour found both species of tern nesting (LGL 2007). Sixty-five nests on Harbour Island were calculated to be 55 Common and 10 Arctic Terns, judging by the ratio of adults present. Twenty-eight active Common Tern nests were found on Crawley Island, despite predator activity destroying many Ring-billed Gulls nests and some tern nests. This was an increase from 11 nests found during a ground search in June 2005 (G. Robertson, CWS, pers. comm.). Aerial surveys of colonial nesting birds in Placentia Bay by CWS in 2005 resulted in the location of 22 tern colonies ranging in size from 10 to 350 individuals, with six >100 individuals (P. Thomas, CWS, pers. comm.).

The Great Skua and South Polar Skua are very uncommon seabirds in eastern Canadian waters. The Great Skua breeds in the northeast Atlantic Ocean in Iceland, The Faeroes and Iceland, and winters farther south but remains north of the equator. In Atlantic Canada, it is a summer visitor and a spring and fall migrant. The South Polar Skua breeds in the Southern Hemisphere on Antarctic islands from December to March. Part of the population migrates to the North Atlantic during May to October. Both species have been recorded in Placentia Bay in the summer. They are likely regular in small numbers in the outer reaches of Placentia Bay from May to October.

There are three species of jaeger: Pomarine, Parasitic and Long-tailed. All three are circumpolar, breeding in the low and high Arctic and wintering at sea in the mid- to south Atlantic. Adults of the three species migrate through Newfoundland waters during spring and fall. Sub-adult birds spend the summer south of the breeding range, including Newfoundland waters. Jaegers are kleptoparasites, meaning that they are predatory in feeding actions by forcing other seabirds to disgorge the contents of their stomach through persistent pursuit. As with most predators, numbers are relatively low compared to the seabirds that are their targets, e.g., Black-legged Kittiwakes and terns. In Placentia Bay, jaegers are expected to be scarce to uncommon in the middle and outer portions of the bay between May and October.

Dovekie, Murres, Razorbill, Puffin, and Guillemots

The Dovekie breeds in the North Atlantic, mainly in Greenland and east Novaya Zemlya, Jan Mayen and Franz Josef Land in northern Russia and winters at sea south to 35°N. This is a very abundant bird, with a world population estimated at 30 million (Brown 1986). A large percentage of the Greenland-breeding Dovekies winter in the western Atlantic, mainly off Newfoundland (Brown 1986). They can be common in Placentia Bay from October to April.

The Common Murre breeds in the North Pacific and North Atlantic Oceans. In the Atlantic it breeds in northern Europe, including Iceland and Greenland, and in the western Atlantic from Labrador to Nova Scotia. It is an abundant breeder in eastern Newfoundland with nearly half a million pairs; 80 per cent of those are on Funk Island. Cape St. Mary's holds 10,000 breeding pairs or about two per cent of the Newfoundland breeding populations. Common Murres include capelin as part of their diet and will following spawning schools far into Placentia Bay during the summer, although they typically feed offshore. From March to July they can be common in Placentia Bay, depending partly on food availability, and during fall migration and in winter it is expected to be scarce to uncommon.

Thick-billed Murres breed from the sub-Arctic to the Arctic in North America and Eurasia. In Atlantic Canada they breed as far south as Newfoundland, wintering in open water within the breeding range and in the northwest Atlantic south to New Jersey. The Thick-billed Murre is the winter murre in eastern Newfoundland. Many of the more than two million Arctic Canada and Greenland breeders winter in Newfoundland and Labrador waters. The Grand Banks have been identified as important wintering areas (Brown 1986; Lock et al. 1994). Relatively small numbers (~2,000) breed in eastern Newfoundland, about half at Cape St. Mary's. This is the main species taken during the traditional winter murre hunt in Newfoundland. Hunters from Long Harbour usually have to go to well outside the Iona Island group (N. Fowler, pers. comm.). January and February are the best months for hunting, but numbers vary from year to year. The kill has been low in recent years (N. Fowler, pers. comm.). The Thick-billed Murre is expected to be scarce to common in Placentia Bay throughout the year, but most numerous in winter.

The Razorbill breeds in the North Atlantic from Maine, eastern Canada, Greenland and Iceland to Great Britain and winters south to North Carolina and France. Razorbills are relatively scarce compared to murres. Most of the 38,000 pairs breeding in Atlantic Canada are in St. Lawrence estuary (Quebec) and southeastern Labrador (Chapdelaine et al. 2001). About 900 pairs breed on the Avalon Peninsula, including about 100 pairs at Cape St. Mary's. They are expected to be scarce in Placentia Bay throughout the year and least common in winter.

The Black Guillemot is ubiquitous along open coastlines of Newfoundland. Newfoundland breeders are augmented by migrants from the Arctic in fall and winter. They usually feed within 2 km of shore.

Breeding numbers are difficult to determine because their breeding sites in crevices and under rocks are difficult to detect. They are expected to be fairly common year-round near shore around the entire coastline of Placentia Bay, including all the islands.

The Atlantic Puffin breeds in the North Atlantic in Maine, Nova Scotia, Newfoundland and Labrador, Greenland, Iceland, and northwest Europe. They are abundant in the North Atlantic with about twelve million pairs (Brown 1986). The number of Atlantic Puffin nesting in Atlantic Canada is between 350,000 and 400,000, of which at least two-thirds nest on the Avalon Peninsula (Rodway et al. 2003; Robertson et al. 2004). Puffins do not breed at Cape St. Mary's. Grand Colombier in Saint-Pierre et Miquelon, with 400 breeding pairs of puffins, is the only breeding colony near Placentia Bay. In North America they are thought to winter from southern Newfoundland to southern Nova Scotia. The Atlantic Puffin occurs in Placentia Bay during migration and in small numbers in summer and probably in winter.

Raptors - Bald Eagle and Osprey

The head of Placentia Bay supports one of the highest densities of nesting Bald Eagles in eastern North America (Dominguez 1999). Significant numbers are also present during the non-nesting season.

The population in Placentia Bay had not been studied prior to industrialization of the inner bay. This area contains 20 to 30 active nests or a breeding concentration at 0.1 occupied nests per km of shoreline (J. Brazil, Wildlife Division, pers. comm.) and exhibits stable reproductive performance (Dominguez 1999). The coastal population is thought to be relatively stable (J. Brazil, pers. comm.) although there is no published information to support this assumption. A population estimate of 125 (including immatures) and 30 nests was provided by the Provincial Wildlife Division for Placentia Bay. Information on other areas of the archipelago and home range of these birds is much more limited or nonexistent.

VBNC augmented information on Bald Eagles collected by the Wildlife Division on their designated survey plots on Long Island, Merasheen Island, Ragged Island, and a section of adjacent western Placentia Bay in 2006 (Goudie and Mactavish 2007). An aerial survey expanded coverage for nesting eagles to the eastern side of Placentia Bay, from Come By Chance to Northern Head near Cape St. Mary's (Figure 2.29).

Long Harbour is an important area for Bald Eagles and relatively large numbers were recorded there, especially in spring during the herring spawn at Rattling Brook Cove and to the north of Rattling Brook Point. By May, these concentrations were more dispersed, and eagles were more evenly distributed throughout all areas investigated. Some high nesting densities were noted in Placentia Bay, and in one case two active nests were only 100 m apart. The availability of herring in spring is likely an important high-energy supplement to the diet of eagles; it could ensure adults attain optimal body condition for nesting. The lack of historical coverage of areas surveyed by LGL precluded comparisons to previous survey numbers.

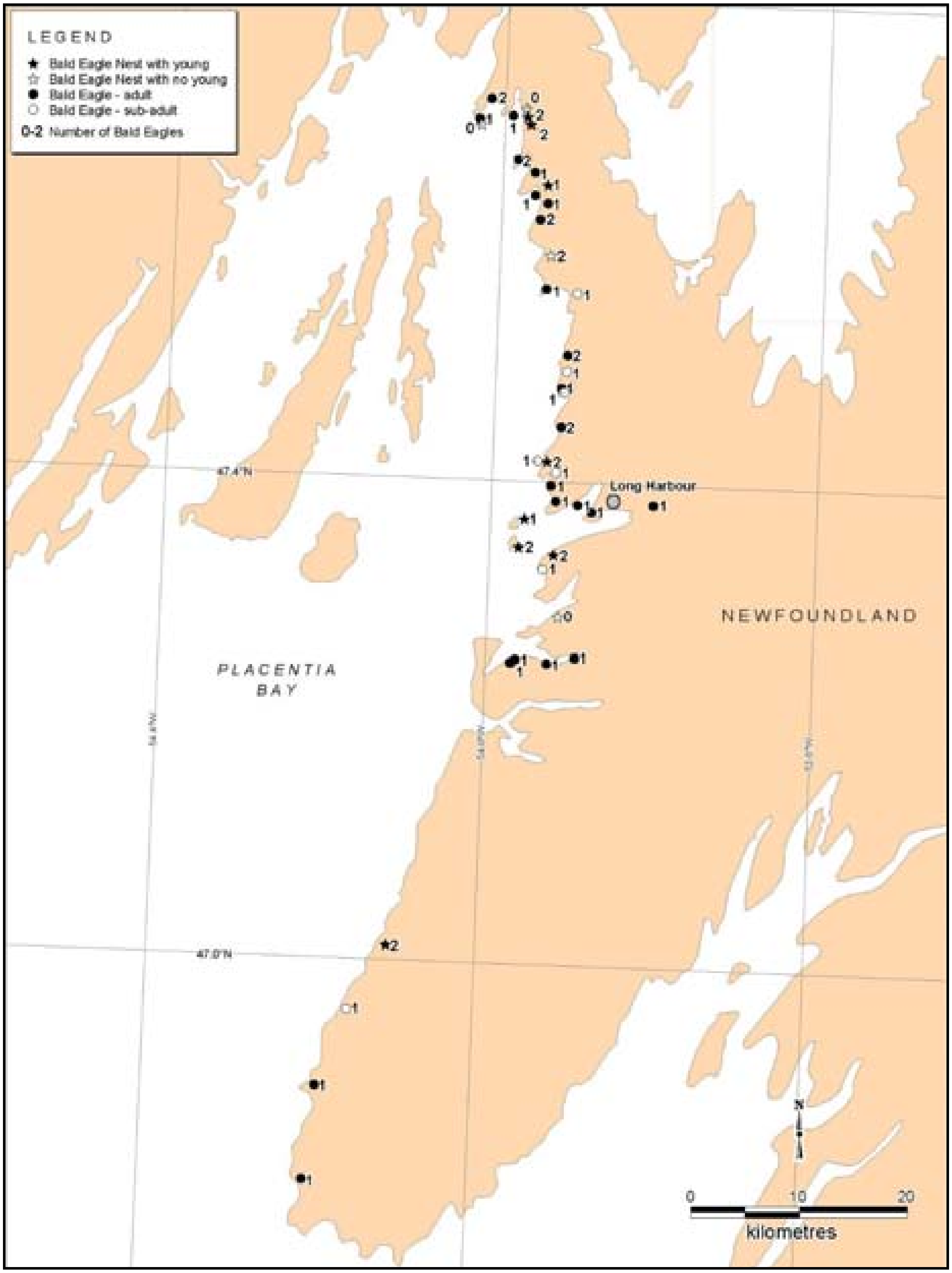

Figure 2.29 Aerial Survey for Nesting Bald Eagles on June 7, 2006

When combined with the Wildlife Division 2006 survey, the results present a fairly complete overview of Bald Eagles nesting in the inner and eastern reaches of Placentia Bay in 2006. It is not fully known how far they range in search of food, although they have been observed between Merasheen Island and the coasts of Placentia Bay. It is highly possible that adults commute the 20 to 25 km from Merasheen Island to Long Harbour for food (J. Brazil, pers. comm.). They can be expected to follow the fish, including spawning capelin, and have been observed following fishing boats and picking up waste fish, including old bait discarded from lobster traps.

Bald Eagles nest in the immediate area of Long Harbour. LGL observers confirmed active nests on the Wild Shore (eastern shore of Long Harbour near Long Harbour Head), Bald Head adjacent to the Brine Islands, and Merchant's Island and Burke's Island of the Iona Islands off the mouth of Long Harbour. Reproductive success in Placentia Bay appears to have been high in recent years as a substantial proportion of the observed population were immature.

The Osprey is a locally common breeding bird in Newfoundland. It is known to be particularly numerous at Bellevue Beach, Trinity Bay, on the north side of the Isthmus of Avalon, where fishing in tidal flats is very good. Ospreys are present in low numbers in most of Placentia Bay, probably because shallow-water coves required for foraging are relatively few. Interaction with the more common and domineering Bald Eagle may also be a limiting factor. During a helicopter survey for Bald Eagles and Osprey along the coast from Come By Chance to near Cape St. Mary's on June 13, 2006, no Ospreys or Osprey nests were observed (Goudie and Mactavish 2007). There were two Osprey observations in Long Harbour by ground crews in 2006; both were from the uppermost reaches of Long Harbour. On May 17, an Osprey was observed catching a flounder in the shallow waters. On July21, an Osprey was observed hunting over the shallow waters but was not successful in capturing prey.

Marine Avifauna Species at Risk

There are three marine bird species listed as 'species at risk' in Newfoundland and Labrador.

Piping Plover

The Piping Plover (*Charadrius melodus*) is listed as *endangered* on Schedule 1 of *SARA*. In 2001, the total global population (all North America) was estimated at 5,945 individuals, with a breakdown of 1,454 in Canada and 481 in Atlantic Canada (Haig 1985; Haig 1992). The 61 adults counted during the 2006 census of Newfoundland indicates a slight increase over recent years, probably as a result of continued protection of breeding sites (P. Harris, CWS, pers. comm.). The Newfoundland breeding range is essentially the southwest corner of the island from Flat Bay Island in St. George's Bay to Grand Barasway near Burgeo. An isolated two pairs have recently (2006) been found breeding at Seal Cove, Fortune Bay (P. Harris, CWS, pers. comm.). One or two pairs nesting at Miquelon, Saint-Pierre et Miquleon, are the closest breeding birds to Placentia Bay. There are no records of Piping Plover for Placentia Bay; however, a sighting from Bellevue Beach indicates the possibility of rare occurrences in

Placentia Bay during migration. The extensive sandy beaches required for breeding sites do not exist in Placentia Bay.

Red Knot

The Red Knot (*Calidris canutus*) was listed as *endangered* by COSEWIC in April 2007 (*rufa* subspecies). It breeds in the Arctic regions of both the Old and New worlds. In the New World, it winters along the coasts from California and Massachusetts south to South America. A significant drop in numbers at migration staging and wintering sites in North America has given cause for concern for the North American population. Red Knot is an uncommon southbound migrant in coastal Newfoundland. It prefers open sandy beaches, often with rotting kelp piles and extensive mud flats, for feeding, and such habitats are rare in Placentia Bay. Red knot has been observed on the tidal flats at Arnold's Cove estuary. Little suitable habitat exists in Long Harbour but this species may occasionally occur there during fall migration, August to October.

Ivory Gull

COSEWIC designated the Ivory Gull (*Pagophila eburnea*) a species of *special concern* in April 1979. Its status was re-examined and confirmed in April 1996 and in November 2001; it was re-examined and designated *endangered* in April 2006. It is under consideration for addition to Schedule 1 under *SARA*. Surveys of breeding sites known from the 1980s were conducted in 2002 and 2003 (Gilchrist and Mallory 2005). An 80 per cent decline of breeding pairs at these sites triggered a worldwide concern about the global population, thought to be <12,800 pairs, but populations from Russia may be overestimated (Stenhouse 2004).

The Ivory Gull inhabits the Arctic Ocean and is usually associated with pack ice. The breeding range is high Arctic Canada, northern Greenland, and Spitsbergen to Novaya Zemlya (Godfrey 1986). Their diet is various small fish including lanternfish and Arctic cod, crustaceans, and carrion (Haney and MacDonald 1995). They traditionally winter as far south as the pack ice off northeast Newfoundland (Godfrey 1986; B. Mactavish, LGL, pers. comm.), but there has been a reduction in the area of pack ice off Newfoundland and a corresponding reduction of sightings. There are very few records of the Ivory Gull for the south coast of Newfoundland, none for Placentia Bay (P. Linegar, pers. comm.), and only three for Saint-Pierre et Miquelon (February 1979, January 1988 and January 2002) (P. Linegar, pers. comm.). The Ivory Gull could occur as a very rare visitor to Placentia Bay, November to April.

2.4.7 Marine-related Mammals and Sea Turtles

Twelve species of marine mammals can be expected to occur in Placentia Bay, including nine species of cetaceans (Table 2.17) and three species of seals (Table 2.18). River otter (*Lutra canadensis*) is also considered under this category because of its marine lifestyle. Several additional species have been sighted in Placentia Bay or likely occur there, but because of their rarity are not considered in this document. The blue whale (*Balaenoptera musculus*), although considered rare in Placentia Bay, is

Table 2.17 Cetaceans with Expected Occurrence Within Placentia Bay

Species		Occurrence	Season	Habitat	COSEWIC Status (date of most recent status report)	*SARA* Status[a]
Common Name	**Scientific Name**					
Baleen Whales	***Mysticeti***					
Humpback whale	*Megaptera novaeangliae*	Common	Spring to fall	Primarily nearshore and banks	Not At Risk (May 2003)	No status
Minke whale	*Balaenoptera acutorostrata*	Common	Year-round but primarily spring to fall	Continental shelf and coastal	Not At Risk (April 2006)	No status
Fin whale	*Balaenoptera physalus*	Common	Spring to fall	Continental slope and pelagic	Special Concern (May 2005)	Schedule 1: Special Concern
Blue whale	*Balaenoptera musculus*	Uncommon	Year-round but primarily spring and fall	Coastal, continental slope, and pelagic	Endangered (May 2002)	Schedule 1: Endangered
Toothed Whales	***Odontoceti***					
Long-finned pilot whale	*Globicephala melas*	Common?	Year-round	Mostly pelagic	Not assessed	No status
Short-beaked common dolphin	*Delphinus delphis*	Uncommon	Summer	Continental shelf and pelagic	Not assessed	No status
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Common	Year-round but primarily spring and fall	Continental shelf and slope	Not assessed	No status
White-beaked dolphin	*Lagenorhynchus albirostris*	Common	Year-round?	Continental shelf	Not assessed	No status
Harbour porpoise	*Phocoena phocoena*	Common	Year-round?	Continental shelf	Special Concern (April 2006)	*No schedule or status; referred back to COSEWIC*

Notes: ? indicate uncertainty
[a] Species designation under the *Species at Risk Act* (COSEWIC 2007).

Table 2.18 Seals with Expected Occurrence Within Placentia Bay

Species		Occurrence	Season	Habitat	*SARA*/COSEWIC Status
Common Name	**Scientific Name**				
True Seals	***Phocidae***				
Grey seal	*Halichoerus grypus*	Common	Primarily summer	Coastal	Not assessed
Harbour seal	*Phoca vitulina*	Common	Year-round	Coastal	Not assessed
Harp seal	*Pagophilus groenlandica*	Uncommon	Late winter/early spring	Ice	Not assessed

described below, because of its *endangered* status on Schedule 1 of *SARA*. Although most species are seasonal inhabitants, the waters of Placentia Bay and surrounding areas are important feeding grounds for some. Data on marine mammal abundance and distribution in Placentia Bay are limited. One of the best sources of information is a cetacean database, maintained by DFO, that contains records (incidental sightings, survey results, entanglements, and stranding data) collected by or reported to DFO since the 1970s; however, it provides information on occurrence only within a particular area, and caution should be taken when interpreting relative abundance (temporal and spatial), given that observational effort is biased and limited in geographic scope. Of the marine mammal species that may occur or are likely to occur in Placentia Bay, only the blue whale and fin whale (*B. physalus*) are considered *at risk* under *SARA*. The harbour porpoise (*Phocoena phocoena*) is considered of *special concern* by COSEWIC and has no schedule or status under *SARA* given the recent (April 2006) re-assessment by COSEWIC.

Mysticetes (Baleen Whales)

Three species of baleen whales or mysticetes occur regularly in Placentia Bay including humpback (*Megaptera novaeangliae*), fin and minke whales (*B. acutorostrata*) (Marques 1996; Hay 1982). There have only been two sightings each of sei whales (*Balaenoptera borealis*) and blue whales in Placentia Bay (DFO, unpubl. data).

Whales arrive in Placentia Bay in late spring or early summer, and the more abundant species remain until September or October, feeding primarily on capelin, but also on krill, squid, herring, and sand lance. The whales follow the migration of capelin and are common around inshore Newfoundland during the summer. The arrival of capelin to the head of Placentia Bay generally occurs in June and July, and it is likely that baleen whales would be most abundant during these months. Most have moved offshore and have begun to migrate south by late October (Lien 1985).

Blue Whale

Blue whale abundance in the North Atlantic is thought to range from 600 to 1,500 individuals, although more reliable and wide-ranging surveys are required for better estimates (Sears and Calambokidis 2002). The blue whale is considered *endangered* on Schedule 1 of *SARA*; accordingly, a Recovery Strategy is being developed and is likely due for release in the near future (J. Lawson, DFO, pers. comm.). Little is known about the distribution and abundance of blue whales in the northwest Atlantic, especially in the waters off eastern Newfoundland. One area of concentration is the Gulf of St. Lawrence, where 350 individuals have been catalogued photographically (Sears 2002).

Blue whales have a coastal and pelagic distribution and are known to frequent areas of the Gulf of St. Lawrence, the lower Estuary part of the St. Lawrence and, to a lesser extent, the west and southwest coasts of Newfoundland. Most sighting effort and sightings of blue whales have been made along the Quebec North Shore from the Mingan and Anticosti islands region, off the Gaspé Peninsula and west into the St. Lawrence Estuary to the Saguenay River (Sears and Calambokidis 2002). Little survey effort has been expended in other regions of the gulf or elsewhere in the northwest Atlantic, especially outside of the summer period. Information on the distribution of blue whales in winter is lacking. Some have become entrapped by ice (during heavy ice years) near the southwest coast of Newfoundland (Stenson et al. 2003). Records of entrapped blue whales date back to 1868, and 41 individual blue whales (23 entrapment events) have been recorded since then. Based on the DFO database, most sightings in Newfoundland have occurred near the coast, which may, in part, be related to the lack of dedicated marine mammal surveys in offshore waters. Blue whales were regularly sighted in offshore waters (~100 to 3,000 m deep) of the Laurentian Sub-basin area during a recent seismic monitoring program in June to September 2005 (Moulton et al. 2006a). In fact, blue whales were the most frequently sighted baleen whale species there. The sighting rate was highest in water depths ranging from 2,000 m to 2,500 m (Moulton et al. 2006a). There have been two recorded sightings in Placentia Bay (Figure 2.30). Five individuals were sighted north of Long Harbour on August 20, 1979, and four (two females with calves) were sighted east of Point May in July 2002. Despite these recorded sightings, they are probably uncommon visitors to Placentia Bay.

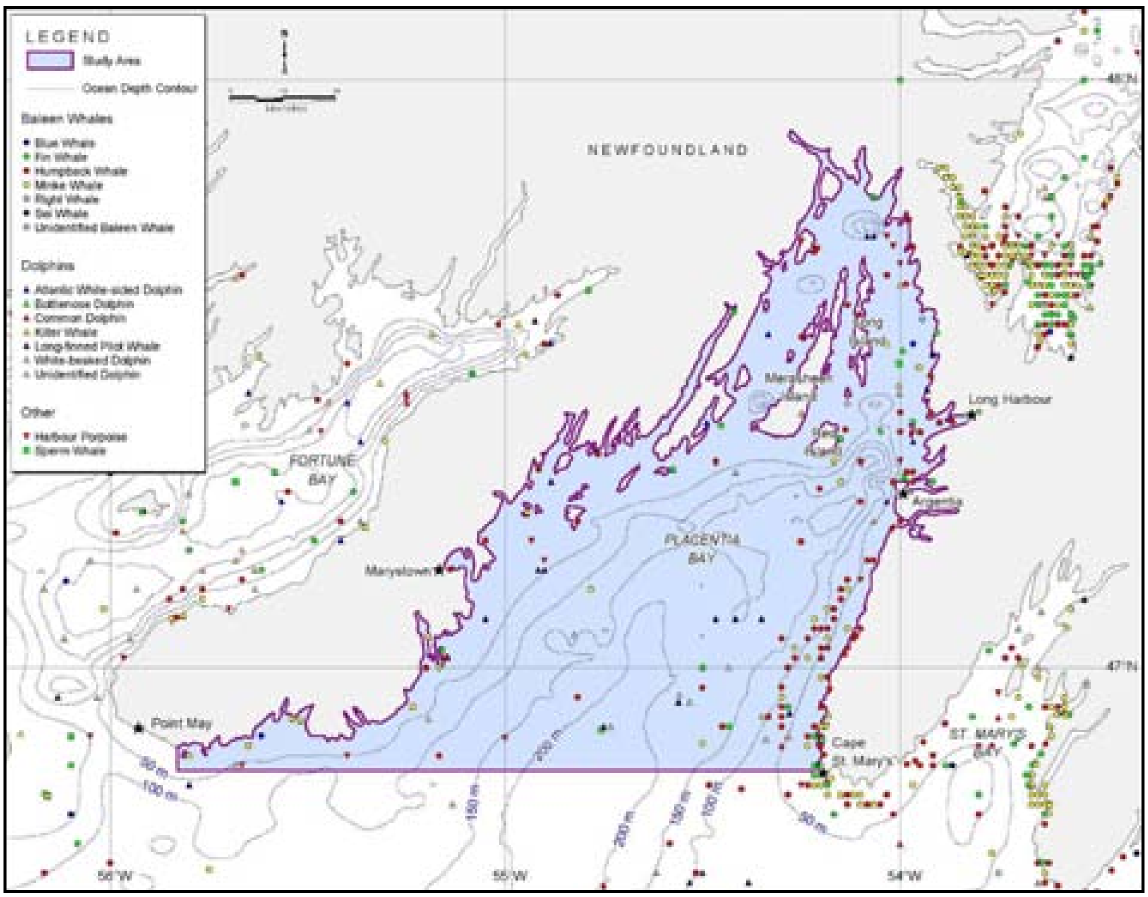

Figure 2.30 Sightings of Marine Mammals in Placentia Bay in the DFO Marine Mammal Sightings Database

Blue whales from the Gulf of St. Lawrence exhibit significant levels of PCBs and pesticides (Sears et al. 1999 *in* Sears and Calambokidis 2002). Concentrations of DDT and PCBs ranged from 210 to 730 ng/g lipid and 113 to 245 ng/g lipid, respectively, in males; levels were lower for females, which is thought to be attributable to transplacental and lactation transfer to their young. Concentrations of contaminants in a female and her calf were within the same range (Metcalfe et al. 2004) Contaminants may affect reproduction, but it is uncertain whether there is a link between elevated contaminant levels and the apparent low calving rate in the Gulf of St. Lawrence (Sears and Calambokidis 2002). It is uncertain whether blue whales that occasionally occur in Placentia Bay are the same ones that inhabit the Gulf of St. Lawrence.

Blue whales feed almost exclusively on euphausiids (krill) such as *Thysanoessa raschii* and *Meganyctiphanes norvegica* (Yochem and Leatherwood 1985), and also on copepods (e.g., *Temora longicornis*) and some fish species (Kawamura 1980; Reeves et al. 1998).

Fin Whale

The fin whale was recently confirmed as a species of *special concern* on Schedule 1 of *SARA*. This species is commonly found on the Grand Banks and in the coastal waters of Newfoundland's south coast during summer months (Piatt et al. 1989), and is often associated with the presence of capelin. Historical records show that the fin whale was by far the most hunted species, with over 10,000 taken in the first half of the 20^{th} century (Sergeant 1966 *in* Lawson 2006). There is no reliable population estimate for Newfoundland waters. Recent genetic studies indicate that fin whale populations that summer in Nova Scotia, Newfoundland, and Iceland may be genetically distinct from each other (Arnason 1995). For the area between Georges Bank and the mouth of the Gulf of St. Lawrence, the best available population estimate is 2,814 individuals (coefficient of variance, CV = 0.21) based on recent aerial surveys conducted by DFO. Aerial surveys were conducted in mid-September to October 2002 and 2003 in the coastal waters of Newfoundland. Most survey transects extended from shore to at least 172 km offshore. Total linear survey effort was approximately 11,000 km (Lawson 2006). There were 12 confirmed sightings (29 individuals); two occurred along the south coast of Newfoundland but not within Placentia Bay. For coastal areas of Newfoundland, preliminary analyses yielded a density estimate of $0.006/km^2$ and an uncorrected point estimate (for September/October) of 1,103 fin whales (95 per cent confidence interval - CI: 459-2654). A density of $0.007/km^2$ was observed during an aerial survey conducted in Placentia Bay on August 6, 1980 (Hay 1982). It is acknowledged that more reliable and wide-ranging surveys are required for better estimates of fin whale numbers in Newfoundland waters (J. Lawson, pers. comm., 2006) and in the northwest Atlantic as a whole (Waring et al. 2004).

It is generally assumed that fin whales, like other baleen whales that occur in Atlantic Canada, migrate between foraging habitat in the north and calving/breeding grounds in the south. However, year-round observations of fin whales in areas such as eastern Nova Scotia suggest that not all individuals complete a full migration route each year (COSEWIC 2005). Fin whales have been reported in Placentia Bay from March to August (DFO, unpubl. data). As with other balaenopterids, migration is segregated, and in the case of fin whales, pregnant females typically initiate seasonal movement, followed by adult males and resting females; lactating females and juveniles are the last to migrate (Aguilar 2002).

Little is known about the distribution and movements of fin whales off Newfoundland during fall, winter, and spring after they leave inshore foraging areas (Hay 1982 *in* Marques 1996). During summer they are known to occur in coastal areas of Placentia Bay where they forage (Marques 1996; see Figure 2.30). Boat-based surveys conducted in June and July of 1993 and 1994 off the southeastern coast of Placentia Bay found that fin whales accounted for 25.8 per cent of the 349 baleen sightings. They were sighted in shallower waters (and closer to shore) than humpback and minke whales, and their abundance appeared to peak later in the season. Relatively few sightings have been reported for the central and western portions of Placentia Bay (Figure 2.30), but this is likely related to observation effort. Marques (1996) suggests that fin whale inshore abundance in Newfoundland has increased based on sighting rates in 1993-94 compared to the early 1980s. Fin whale abundance in Placentia Bay (mean: 0.53/h) was much higher than that reported 1982-85 (mean: 0.11/h; Piatt et al. 1989). Based on DFO's sighting database, fin whales were most commonly reported in June (29.1 per cent of 48 sightings), followed by July (27.1 per cent) and August (20.8 per cent; DFO, unpubl. data).

Breeding and calving are thought to occur during winter at lower latitudes. Gestation is 11 to 12 months and calves nurse for about six months. The generation time is estimated at 20 to 30 years (COSEWIC 2005).

Available evidence suggests that PCB and DDT levels in fin whales samples collected from Newfoundland and Nova Scotia in the early 1970s were higher than levels collected in 1991 in the Gulf of St. Lawrence (Hobbs et al. 2001). This is consistent with decreasing organochlorine levels for other marine mammals in eastern Canada (Hobbs et al. 2001).

The predominant prey item of fin whales in waters off Newfoundland is capelin (Whitehead and Carscadden 1985; Piatt et al. 1989). In Placentia Bay, fin whales are also known to feed on euphausiids and mackerel (Marques 1996).

Fin whales sometimes travel in groups of two to seven individuals (Aguilar and Lockyer 1987 *in* COSEWIC 2005); larger aggregations can occur during feeding, but for only a short period of time. Fin whales are known for their fast swimming speeds; their normal traveling speed is 2.6 to 4.1 m/s, and they can sustain speeds of 7.7 m/s for short periods of time. Dives typically last three to 10 minutes and usually are limited to depths of 100 m to 200 m (Aguilar 2002).

Humpback Whale

Humpback whales regularly occur along the south coast of Newfoundland, including Placentia Bay, and these whales belong to the northwest Atlantic population. It is estimated that 11,570 individuals comprise the entire North Atlantic population (Stevick et al. 2001) but this is likely an underestimate. Based on data from 1992 to 1993 it is estimated that >2,500 humpback whales occur in eastern Canada;

this is most likely an underestimate (Anonymous 2001 *in* Baird 2003). The stock structure of this population is not clear, but it has been suggested that a separate feeding stock exists for Newfoundland and Labrador (Baird 2003). There is no reliable population estimate for Newfoundland. COSEWIC (2007) lists the species as *not at risk*.

Like most baleen whales, humpbacks exhibit seasonal migrations from high-latitude feeding areas in summer to low-latitude breeding and calving areas in winter. They typically arrive in Newfoundland waters around June and have mostly left by September. Based on sightings from the DFO database where month was recorded, June and July (77.2 per cent of 232 sightings) appear to be the period of peak occurrence in Placentia Bay. Humpback whales have typically been considered (and described) as a coastal species, but recent acoustic evidence (along with data from offshore seismic monitoring programs) shows that some whales do use offshore areas during non-migration periods (Baird 2003; Moulton and Miller 2004; Moulton et al. 2005, 2006a,b). A humpback whale density of 0.004/km^2 was observed during an aerial survey conducted in Placentia Bay on August 6, 1980 (Hay 1982). Humpback whales occur throughout the bay, including areas near Long Harbour (Figure 2.30), and it is the most abundant baleen whale recorded there (232 sightings; DFO, unpubl. data).

DDT and its metabolites, PCBs and other contaminants were detected in blubber biopsy samples of humpback whales in the Gulf of St. Lawrence (Metcalfe et al. 2004). Concentrations of contaminants were similar in adult females and their calves, which suggests that bioaccumulation via transplacental and lactational transfer is sufficient to establish equilibrium in contaminant levels.

In the northwest Atlantic, humpback whales feed during spring, summer and fall over a wide range (Katona and Beard 1990). They have a generalist diet consisting of euphausiids and different species of small schooling fish such as herring, sand lance, capelin, and mackerel (Clapham 2002). In Newfoundland, their summer distributions are principally controlled by those of their prey. Large groups can concentrate in an area where prey is abundant. Humpbacks give birth from December through April and breeding also occurs at this time; gestation lasts 11 to 12 months.

Minke Whale

Current population estimates for minke whales in Newfoundland are not available. Boat-based surveys conducted in the southeastern area of Placentia Bay (near Cape St. Mary's) in 1993 and 1994 found relative abundances of 0.26 and 0.66 per hour, respectively (Marques 1996). The best estimate available is for the area extending from George's Bank to the mouth of the Gulf of St. Lawrence and in the Gulf of St. Lawrence, where the estimate is 3,618 (CV = 0.18) (Waring et al. 2006). This species is not listed under *SARA* and COSEWIC recently (April 2006) listed it as *not at risk*.

Like other baleen whales, minkes undergo seasonal migrations from high-latitude feeding grounds in the summer to low-latitude breeding grounds in the winter. Some minke whales, however, are seen at high latitudes in the winter, including off Newfoundland (Lynch 1987). They are common off Newfoundland from May to August, where they feed principally on capelin (Sergeant 1963). Minkes have been recorded in Placentia Bay from April to November and were most commonly recorded in July (46.2 per cent of 52 sightings), followed by June (30.8 per cent of sightings) (DFO, unpubl. data). This species has recently been observed in late winter (2006) and early spring (2007) in Long Harbour (B. Mactavish and J. Christian, LGL, pers. comm.), perhaps in pursuit of herring. Minke whales were less abundant than humpback and fin whales in southeastern Placentia Bay during the summers of 1993 and 1994 (Marques 1996).

Chlorinated biphenyls (CBs), DDT, and α-hexachlorocyclohexane (HCH) were found in blubber samples of minke whales summering in the Gulf of St. Lawrence (Gauthier et al. 1997). Concentrations of DDT were significantly lower and concentrations of mirex were significantly higher in minke whales than in the blue, fin, and humpback whales tested.

Minke whales are relatively solitary, usually seen individually or in groups of two or three, but they can occur in large aggregations of up to 100 animals at high latitudes where food resources are concentrated (Perrin and Brownell 2002). Females give birth every year and calving typically occurs between November and March (Sergeant 1963). In Newfoundland capelin and cod are considered dominant prey (Perrin and Brownell 2002).

Odontocetes (Toothed Whales)

Four species of odontocetes have been regularly sighted in Placentia Bay, including the Atlantic white-sided dolphin, white-beaked dolphin, harbour porpoise, and long-finned pilot whale. There have been relatively few sightings of common dolphin (*Delphinus delphis*), killer whale (*Orcinus orca*) and sperm whale (*Physeter macrocephalus*).

Most odontocetes occur seasonally in Placentia Bay; little is known about their distribution and population size. Some species may remain in waters of southern Newfoundland throughout the autumn and winter, but the seasonal movement patterns of most species are unknown. Most toothed whales that occur in Placentia Bay are known or thought to eat squid, fish (capelin, cod, sand lance, herring, mackerel), and/or amphipods. It is likely that the distribution patterns of most odontocetes are related to the occurrence of their prey. Contaminants such as mixtures of PCB and DDT, which are associated with industrial sites, have been implicated in immune system suppression in some dolphin species and in harbour porpoise and harbour seals (Weisbrod et al. 2001). It is unknown if odontocetes that occur in Placentia Bay are exposed to or affected by hazardous concentrations of contaminants throughout their range.

Atlantic White-sided Dolphin

This species is found in temperate and sub-polar waters of the North Atlantic Ocean. In the northwest Atlantic three stocks may exist: the Gulf of Maine, the Gulf of St. Lawrence, and the Labrador Sea; the combined northwest Atlantic population is thought to number 27,000 individuals (Palka et al. 1997). However, Waring et al. (2006) estimates that the Gulf of Maine stock is ~51,600 individuals. It is uncertain which stock of dolphins occurs in Placentia Bay. COSEWIC lists this species as *not at risk* (COSEWIC 2007).

White-sided dolphins range from about Cape Cod to Davis Strait and Greenland (Katona et al. 1993). They are regularly sighted along the south coast of Newfoundland during summer and early fall, with one recorded sighting in April (DFO database, unpubl. data).

It has been reported that white-sided dolphins prefer waters >50 m deep (Katona et al. 1993) and that they are found primarily in continental shelf waters to the 100 m depth contour (Waring et al. 2006). They are also regularly sighted in slope areas and deeper oceanic waters (Cipriano 2002). Based on the DFO sighting database, this species appears to have a scattered distribution along the south coast of Newfoundland. Six sightings have been recorded in Placentia Bay, four in August and one in each of June and October (DFO, unpubl. data). It is speculated that white-sided dolphins may be at greater risk from contaminants than other dolphins, given that their coastal distribution is more likely to coincide with industrialized areas (Weisbrod et al. 2001).

In the western Atlantic, calving season peaks in mid-summer after an 11-month gestation period; lactation occurs for ~18 months (Weinrich et al. 2001; Cipriano 2002). Katona et al. (1993) report that females give birth every 2.5 years, but some individuals may breed annually (Cipriano 2002).

In the inshore waters of Newfoundland, group sizes of 50 to 60 are typical. Their prey includes herring, mackerel, gadoids (e.g., cod), smelt, hake, sand lance and squid (Cipriano 2002). This species does not appear to be a deep diver; the maximum time recorded for a tagged individual was four minutes (Mate et al. 1994).

White-beaked Dolphin

The white-beaked dolphin tends to be a coastal, cool-water species (Reeves et al. 1999) remaining at relatively high latitudes throughout fall and winter (Lien et al. 1997), but the nature of their seasonal movements is uncertain.

There are indications (based on morphometric data) that there are at least two different stocks of white-beaked dolphins, the eastern and western North Atlantic stocks (Mikkelsen and Lund 1994 *in* Waring et al. 2006). There are no total abundance estimates for Canadian waters. The total North Atlantic population may range from the high tens of thousands to low hundreds of thousands (Reeves et al. 1999). COSEWIC lists this species as *not at risk* (COSEWIC 2007). High densities of this species have been observed in Placentia Bay (0.29 /km^2) and Fortune Bay (0.24/km^2) in August 1980 (Hay 1982).

In the northwest Atlantic, the largest concentrations occur off Labrador and southwestern Greenland (Kinze 2002). White-beaked dolphins have been observed along the south coast of Newfoundland, and most of these sightings have occurred in the nearshore waters of Placentia Bay (DFO, unpubl. data; Figure 2.30); however, this may be related to observation effort. Sightings have been recorded in

Placentia Bay from April to September, with the majority in August (64.9 per cent of 37 sightings; DFO, unpubl. data). Ice entrapments along the Newfoundland northeast, south and west coasts (Hai et al. 1996) suggest that, like blue whales, some white-beaked dolphins remain associated with the ice edge through winter (J. Lawson, DFO, pers. comm.). As many as 150 white-beaked dolphins were entrapped by pack ice near Point Verde in March 1983 (Hai et al. 1996).

Their diet consists mainly of mesopelagic fish species, especially cod, whiting, and other gadids, as well as squid, octopus, and sometimes benthic crustaceans (reviewed in Lien et al. 2001; Kinze 2002). Groups of a few or several dolphins may occur in Placentia Bay, but large groups of up to 1,500 animals have been observed off Newfoundland (Katona et al. 1993). Little is known about their reproductive parameters. Births occur during summer and gestation lasts 10 to 11 months (Kinze 2002).

Long-finned Pilot Whale

Long-finned pilot whales are abundant throughout the North Atlantic Ocean as far north as 70°N (Bernard and Reilly 1999), with some evidence of segregation between the western and eastern North Atlantic (Bloch and Lastein 1993).

The northwest Atlantic population probably numbers between 4,000 and 12,000 individuals (Nelson and Lien 1996). In August 1980, an aerial survey of whales in the coastal and offshore waters (ca. 100 km offshore) of eastern Newfoundland and southeastern Labrador yielded a minimum abundance estimate based on line-transect analysis of 13,167 (± 3,155) pilot whales (Hay 1982). There are no available estimates for numbers that occur in Placentia Bay. COSEWIC (2007) lists the long-finned pilot whale as *not at risk*.

The long-finned pilot whale is considered the most common toothed cetacean on the Grand Banks and is also one of the few year-round residents, considered abundant in the Grand Banks area from July through December. There have been 30 sightings in Placentia Bay recorded in DFO's database (from 1979 to 2006), 90 per cent of which occurred during June to August, with pilot whales most frequently recorded in July (DFO, unpubl. data). However, no pilot whales were sighted in Placentia Bay during an aerial survey on August 6, 1980 (Hay 1982). There are probably not enough systematic survey data to determine if they are common in Placentia Bay.

Pilot whales are very social and are usually found in large groups, and pods are known to strand frequently en masse. It is a common belief that long-finned pilot whales in the northwest Atlantic prey mainly on short-finned squid in summer; however, this statement is based largely on evidence from inshore waters of Newfoundland (Sergeant 1962), and other evidence suggests that they also prey on a variety of fish species, as well as additional species of cephalopods (especially long-finned squid, *Loligo pealei*) at other times and in other areas (Waring et al. 1990; Overholtz and Waring 1991; Desportes and Mouritsen 1993; Nelson and Lien 1996; Gannon et al. 1997). Mating typically occurs in spring or early summer and gestation is 12 months (or perhaps 16 months; see Katona et al. 1993). Lactation lasts for at least three years (Olson and Reilly 2002).

Common Dolphin

Common dolphins are widely distributed in tropical and temperate oceans around the world. The northernmost limit of their range is typically about 50°N in the Atlantic (Evans 1994). In the northwest Atlantic they have been sighted in August as far north as 47°N off Newfoundland (Gaskin 1992). Common dolphin distribution has been shown to be associated with steep underwater topography (Evans 1994).

There are no available population estimates for Atlantic Canada or Newfoundland. Waring et al. (2006) provided an abundance estimate of 90,547 (CV = 0.24) for common dolphins from Maryland to the Bay of Fundy. COSEWIC (2007) lists the common dolphin as *not at risk*.

Only three sightings in Placentia Bay are recorded in the DFO marine mammal database, two in 1980 and one in 1986. Migration onto the Continental Shelf off Newfoundland occurs during summer and autumn when water temperatures exceed 11°C (Sergeant et al. 1970). Common dolphins are likely uncommon in Placentia Bay.

Common dolphins often travel in fairly large groups; schools of hundreds or even thousands are commonly seen, although their basic social units likely number less than 30 individuals (Evans 1994). They feed on a variety of prey including small mesopelagic fish and squid, small scombroids and clupeoids. Foraging dives have been recorded to 200 m (Perrin 2002). The biology of common dolphins in the northwest Atlantic has not been studied in detail. Based on other regions, gestation lasts 10 to 11 months and lactation lasts five to six months (Perrin 2002).

Harbour Porpoise

The harbour porpoise is found in shelf waters throughout the northern hemisphere, usually in waters colder than 17°C (Read 1999). The northernmost limit of their range is 70°N, but they are present in northern coastal waters only during the summer months (IWC 1996).

Harbour porpoises can be divided into genetically different subpopulations within the western North Atlantic: the Bay of Fundy/Gulf of Maine, Gulf of St. Lawrence, and eastern Newfoundland (Wang et al. 1996; Westgate and Tolley 1999). Estimates for the Newfoundland subpopulation do not exist. The northwest Atlantic population is considered of *special concern* by COSEWIC (2007) and it is currently under consideration for listing under Schedule 1 of *SARA*. Sightings of harbour porpoises in the Gulf of St. Lawrence occurred in shallow waters out to about a depth of 285 m (Kingsley and Reeves 1998). A density of 0.0545 (CV = 0.26)/km^2 for the entire Gulf of St. Lawrence was found in that study. The best estimate of abundance for the Gulf of Maine/Bay of Fundy subpopulation is 89,700 (CV = 0.22) (Waring et al. 2006).

Very little is known about the distribution, abundance and movements of harbour porpoises in Newfoundland. Based on DFO's database (DFO, unpubl. data), there have been 19 sightings scattered throughout the nearshore waters of Placentia Bay (Figure 2.30). This species appears to be most abundant in Placentia Bay from June to September; one harbour porpoise was observed in each of November and December. Based on bycatch in the fixed-gear fishery for Atlantic cod in 2002 in Newfoundland, the highest bycatch rates were recorded in Placentia Bay during April to June (Lawson et al. 2004). Relative to other coastal areas of Newfoundland, bycatch data suggest that Placentia Bay (and St. Mary's Bay) may be harbour porpoise "hot-spots" (Lawson et al. 2004). Based on the available information, harbour porpoises within Long Harbour are likely uncommon but are probably common (at least in low numbers) in other parts of Placentia Bay during late spring and summer. There has been little survey effort outside of the summer period.

PCBs and chlorinated bornanes have been the dominant contaminants found in harbour porpoises of all three subpopulations in the western North Atlantic (Westgate et al. 1997). It is uncertain what effect these contaminants have on health, but they may compromise the immune system.

Harbour porpoises are usually seen in small groups of one to three animals, often including at least one calf; occasionally they form much larger groups (Bjørge and Tolley 2002). They feed independently on small schooling fishes (Read 1999); in Newfoundland, their diet consists primarily of capelin, Atlantic herring, sand lance, and horned lantern fish; this assessment was based on the stomach contents of by-caught individuals (COSEWIC 2006c). Breeding occurs in late spring or early summer; gestation lasts for 10 to 11 months and lactation lasts for at least eight months (COSEWIC 2006c).

Seals

Harbour Seal

Harbour seals (*Phoca vitulina*) have one of the largest distributions of any pinniped. They can be found in most coastal waters of the North Atlantic and North Pacific to as far north as about 80°N off Spitzbergen (Bigg 1981).

Harbour seals in Newfoundland waters belong to the western Atlantic population and the size of this population is not known with any degree of certainty. From 30,000 to 40,000 were thought to be present in Canadian waters in 1993 (Burns 2002). The population in Atlantic Canada was estimated to be 31,900 in 1996 (this estimate was based on data provided in Boulva and McLaren (1979)) and, at that time, it was increasing at a rate of 5.6 per cent per year (Hammill and Stenson 2000). Harbour seals are year-round residents along the south coast of Newfoundland. In 1973, approximately 930 were estimated to be present in coastal areas in St. Mary's and Placentia bays (Boulva and McLaren 1979). There are no recent population estimates available for this species in Newfoundland or Placentia Bay. The COSEWIC status is *data deficient*. A draft COSEWIC status report is in preparation.

In recent years (2001-03), DFO has conducted boat and shore-based surveys at known harbour seal haul-out sites along the south coast of Newfoundland (Sjare et al. 2005). Although the surveys do not provide population estimates, they do provide the best available and most recent information for local abundance. Small numbers were counted in Placentia Bay (13 to 27). Harbour seals, including female and pup pairs, were observed in the Marystown estuary in May and June (2002 and 2003; Table 2.14) and at King Island, adjacent to Merasheen Island, including a female and pup. However, relatively little is known about breeding activity at these and other sites within Placentia Bay.

Harbour seals breed on the Grand Barachois of Miquelon, which is ~16 km south of outer Placentia Bay. From 1981 to 1990, the population estimate on Grand Barachois ranged from 400 to 908 seals. In recent years numbers have declined, and in 2003 and 2006 fewer then 200 were counted (B. Sjare, DFO, pers. comm.). In St. Mary's Bay, 269 were counted during a DFO survey in August 2003. It is possible that some of the seals at Miquelon and St. Mary's Bay travel to Placentia Bay to forage.

Immune function decreased relative to increased levels of PCBs in free-ranging harbour seals in British Columbia and Washington State (Mos et al. 2006). Veinott and Sjare (2006) tested harbour seals from five locations (Labrador, west coast of Newfoundland, Burgeo/Rose Blanche, Placentia Bay, and Chance Cove/Renews) for levels of heavy metals such as mercury, cadmium, and selenium. Concentrations of trace elements agreed with those reported for harbour seals in Alaska and Germany, and with northern pinnipeds in general (see Veinott and Sjare 2006). There was some evidence that the bioaccumulation of cadmium (in renal tissue) was site-dependent, with Placentia Bay suggested as a potential source.

Harbour seal pups are born in late spring or summer, and mating occurs in the water around the time that the pups are weaned, at about four weeks of age (Burns 2002). Moulting occurs during mid-summer to early fall, during which time harbour seals haul-out more frequently than at most other times of the year. In general, they have a varied diet, including pelagic and demersal fish as well as cephalopods and crustaceans (see, for example, Boulva and McLaren 1979; Bowen and Harrison 1996). In Newfoundland and Labrador, Arctic cod and capelin as well as shorthorned sculpin are important prey items. Based on preliminary analyses, Sjare et al. (2005) note that diet varied by region, with seals on the south coast (Placentia and St. Mary's bays) consuming more Atlantic cod (27% of stomach wet mass) and those on the northeast coast consuming more shorthorned sculpin (28%) and winter flounder (26%).

Grey Seal

Grey seals that may occur in the Placentia Bay area are migrants from the Sable Island and Gulf of St. Lawrence breeding populations. The number of grey seals that migrate into Placentia Bay is unknown, but is believed to be low. In summer, more than 100 grey seals haul-out within the Grand Barachois of Miquelon (J. Lawson, DFO, pers. comm.). This species may occur in the Placentia Bay area year-round, but are thought to be most common in July and August (Stenson 1994). Their diet includes at least 40 species, some of which are commercially important (e.g., Atlantic cod, herring, and capelin) (Benoit and Bowen 1990; Hammill et al. 1995). Grey seals breed in early winter, peaking in mid-January, and moult from mid-May to mid-June. They are considered *not at risk* by COSEWIC.

Harp Seal

Harp seals in Placentia Bay are migrants from the Gulf of St. Lawrence and the "Front" breeding populations. Breeding occurs in March and the moult follows shortly thereafter. The number of harp seals that migrate into Placentia Bay is unknown, but numbers may be increasing as the range of this species appears to be expanding southward (e.g., McAlpine et al. 1999). Harp seals would likely be most common in autumn and winter, as individuals summer in the Arctic. They eat a variety of prey; on the Grand Banks, capelin predominates, followed by sand lance, Greenland halibut, and other pleuronectids (Wallace and Lawson 1997; Lawson et al. 1998). The population is currently estimated at 5.9 million (CV=0.13; ICES 2005). Harp seals are considered *not at risk* by COSEWIC.

Sea Turtles

Three species of sea turtles may occur in the Placentia Bay: leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*) and Kemp's ridley (*Lepidochelys kempi*) (Ernst et al. 1994). Of these species, leatherbacks are the most abundant in Placentia Bay. Loggerhead and Kemp's ridley turtles are considered very rare in the area.

The leatherback is considered *endangered* on Schedule 1 of *SARA*. It is the largest living turtle and it also may be the most widely distributed reptile, as it ranges throughout the Atlantic, Pacific and Indian oceans and into the Mediterranean Sea (Ernst et al. 1994). Because of its primarily pelagic distribution, it is difficult to obtain a total population estimate. A study conducted in 1995 based on data from 28 nesting beaches throughout the world yielded an estimate of 34,500 females (Spotila et al. 1996). There are no reliable population estimates in Atlantic Canada as the scattered nature of the data (primarily incidental sightings) makes estimating difficult.

Adults engage in routine migrations between temperate and tropical waters, presumably to optimize both foraging (temperate water) and nesting (tropical water) opportunities. Females tagged at nesting beaches in French Guiana and Suriname, and on the Caribbean coast of Costa Rica, have been observed in Atlantic Canadian waters (James 2004). Canadian waters are thought to support one of the highest summer and fall densities of leatherbacks in the North Atlantic, and it has been suggested that waters in Atlantic Canada should be considered critical foraging habitat (James et al. 2006a). Adults are regularly sighted in the waters off Newfoundland from June to October (with peak abundance in August and September), where they likely come to feed on jellyfish, their primary prey (Bleakney 1965; Cook 1981, 1984; ALTRT 2006). Leatherbacks can remain active in water as cold as 0.4°C (James et al. 2006b). Adults and juveniles undergo annual migrations that include areas off southern Newfoundland (James et al. 2005). The analysis of satellite telemetry, morphometric and fishing entanglement data identified areas of high-use habitat in northwest Atlantic waters. It was shown that leatherbacks do not migrate along specific routes, but broad areas of the Atlantic. They exhibit foraging site fidelity to shelf and slope waters off Canada and the northeastern United States (James et al. 2005).

Little is known about the distribution and abundance of leatherback turtles in the Placentia Bay, but they are known to occur there. The primary source of information on the distribution and occurrence of sea turtles in Newfoundland and Labrador waters is a DFO database, maintained by Dr. J. Lawson, which primarily contains records of incidental sightings, and interpretation of the data must be made cautiously. Nonetheless, the database offers valuable information about species occurrence in Placentia Bay. Overall, there have been 41 reports of leatherbacks reported in Placentia Bay, based on incidental sightings, surveys, entanglements and stranding data (DFO, unpubl. data; see Figure 2.31). Based on data with month recorded, sightings were relatively more frequent in September (53% of 32 sightings) and August (25%) compared to July (9.4%) One was reported in January near Fox Harbour. Most sightings have been made in coastal areas (Figure 2.31), but this may be related to observation effort. One leatherback turtle was observed in Long Harbour on September 14, 1987.

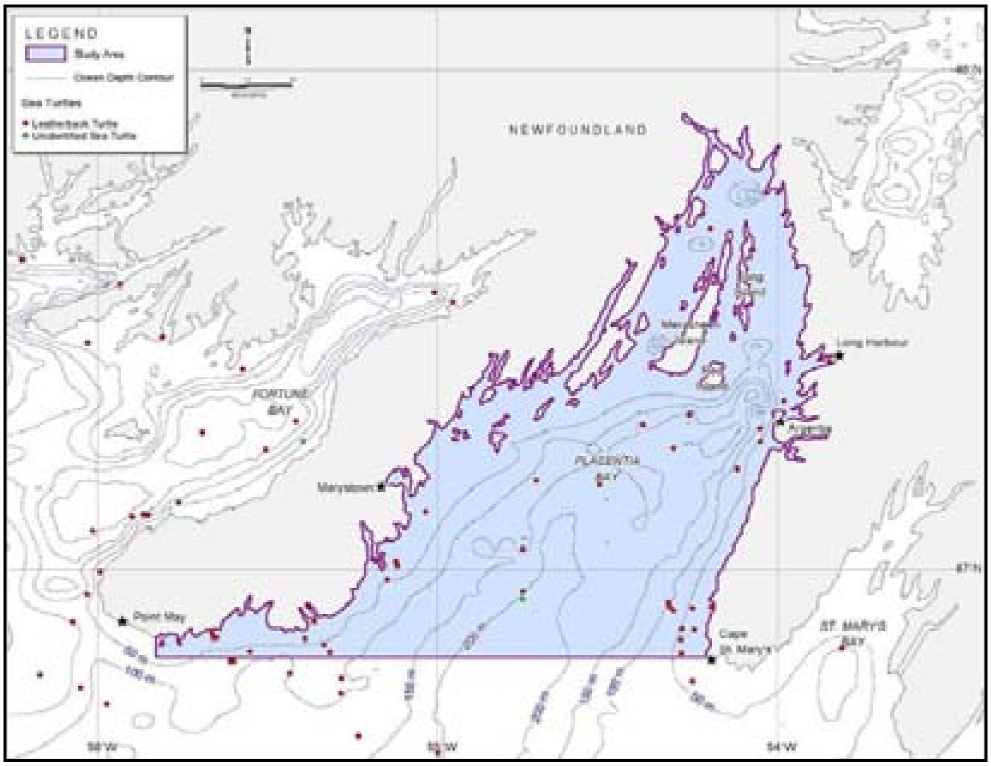

Figure 2.31 Sightings of Sea Turtles in Placentia Bay in the DFO Marine Mammal Sightings Database

Contaminant levels in leatherback turtles in and near Placentia Bay have not been determined. Heavy metals and PCBs may bio-accumulate in turtles that feed on plankton-feeding jellyfish (Davenport and Wrench 1990 *in* ALTRT 2006). Metal and PCB concentrations recorded for stranded leatherbacks in the UK found no evidence of significant chemical contamination, beyond the predictable finding of trace concentrations (Davenport et al. 1990; Godley et al. 1998). Keller et al. (2006) found that relatively low concentrations of organochlorines in loggerhead sea turtles compared to those in fish-eating wildlife (like marine mammals) were correlated with a modulated immune function.

It is possible that sea turtles, including leatherbacks, may exhibit immune responses to low levels of contaminants.

The diving behaviour of leatherbacks differs during transit versus foraging periods. Transisting turtles typically spend more time at greater depths, and dive durations are longer (Jonsen et al., in press.). It has been suggested that leatherbacks make deeper scouting dives for prey while transiting, and shallower dives associated with extended foraging may reduce the energetic demands of foraging at depth (Jonsen et al., in press.).

Their diving behaviour in continental shelf and slope waters of the northeastern United States and eastern Canada suggests they spend 43 to 50 per cent of their time at the water surface (<3 m; James et al. 2006c). The primary prey of leatherbacks is jellyfish (Lutcavage and Lutz 1986) and in eastern Canada the movements of leatherbacks are thought to be closely linked with the seasonally abundant *Cyanea* sp., their principal jellyfish prey (James and Herman 2001). Large flotillas of these jellyfish are evident at the surface during summer and fall but they may also be abundant lower in the water column (James and Herman 2001). Leatherbacks have been observed consuming large *Cyanea capillata* at the water surface in Atlantic Canada, and James et al. (2006c) suggest (based on diving profile data) leatherbacks do not have to undertake deep dives to locate jellyfish prey in shelf waters within their northern foraging areas (i.e., offshore Nova Scotia and Newfoundland).

Satellite tag data collected from leatherbacks after nesting in the Caribbean indicates they spent most of their time in the epipelagic zone (near-surface) and over 99 per cent of dives were <250 m (Hays et al. 2004). More than half of an individual's time was spent diving to depths below 10 m.

River Otter

The river otter (*Lutra canadensis*) is not technically a marine mammal, but in Placentia Bay many individuals have adopted a marine lifestyle and thus the species is considered here as a marine mammal. Placentia Bay is known to support a relatively large population of river otter.

The river otter is a large member of the family Mustelidae that includes the weasel, mink, and marten. It is ubiquitous, ranging the temperate latitudes of North America and inhabiting both marine and freshwater environments. Its role as a top predator, and its relatively large spatial requirements, make the species sensitive to anthropogenic stress, including contamination by water-borne pollutants, drainage of wetlands, and other forms of habitat degradation (Duffy et al. 1993; Bowyer et al. 1995). Because of this susceptibility, river otters are useful as indicators of the health of aquatic ecosystems (Duffy et al. 1993; Elliot et al. 1999). In various areas of its range, this species may live a largely marine existence or alternate between coastal and interior habitats (Larsen 1984; Stenson et al. 1984). Although technically semi-aquatic in habits, it spends a very large proportion of its time in water relative to other members of the Mustelidae, with the exception of the sea otters of the Pacific Ocean.

In Placentia Bay, the offshore contains an archipelago that supports marine otters. River otters are abundant and widespread in the archipelago and along the adjacent western and inner mainland shoreline. There is a strong anecdotal knowledge base because of active trapping of this furbearer population over many decades. The Newfoundland and Labrador Wildlife Division of the Department of Environment and Conservation has long acknowledged that the inner reaches of Placentia Bay, particularly around Merasheen Island and Long Island, support one the highest densities of river otter in the province. The complexity of shoreline may be an important habitat feature that favours the productive use of the archipelago by otters, as was postulated for the coast of Maine (Dubuc et al. 1990).

There are few available data on this mammal and its habitat in Placentia Bay. In an effort to improve the information base, VBNC collected baseline data on the presence of otters in the area of Long Harbour, the adjacent headlands and the Iona Islands - Brine Islands area (Figure 2.32) (Goudie 2007b).

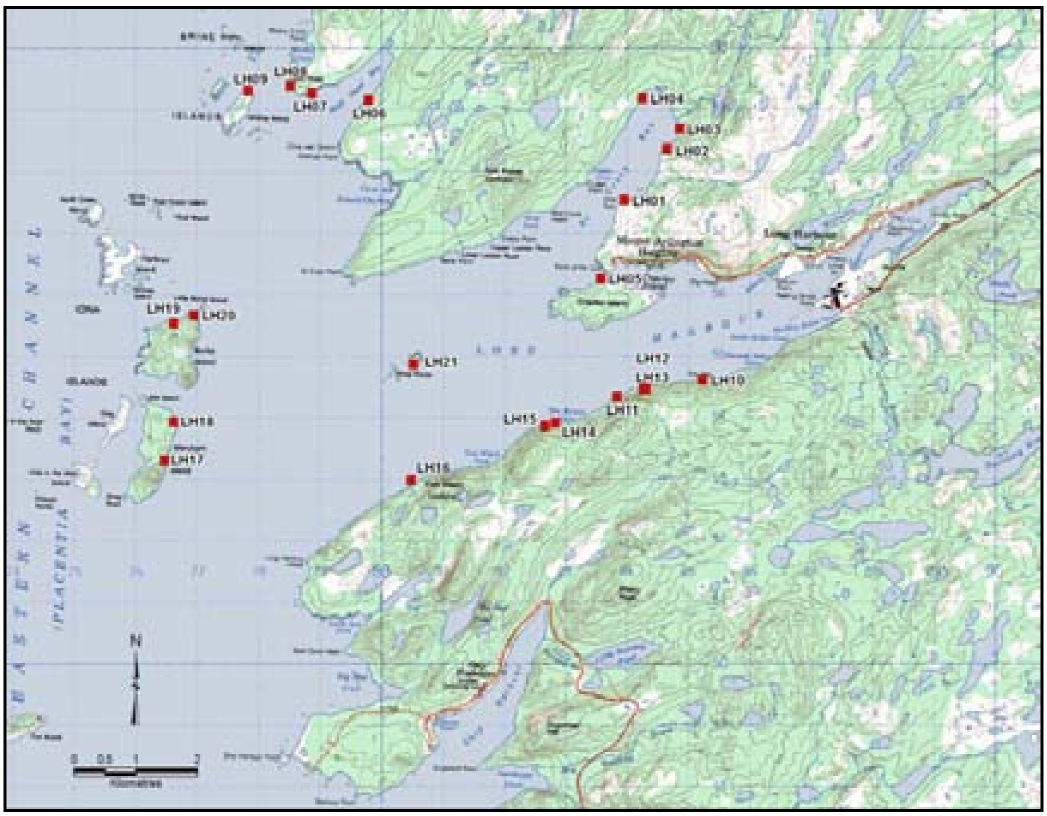

Figure 2.32 Otter Haul-outs Based on Boat Surveys by LGL Near Long Harbour in Summer and Fall 2006

Otters appear to consume primarily inshore marine fish species, as the main prey items identified from scats collected at otter haul-out sites in Placentia Bay included cunners (*Tautogolabrus adspersus*), gunnels/pouts (*Pholis gunnellus*), sculpins (*Artediellus uncinatus*), flounders (*Pseudopleuronectes americanus*) and sticklebacks (Family Gasterosteidae) (Cote et al. in prep.). Twenty-one sites were identified as otter 'rubs' in the area of Long Harbour - St. Croix Bay to Iona Islands and along the 'Wild Shore' (east side of Long Harbour) (Figure 2.33). Fourteen of these sites had signs of recent use in midto late August 2006. Many sites were promontories, although straight shoreline areas with bedrock and boulders were also frequently used as rubs. Over a two to three month period, 15 of 20 sites had been reused. Incidental to an aerial survey for nesting Bald Eagles conducted on June 7, 2006, thirty-five sites were identified as otter haul-outs (rubs) in the inner and eastern portion of Placentia Bay (Figure 2.33).

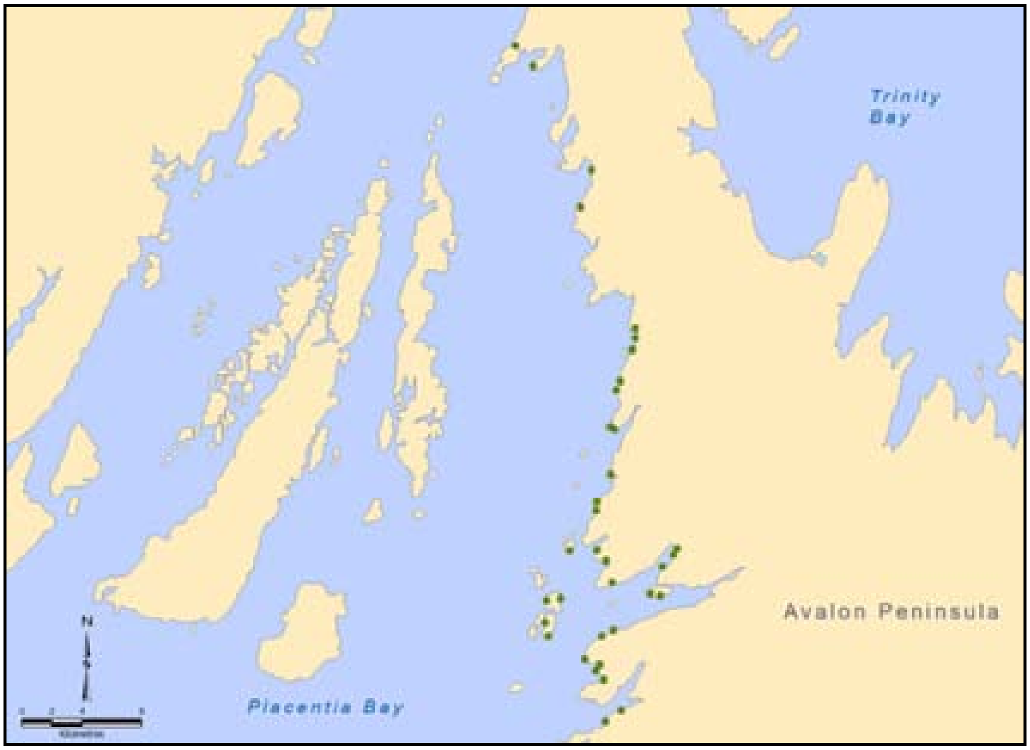

Figure 2.33 Otter Haul-out Sites on the East Side of Placentia Bay based on Aerial Survey by LGL, June 7, 2006

Results of the surveys suggest that the river otter is ubiquitous in the Long Harbour area. The assessment of 21 areas where otters were actively 'hauling-out' confirmed that many were currently being used, and the majority had evidence of recent use.

It is likely that the population of otters using Placentia Bay is relatively contiguous, given the large home range of this species and the results of studies of populations in other coastal areas (e.g., >60 km range in Bonavista Bay *in* Cote et al. in prep.). In the 1970s, one juvenile otter captured and tagged in the Kings Island area of the Merasheen archipelago, Placentia Bay, was later caught by a trapper in the Come By Chance area, representing some 40 to 50 km of range (D. Slade, retired wildlife technician, pers. comm.). These findings support the hypothesis that otters in the survey area might use most of the archipelago. Placentia Bay otters could also conceivably interchange regularly with the Trinity Bay population, and vice versa.

2.5 Species at Risk

Species at Risk are defined broadly here to consider a variety of species that are listed under both federal and provincial lists. Species at Risk have been described above under the previous sections dealing with the terrestrial, freshwater and marine environments, but they must be assessed as a separate VEC because of their potential legal standing. Consideration is also given to the COSEWIC listings because some of these species may become listed under federal legislation in the near future.

2.5.1 Provincial Listings

The provincial legislation that concerns Species at Risk is the *Endangered Species Act*. As of October 6, 2006, five species are listed:

1. Boreal felt lichen;
2. Harlequin Duck;
3. Banded Killifish;
4. Red Crossbill; and
5. Peregrine Falcon.

Of all these species, only the boreal felt lichen and the Red Crossbill have been reported near the Project Area (I. Goudie and B. Mactavish, LGL, pers. comm.). The boreal felt lichen is specific in its habitat requirements (I. Goudie, LGL, pers. comm.) whereas the Red Crossbill, while rare, is very widely distributed and may be seen throughout the Island of Newfoundland (B. Mactavish, LGL, pers. comm.).

2.5.2 Federal Listings

The relevant *SARA* Schedule 1 listing is provided below (November 3, 2006).

SARA Schedule 1 Endangered Species

Common Name	**Scientific Name**
Newfoundland marten	*Martes americana atrata*
Blue whale, Atlantic population	*Balaenoptera musculus*
North Atlantic right whale	*Eubalaena glacialis*
Piping Plover	*Charadrius melodus*
Red Crossbill, *percna* subspecies	*Loxia curvirostra percna*
Leatherback sea turtle	*Dermochelys coriacea*

SARA Schedule 1 Threatened Species

Common Name	Scientific Name
Northern wolffish	*Anarhichas denticulatus*
Spotted wolffish	*Anarhichas minor*

SARA Schedule 1 Special Concern

Common Name	Scientific Name
Fin whale, Atlantic population	*Balaenoptera physalu*
Barrow's Goldeneye Eastern population	*Bucephala islandica*
Harlequin Duck, Eastern population	*Histrionicus histrionicus*
Peregrine Falcon *anatum* subspecies	*Falco peregrinus anatum*
Ivory Gull	*Pagophila eburnea*
Banded Killifish, Newfoundland population	*Fundulus diaphanus*
Atlantic Wolffish	*Anarhichas lupus*
Boreal felt lichen, Boreal population	*Erioderma pedicellatum*

Of the above federally-listed species, only three might be encountered, in or immediately adjacent to the Project Area:

1. Boreal felt lichen;
2. Red Crossbill; and
3. Wolffishes.

However, many of the listed fish, sea turtle and marine mammal species, and several of the bird species, could potentially be encountered in Placentia Bay, with the exception of the banded killifish, a freshwater species that may occur occasionally in the general area. The killifish has not been reported in the Project Area after surveys by electrofishing, fyke nets, gill nets and baited pots (AMEC 2007a).

2.5.3 COSEWIC Listings

As stated previously, it is advisable to examine the COSEWIC listing as some of these species may attain (or change) the federal and/or provincial legal listings during the life of the Project.

An analysis of the COSEWIC listings (August 2006) concludes that the Ivory Gull will likely change *SARA* status from *special concern* to *endangered*. Other potential relevant changes to *SARA* include potential inclusion of porbeagle shark (*Lamma nasus*) as endangered; shortfin mako shark (*Isurus oxyrinchus*) as threatened; and harbour porpoise (*Phocena phocena*), Sowerby's beaked whale (*Mesoplodon bidens*), and American eel (*Anguilla rostrata*) as *special concern*. All of these species have been included in the species descriptions and considered for inclusion in this EIS as a precautionary measure.

For legal purposes, the *SARA* establishes Schedule 1 *endangered* and *threatened* species as the official list of Species at Risk. Species that were designated at risk by COSEWIC prior to October 1999 must be reassessed using revised criteria before they can be considered for addition to Schedule 1 of *SARA*.

2.5.4 Species Profiles

Most species profiles are provided above in the relevant sections. Additional descriptive material is provided below.

Wolffishes

Three wolffish species may occur in Placentia Bay. Northern wolffish and spotted wolffish are listed as *threatened* on Schedule 1 of *SARA*, and the Atlantic wolffish is listed as a species of *special concern*. Of the three species, northern wolffish is the deepest residing species and Atlantic wolffish is the shallowest. Based on DFO trawl surveys in Newfoundland and Labrador waters between 1971 and 2003 (Kulka et al. 2004), northern wolffish were most concentrated during December to May in areas where depths ranged from 500m to 1,000 m, shifting to slightly shallower areas from June to November. Spotted wolffish concentrations were highest in areas with water depths ranging from 200 m to 750 m at all times of the year, peaking in 300 m areas from June to November. Atlantic wolffish were most concentrated in areas with depths approximating 250 m at all times of the year.

These three species were described in more detail in Section 2.4.5 above.

Banded Killifish

The Newfoundland population of banded killifish was designated as *special concern* by COSEWIC in May 2003 (COSEWIC 2003) and was listed as a species of *special concern* on Schedule 1 of *SARA* in June 2003; a draft management plan for this population has recently been prepared (Osborne and Brazil 2006).

The Newfoundland population represents the easternmost extent of this species' range. There are seven documented populations of banded killifish on the Island of Newfoundland, including two on the Burin Peninsula (Winterland and Freshwater Pond).

The banded killifish is a euryhaline species but typically inhabits freshwater streams and ponds. Its documented occurrence in estuarine habitat is rare. It was reported many years ago that four specimens were caught in brackish water in St. George's Bay on the west coast of Newfoundland (Scott and Crossman 1964 *in* Scott and Scott 1988). The killifish has not been reported in the Project Area after surveys by electrofishing, fyke nets, gill nets and baited pots (AMEC 2007a).

3.0 Assessment Methods

The methods of effects assessment used are generally comparable to other current environmental assessments and conform to the *Canadian Environmental Assessment Act* (*CEAA*) (Government of Canada 2003), the Responsible Authority's Guide (CEA Agency 2000), and the provincial *Environmental Protection Act*. Guidance was also provided by the federal/provincial Guidelines for the Environmental Impact Statement (EIS). Cumulative effects were assessed in accordance with the *CEAA* (see CEA Agency 1994a, 1999; Barnes et al. 2000).

3.1 Scope

Scoping of an environmental assessment includes determining the spatial and temporal boundaries of the assessment, selecting which components (i.e., sensitive and/or representative species or species-groups and associated habitats) of the ecosystem to assess, and which project activities to analyze. Input was sought from relevant government agencies such as the CEA Agency, DFO, Environment Canada, NRCan, Transport Canada, municipalities, stakeholders, the public, VBNC, and consultants.

Both the Project Registration and Draft EIS Guidelines were available for public review and comment. In addition, VBNC has been conducting public and stakeholder information and consultation sessions for several years as detailed in Volume 1. All relevant information on Project activities and available literature on the effects of nickel ore processing activities (with emphasis on previous environmental assessments for Newfoundland and Labrador) were reviewed in order to assist in issue scoping. Furthermore, VBNC commissioned a series of modelling studies (as described below) to further aid in identifying potential issues and to assist in defining Study Area and potentially affected area boundaries.

As a minimum, the scope of the Project assessed in this EIS is in accordance with the descriptions provided in the Guidelines and in the federal Screening Scoping Document. In addition, the Scope of Assessment takes into account and addresses all the factors laid out in these two documents.

3.2 Information Base and Supporting Studies

A wide variety of databases and existing information were used in this EIS. These sources are described in 'Existing Environment' (Chapter 2.0) and the individual VEC sections that follow. VBNC also commissioned a series of baseline and supporting studies:

- Atmospheric Environment – SENES (2007a,b);
- Terrestrial Environment – JWL (2007a);
- Freshwater Environment – AMEC (2007a);
- Marine Environment – LGL (2007a); and
- Ecological Risk Assessment - Intrinsik (2007, 2008).

Other environmental assessments have been completed for Placentia Bay and may contribute relevant information:

- Argentia offshore support site (ADC 1983);
- Placentia Bay environmental impact study (Newfoundland Environmental Consultants Limited et al. 1986);
- Long Harbour phosphorus plant decommissioning (Albright & Wilson Americas 1994a,b);
- Oil transhipment terminal (Chevron et al. 1996); and
- Newfoundland and Labrador Refining Corporation (NLRC 2007).

Air emissions were modelled for the Construction and Operation phases of the Project by SENES (2007a) using the CALMET/CALPUFF modelling system. Airborne noise was modelled by SENES (2007b). Marine effluent discharge and dilution modelling was conducted by Oceans (2006). Equilibrium modelling (PHREEQC) and sediment modelling (BBLTv7 and SEDTRANS96) were conducted by AMEC (2007b,c). A formal Environmental Risk Assessment (ERA) and a human health risk assessment (HRA) were conducted by Intrinsik (2007, 2008). The ERA analysed a number of potential ecological vectors for a suite of metals including nickel. A variety of "reasonable worst-case" accidents were modelled by AMEC and SGE-Hatch for accidental events such as fuel and acid spills, dam failures, and chlorine release.

3.3 Boundaries

Temporal and spatial boundaries have been defined using the federal/provincial EIS Guidelines, CEA Agency (2003), and the results of modeling as guidance.

3.3.1 Temporal

Effects have been assessed for the three project phases: (1) Construction (Year 1 to Year 4, tentatively); (2) Operation (15 years); and (3) Decommissioning (approximately six years). Temporal boundaries are therefore from 2008 to 2031, a period of 25 years.

3.3.2 Spatial

Project Area. The Project Area is considered to be the footprint of the Project's infrastructure and major activities (e.g., plant site, disposal area, wharf, pipeline, and diffuser) and any exclusion zones that may be set up during construction for safety reasons (Figure 3.1). On land, the Project Area boundary is defined by the property boundaries, although the actual physical footprint of the facilities will be smaller. In the marine environment, the Project Area is defined as the wharf, the effluent pipeline corridor, and a shipping corridor from the entrance to Long Harbour to wharfside.

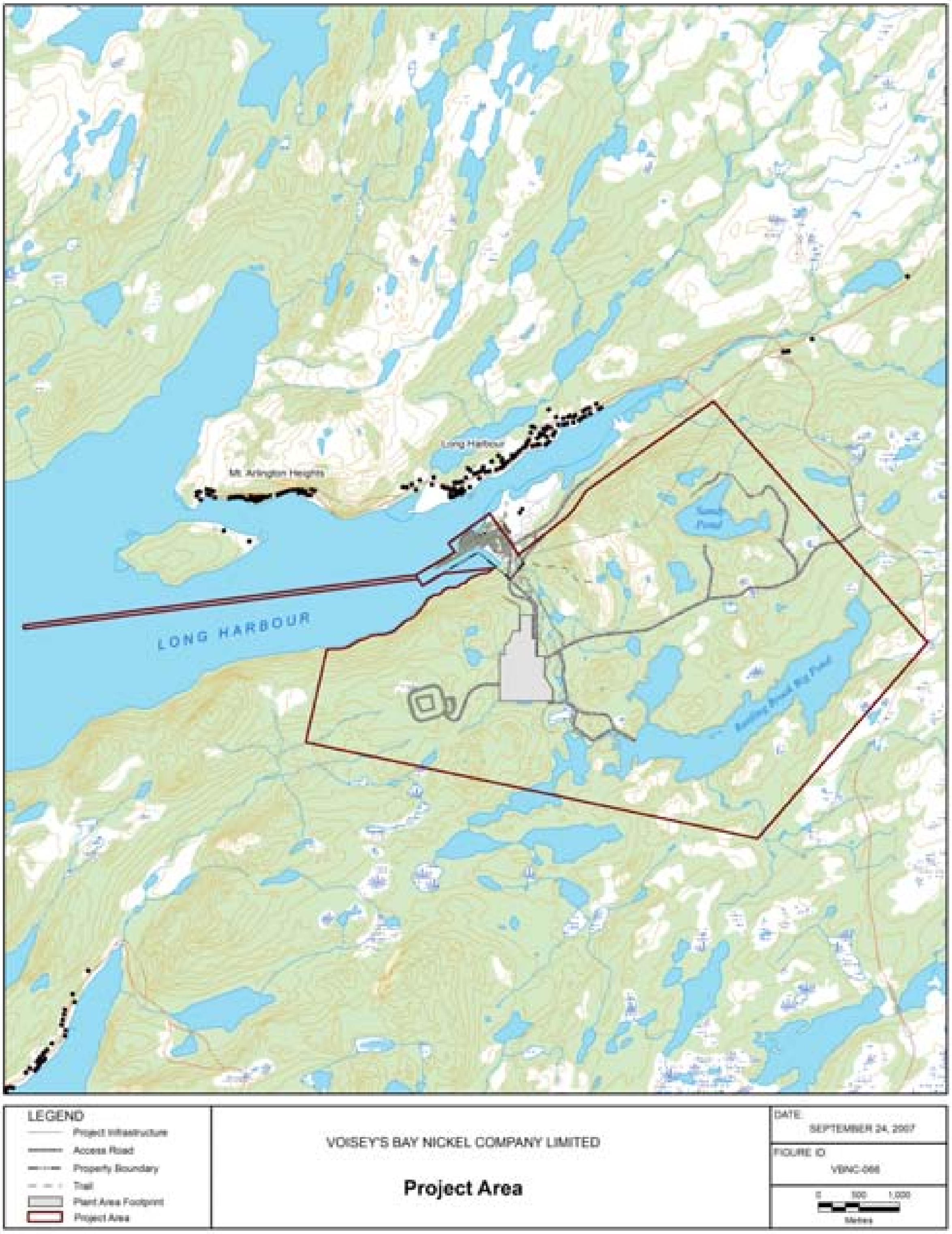

Figure 3.1 Project Area

Geographic Extent. This term originated with *CEAA* and refers to the geographic area of specific effects on a species, a species group, or their habitats. It varies according to the timing and type of Project activity and the sensitivities being assessed. The geographic extent boundaries were determined with the aid of existing literature and modeling exercises.

Study Areas. The Study Areas (Figure 3.2 and Figure 3.3) have been defined to encompass the farthest extent of Project potential influence. A large accident represents the worst-case scenario and its geographic envelope was defined by modelling. Note that the Study Areas may vary by ecosystem. For the purposes of defining atmospheric, terrestrial, and freshwater Study Areas, the zone of potential influence for a major accident falls within a 10-km radius of the centre of the Project Area. For routine project activities, the focus is on the watersheds within and adjacent to the Project Area, i.e., Rattling Brook, Sandy Pond and proximate small drainage basins. The marine Study Area is defined as Placentia Bay, although the focus is on Long Harbour.

Regional Areas. Regional ecological areas are defined as Placentia Bay on the seaward side and the Avalon Peninsula on the landward side. The Regional Area definition is useful in focusing broad-scale environmental variables such as currents, climate, and fisheries. It is also useful in the discussion of cumulative effects, especially in cases where there is uncertainty in the geographic scope of effects.

Other Boundaries. Other boundaries include administrative boundaries, such as the Assessment Area and Region commercial fisheries statistical boundaries, development zones, municipal, and provincial boundaries as described in Volume 3.

3.4 Biophysical Effects Assessment

The systematic assessment of the potential effects of the Project involved three major steps:

1. Identification of all potential interactions between Project activities and each VEC;
2. Evaluation of each interaction, consideration of mitigation measures and predictions of likely effects; and
3. Description and evaluation of the residual effects, including consideration of cumulative effects.

Interaction matrices were prepared to identify all possible Project activities that could interact with any of the VECs. The matrices list activities by phase and identify potential interactions; however, they make no assumptions about the potential consequences of the interactions. At the next stage of assessment, each identified interaction is evaluated for its potential to cause effects. Where the potential was deemed unlikely or incidental, they were not considered further. In this way, the assessment focused on key issues and substantive environmental effects.

Figure 3.2 Marine Study Area

Figure 3.3 Airshed, Terrestrial and Freshwater Study Areas

An interaction was considered to be a potential effect if it could change the abundance or distribution of VECs directly or indirectly. The potential for an effect was assessed by considering six criteria:

1. The location and duration of the interaction;
2. The existence of any pathways between the project activity and the receiving environment,
3. Modelling exercises;
4. Existing literature on similar interactions and associated effects (including previous environmental assessments);
5. Consultation with experts; and
6. Results of monitoring done in other areas.

When data were insufficient to allow certain or precise effects evaluations, predictions were made based on professional judgment. In such cases, the uncertainty is documented in the EIS. In most cases, the potential effects of coastal developments are reasonably well known. Effects were evaluated for the proposed Project, which includes many mitigation measures that are mandatory or have become standard operating procedure in the industry.

The characterization of effects included the consideration of key factors that are considered for determining adverse (i.e., negative) environmental effects, per the CEA guidelines (CEA Agency 1994b), namely:

- Negative effects on the health of biota;
- Loss of rare or endangered species;
- Reductions in biological diversity;
- Loss or avoidance of critical/productive habitat;
- Fragmentation of habitat or interruption of movement corridors and migration routes;
- Transformation of natural landscapes;
- Discharge of persistent and/or toxic chemicals;
- Toxicity effects on human health;
- Loss of, or detrimental change in, current use of lands and resources for traditional purposes;
- Foreclosure of future resource use or production; and
- Negative effects on human health or well-being.

[A negative effect in this EIS is as described below. A positive effect is not normally considered under CEAA. In this EIS, a positive effect is simply an improvement over existing conditions.]

Many potential effects can be moderated, reduced or eliminated through the application of mitigation measures, many of which have become standardized into operating procedures and regulatory requirements. In some cases, project or interaction – specific measures are developed, including changes in equipment, procedures, or timing of activities. As an important stage of effects prediction, mitigation measures are identified and committed to, and their effectiveness taken into account, in considering the "residual" or remaining potential effects of Project activities. Note that many of these mitigation measures have been incorporated into the Project Design, often as a consequence of the Demonstration Plant experience, which provided a unique opportunity to test the applicability of such measures. The designed-in approach to mitigation means that most of these measures are described in the Project Description (Volume 1) and already committed to by Vale Inco NL.

3.4.1 Evaluation Criteria

Consistent with the *CEAA* and CEA Agency guidance, five criteria must be used when evaluating the nature and extent of environmental effects:

1. Magnitude;
2. Geographic extent;
3. Duration and frequency;
4. Reversibility; and
5. Ecological, socio-cultural and economic context.

Magnitude

Magnitude describes the nature and extent of the environmental effect for each activity. For biological VECs the following definitions apply:

Negligible — An interaction that may create a measureable adverse effect on individuals but would never approach the 10 per cent value of the 'low' rating. Rating = 0.

Low — Affects >*negligible* to 10 per cent of individuals in the affected area (e.g., geographic extent). Effects can be outright mortality, sublethal adverse effects or exclusion due to disturbance. Rating = 1.

Medium — Affects >10 to 25 per cent of individuals in the affected area (e.g., geographic extent). Effects can be outright mortality, sublethal adverse effects or exclusion due to disturbance. Rating = 2.

High — Affects more than 25 per cent of individuals in the affected area (e.g., geographic extent). Effects can be outright mortality, sublethal adverse effects or exclusion due to disturbance. Rating = 3.

For physical VECs (e.g., air or water quality), magnitude was defined as:

Negligible — An interaction that may create a measureable effect on normal ambient conditions but would never approach the 10 per cent value of the 'low' rating. Rating = 0.

Low	Causes >*negligible* to 10 per cent change in the affected area (e.g., geographic extent). Rating = 1.
Medium	Causes >10 to 25 per cent change in affected area (see geographic extent). Rating = 2.
High	Causes more than 25 per cent change in the affected area (e.g., geographic extent). Rating = 3.
Note:	Where a regulatory standard is in place, compliance will justify assignment of a Low or Negligible magnitude where compliance can be confirmed.

Geographic Extent

Geographic extent for the biophysical effects is simply the spatial extent (e.g., km^2) of an effect, which may be defined in various ways, including chemical, biological, or behavioural.

Six ranges were used for geographic extent:

1 = <1 km^2;
2 = 1 – 10 km^2;
3 = 11 – 100 km^2;
4 = 101– 1,000 km^2;
5 = 1,001– 10,000 km^2; and
6 = >10,000 km^2.

These ranges are consistent with numerous major East Coast Canada *CEAA* environmental assessments conducted over the last decade, including White Rose, Laurentian Sub-basin, Orphan Basin, and others.

Duration

Duration describes the temporal aspects of an interaction or effect. For biophysical VECs, duration is classed as:

1 = <1 month;
2 = 1 – 12 months;
3 = 13 – 36 months;
4 = 37 – 72 months; and
5 = >72 months.

Short duration can be considered 12 months or less, and medium duration can be defined as 13 to 36 months.

Frequency

Frequency for biophysical effects addresses interactions with short but repeated duration. Frequency is usually expressed in terms of a one-year cycle.

Reversibility

Reversibility refers to the ability of a VEC to return to an equal, or improved condition, at the end of the Project. It should be noted that a biological effect may be irreversible at the individual level (e.g., mortality of an individual animal) but reversible at the population level.

Socio-Economic Context

The ecological, socio-cultural, and economic context describes the current status of the area affected by the Project in terms of existing environmental efforts.

3.4.2 Cumulative Effects Assessment

Cumulative effects must be assessed for within-project activities as well as for external projects. Other projects and activities within Placentia Bay considered in the cumulative effects assessments are described in Section 3.7.

3.4.3 Residual Environmental Effects

Once potential effects have been identified and characterized, mitigation measures are described and, based on an evaluation of effectiveness, the residual environmental effects are identified and noted for significance with respect to:

- Each Project activity or accident scenario;
- Cumulative effects of project activities within the Project; and
- Cumulative effects of combined projects within the Regional Area, with emphasis on the Study Area.

These ratings are presented in summary tables of residual environmental effects. The last of these points considers all residual environmental effects, including Project and other-project cumulative environmental effects. As such, this represents an integrated residual environmental effects evaluation.

The analysis and prediction of the significance of environmental effects, including cumulative environmental effects, encompasses three criteria:

1. Determination of the significance of residual environmental effects;
2. Establishment of the level of confidence for the prediction; and

3. Evaluation of the likelihood of a predicted significant effect occurring and the scientific certainty and probability of occurrence of the residual impact prediction.

Ratings for level of confidence, probability of occurrence, and determination of scientific certainty associated with each prediction are presented in the tables of residual environmental effects. The guidelines used to assess these ratings are discussed in detail in the sections below.

Significant environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EIS, a *significant* effect (biophysical) is defined as:

> *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2.*

The prediction of residual environmental effects can be based on different prediction mechanisms, e.g., relevant literature, consultation with experts, mathematical models, and professional judgment. Different levels of certainty or reliability may apply, especially where there are limitations of available data. Ratings are therefore provided to indicate, qualitatively, the level of confidence for each prediction.

It is acknowledged that the definition of significance employed is not suited to every situation. For example, it might be possible for some endangered species critical habitat to be less than 100 km^2, in which case a more stringent criterion would be appropriate. For the Project, however, no such situations have been encountered. Given the scale of the undertaking and its zone of influence (as shown, e.g., through modeling) the definition appears reasonable. As a consequence, the definition has been applied consistently within the biophysical assessment and in a manner consistent with other Canadian environmental assessments. This consistency has relevance, especially in consideration of cumulative effects assessment.

3.4.4 Likelihood of Occurrence of Significant Effects

The two criteria for the evaluation of the likelihood of significant effects were probability of occurrence and scientific certainty.

Note that likelihood criteria only apply where the prediction is for a significant effect.

3.5 Accidental Events Assessment

Potential major accident scenarios were modelled to help estimate the extent of effects, should one of these unplanned events occur. The results of the modeling simulations are approximations and indicate the order of magnitude of the potential events that could discharge to water (fresh and sea), land or air.

The accidental event scenarios were examined and refined to indicate reasonable "worst-case" scenarios for catastrophic events. Of course in actual practice, every measure will be taken to prevent such occurrences and to have a high level of emergency preparedness in place. Nonetheless, for the purposes of effects assessment, five scenarios were identified for consideration.

The effect on each VEC is described, followed by an assessment of the effect using the criteria and rating system described above.

3.6 Follow-up and Monitoring

Environmental effects monitoring (EEM) or follow-up monitoring are designed to confirm effects predictions and to establish the effectiveness of mitigation measures. The process of effects predictions will therefore provide a basis for the development of appropriate and focused monitoring programs, which will be developed and implemented as part of all Project phases. In many cases, the data collected in support of the EIS will provide a basis for EEM design.

3.7 Other Projects Used for Cumulative Effects Assessment

Overview descriptions of existing and proposed projects or activities that were analysed for the cumulative effects predictions are provided below.

3.7.1 Vale Inco NL Activities

Vale Inco NL is operating a hydrometallurgical nickel-processing demonstration plant in Argentia, Newfoundland, that is capable of processing up to 10 tonnes per day of concentrate containing nickel, cobalt, and copper. This Demonstration Plant started in October 2005 with a staff of 150 people to undertake a development program on hydrometallurgical technology, and is scheduled to continue operating until June 2008.

3.7.2 Oil Transshipment Facility

The Newfoundland Transshipment Terminal (NTT) is located at Whiffen Head, on the northeastern shore of Placentia Bay. The terminal was constructed to accept production from the Hibernia oil field and from other oil fields on the Grand Banks. Crude oil is transported year-round to the facility by 127,000 DWT shuttle tankers (cargo capacity of about 850,000 barrels), and to market by various second-leg tankers.

A U.S.-based terminal operator, International Matex Tank Terminals (IMTT), employs a staff of 21 to manage and operate the terminal; 20 Canship Ugland employees work on the tugs, and the facility is able to store three billion barrels of crude oil.

Three shuttle tankers supporting the Hibernia and Terra Nova offshore fields deliver approximately two million barrels a week to the terminal. Conventional oil tankers then transport the oil to the Canadian and eastern U.S. markets. In support of the Grand Banks oil fields, the facility handles about 300 tankers per year. In addition, the terminal employs the services of two purpose-built escort and firefighting tugs. The *Placentia Pride* and *Placentia Hope* are used to escort and assist tankers into and out of the terminal port.

3.7.3 Come By Chance Oil Refinery

The Come By Chance Oil Refinery is located on the eastern shore near the head of Placentia Bay. The 115,000 barrel-a-day refinery operates under the management of North Atlantic Refining Limited. It produces low-sulphur, clean fuels from Middle Eastern, Russian and Venezuelan sour crude, and employs a workforce of over 700. Both crude and refined product is transported in tankers (see 3.7.11).

3.7.4 Burin Peninsula Ship Yards

Marystown Shipyard and the Cow Head Steel Fabrication Facility are located near Marystown on the Burin Peninsula, on the west side of Placentia Bay. The shipyard has been an important supplier of goods and services for offshore industries. The Cow Head Facility is a self-contained steel fabrication plant, which includes fabrication facilities for plate, profiles, pipe and titanium as well as a blast and paint shop.

The KOS Shipyard (Marystown shipyard) is owned by Peter Kiewit and Sons, a member of the ThyssenKrupp Marine Systems Canada group. Kiewit is one of two consortia bidding on a $2.1-billion joint support ships (JSS) contract. The contract is to be awarded in June/July 2008 and the first ship must be delivered by 2012. If Kiewit's bid is successful, construction of these ships would begin in late 2009 or early 2010, overlapping construction of the Project. The JSS contract is estimated to take between 550 and 600 people from the labour pool.

3.7.5 Commercial Fish Industry (including aquaculture)

Placentia Bay hosts a diverse fishery prosecuted by a variety of gear types, including fixed gear such as pots, traps, longlines, and gillnets. In addition, there are a number of blue mussel farms as well as some potential future ones. Commercial fisheries and aquaculture are described in detail in Volume 3.

3.7.6 Argentia Marine Terminal

The Marine Atlantic Terminal is one of three wharves administered by the Argentia Port Corporation, a wholly owned subsidiary of the Argentia Management Authority Inc. Marine Atlantic, a federal Crown corporation, provides passenger and vehicle ferry service between Argentia and Nova Scotia from June to September. The ferry wharf can be used by other vessels between October and May with permission from Marine Atlantic (AACC 2003).

In each of 2005 and 2006 there were 80 ferry crossings (Newfoundland and Labrador Department of Tourism, Culture and Recreation, NLDTCR 2007).

3.7.7 Hunting and Trapping

Hunting and trapping activities are described in Volume 3. Inland hunting in the Placentia Bay area targets moose, caribou, black bear, rabbit, waterfowl, ptarmigan, and grouse. Marine-based hunting targets murres (‘turres’) and a few harp seal. It is known that a large number of turres are taken in Placentia Bay in late winter and early spring, but exact numbers are unknown (P. Ryan, CWS, pers. comm.).

3.7.8 Forestry

Wood harvesting is described in Volume 3. It includes local harvesting of firewood, small sawmill operators, and a commercial harvest on the Avalon Peninsula.

3.7.9 Proposed Oil Refinery

Newfoundland and Labrador Refinery Corporation proposes to construct an oil refinery at Southern Head, between North Harbour and Come By Chance, at the head of Placentia Bay. An Environmental Assessment of the proposed project is currently under way and an Environmental Impact Statement was recently submitted to Government. The oil refinery is proposed to have an initial production capacity of 300,000 barrels per day with the option to expand to 600,000 barrels per day. Primary products of the oil will be gasoline, kerosene/jet fuel, ultra-low sulphur diesel, and refining by-products. Infrastructure will include process facilities, marine terminal, crude and product storage tanks, access road, and utilities. Annual shipping is estimated at 400, and possibly as many as 425 tankers and bulk carriers, depending on vessel size. Construction will take approximately three years to complete, with a peak construction workforce of 3,000 people. Production will support 750 operations jobs.

3.7.10 Proposed Liquefied Natural Gas Transshipment Terminal

Newfoundland LNG Limited proposes to construct a Liquefied Natural Gas (LNG) Transshipment and Storage Terminal near the head of Placentia Bay at Grassy Point, Arnold’s Cove. The terminal will provide storage and offloading for large LNG vessels for transfer to small LNG carriers for distribution to northeastern U.S. and Canada. The purpose of the project is to provide cargo transfers and for the short-and long-term storage of natural gas (primarily methane) in its super-cooled liquid state. The project will involve construction of a wharf comprised of three jetties with berthing capacity for LNG tankers up to 265,000 m^3 capacity (345 metres long), eight LNG storage tanks with a capacity of 160,000 m^3 each, a tug-boat basin, and supporting infrastructure including an access road, office facilities, and security fencing. Annual shipping is estimated at up to 400 tankers, depending on vessel size.

3.7.11 Marine Transportation

Vessels navigating in Placentia Bay comprise oil tankers and chemical tankers transiting to refineries and transshipment facilities at the head of the bay, fishing vessels, ferries, and general cargo vessels to Argentia and Marystown. Navigation is governed by regulations issued pursuant to the *Canada Shipping Act* and other Acts, and follows a vessel routing system (traffic separation scheme) known as the Placentia Bay Routing System (PBRS). Table 3.1 shows the volume of vessel traffic in 2006, provided by the Canadian Coast Vessel Traffic Services (VTS). Many movements within the bay (4,538) are by tugs operating from the refinery and terminal (1,651), vessels less than 20 m (1,046) and ferries (1,841).

Most of the projects and activities described in the previous sections contribute some type of marine transportation. It should be noted that only those vessels that report to the VTS are included in Table 3.1 which undoubtedly does not contain all the fishing vessel and boat traffic.

Table 3.1 Ship Movements in Placentia Bay from Vessel Traffic Services (VTS) Data, (A) January to December 2006 and (B) January to May 2007

(A) January to December 2006						
Vessel Type	**Inbound**	**Outbound**	**Transit**	**In-Zone**	**Out-Zone**	**Total**
Tanker (<50,000 DWT)	118	129	30	59	0	336
Tanker (>50,000 DWT)	239	238	15	123	0	615
Chemical tanker	15	4	3	9	0	31
LPG/LNG carrier	0	0	0	0	0	0
General cargo	22	26	36	14	0	98
Bulk cargo	8	8	11	2	0	29
Container	60	59	232	7	0	358
Tug	10	10	1	1,630	0	1,651
Tug with oil barge	1	0	0	0	0	1
Tug with chem barge	0	0	0	0	0	0
Tug with tow	6	6	4	6	0	22
Government	35	34	35	74	0	178
Fishing	29	27	10	6	0	72
Passenger	2	2	2	0	0	6
Other (20 m)	7	6	1	935	0	949
Vessels (<20 m)	0	20	17	1,009	0	1,046
Sub-total movements	552	569	397	3,874	0	5,392
Ferry	40	40	29	1,732	0	1,841
Total	592	609	426	5,606	0	7,233
(B) January to May 2007						
Vessel Type	**Inbound**	**Outbound**	**Transit**	**In-Zone**	**Out-Zone**	**Total**
Tanker (<50,000 DWT)	47	53	7	27	0	134
Tanker (>50,000 DWT)	125	126	7	88	0	346
Chemical tanker	6	0	2	0	0	8
LPG/LNG carrier	0	0	0	0	0	0
General cargo	16	14	8	2	0	40
Bulk cargo	2	2	1	0	0	5
Container	21	21	94	12	0	148
Tug	8	11	4	822	0	845
Tug with oil barge	0	0	0	0	0	0
Tug with chem barge	0	0	0	0	0	0
Tug with tow	5	2	7	0	0	14
Government	20	20	9	29	0	78
Fishing	9	11	7	7	0	34
Passenger	0	0	0	0	0	0
Other (>20 m)	2	2	0	409	0	413
Vessels (<20 m)	0	5	6	293	0	304
Sub-total movements	261	267	152	1,689	0	2,369
Ferry	4	3	15	709	0	731
Total	265	270	167	2,398	0	3,100

Notes: Ship Movements: Ships are those with which VTS has direct communications and/or radar contact and which VTS is able to identify.
Inbound: A vessel entering a VTS Zone from outside the zone limits.
Outbound: A vessel exiting the limits of a VTS Zone.
Transit: No arrival nor departure port within the zone.
In-zone: Any movement which begins and ends within the limits of a VTS Zone and does not exit the zone.
Out-zone: Any vessel participating in VTS but which is not within a VTS zone of responsibility.
Source: S. Hynes, pers. comm., 2007.

4.0 Air Quality Effects Assessment

This VEC serves as a pathway for transport of contaminants that can interact with several other VECs; consequently many effects associated with altered air quality will be addressed for these receptor VECs. There are standards for air quality that apply to industrial emitters and these can be applied in making effects predictions.

4.1 Existing Conditions

Existing air quality conditions in the Region, based on available air quality monitoring data, are described in detail in the Air Dispersion Modeling Assessment (SENES 2007a) and summarized below in Table 4.1. There are no known major sources of airborne metals in the vicinity of the Project Area; hence the actual baseline concentrations at the Long Harbour Project site are probably lower than shown.

Table 4.1 Representative Background Air Concentrations in the Regional Study Area

Parameter	Newfoundland Air Quality Standard ($\mu g/m^3$)		Background Concentration ($\mu g/m^3$)	
Averaging Time	**(24-hour)**	**(annual)**	**(24-hour)[1]**	**(annual)**
Nitrogen dioxide (NO_2)	200	100	4	2
Particulate matter (PM_{10})	50	-	12	5
Respirable particles ($PM_{2.5}$)	25	-	7	2.5
Sulphur dioxide (SO_2)	300	60	78	3

Note: [1] Average of available 90th percentile data (see SENES 2007a for further details on the sources of data).

4.2 Assessment Criteria

The three study areas defined in Chapter 3.0 have been generally adopted for the characterization of air quality. An effect on air quality was considered to be potentially significant if the concentration at the closest residential receptors increases 10 per cent or more above existing concentrations on a 24-hour or annual basis.

4.3 Issues and Concerns

Air quality has the potential to affect all living things in the local and regional area, including plants, animals, and humans. Generally, elevated levels of total particulate matter are primarily a visibility issue. However, elevated levels of other contaminants such as fine particulate, nitrogen oxides, sulphur dioxide, and metals can affect human health as well as terrestrial biota. As such, the potential effects on air quality determined in the Air Dispersion Modeling Report (SENES 2007a) are addressed in the Environmental Risk Assessment (ERA) and Human Health Risk Assessment (HRA) studies (Intrinsik 2007, 2008).

4.4 Existing Knowledge

Information on background air quality is summarized in Table 4.1. Elevated particulate levels, associated primarily with civil construction activities, and to a lesser extent also with many industrial operations activities, are known to affect air quality. Elevated levels of particulate matter can also affect visibility within the Project Area.

Elevated levels of nitrogen oxides and sulphur dioxide, associated primarily with combustion equipment used during Construction and Operation, have the potential to affect air quality. Elevated levels of nitrogen oxides and sulphur dioxide could have negative health effects on people residing within the affected area.

Elevated levels of metals, in particular nickel, cobalt, and iron associated with the Operation Phase, have the potential to affect air quality. Elevated levels of metals could have negative health impacts.

4.5 Effects of Construction

Potential interactions between the Project and the atmosphere are illustrated in Table 4.2 for the Construction Phase. Based on the construction schedule (ongoing from Year 1 to Year 4), it was determined that activities that overlap during the initial year of construction are the most likely to result in potential "reasonable worst-case" effects on the closest residences to the site. The construction activities during this period and their potential interactions with various components of air quality are listed in Table 4.2.

The most notable activities include earthworks, wharf expansion, and vehicle traffic. These activities have the potential to generate higher levels of dust than activities that occur during the latter half of the Construction Phase, such as the construction of underground services, cross-country pipelines, concrete foundations, process and non-process building erection, mechanical and piping, field tankage, electrical and instrumentation. In addition to the potential to generate dust, the estimated peak heavy construction equipment numbers for the chosen period are higher than those for other construction periods, resulting in elevated levels of combustion gases such as NO_x.

Based on the location of primary clearing and grubbing zones for the first-year construction period, the largest concentrated areas of activities were estimated to be the development of the plant and wharf areas. These construction areas are also closest to the human receptors at Long Harbour-Mount Arlington Heights.

As demonstrated in Table 4.3 and discussed in the following section, the effects of the Construction Phase works and activities on air quality are expected to be minimal.

Table 4.2 Potential Interactions between Construction and Air Quality

Valued Ecosystem Component: Air Quality		
Project Activity	Air Quality Components	
	NO_x	Dust
Construction Activities and Physical Works		
Earthworks[1]	✓	✓
Wharf expansion	✓	✓
Dredging	✓	
Shore and scour protection		
Blasting	✓	✓
Effluent pipeline	✓	
Atmospheric emissions (incl. dust)	✓	✓
Roads	✓	✓
Storm system	✓	✓
Sewage system	✓	✓
Pipelines	✓	✓
Water supply dam	✓	✓
Residue storage dams	✓	✓
Power lines	✓	✓
Shipping	✓	
Vehicle traffic	✓	✓
Sewage		
Solid waste	✓	✓
Temporary power	✓	
Lighting		
Noise		

Note: [1] Includes all activities involving earthworks, including grubbing, excavation, grading and leveling.

Table 4.3 Effects Assessment of Construction on Air Quality

Valued Ecosystem Component: Air Quality								
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Construction Activities and Physical Works								
Earthworks	N	Watering and/or other dust mitigation measures will be applied if necessary.	1	1	6	4	R	1
Wharf expansion	N		1	1	6	4	R	1
Dredging	N	Not part of maximum emissions scenario						
Blasting	N							
Effluent pipeline	N							
Atmospheric emissions (incl. dust)	N		1	1	6	4	R	1
Roads	N	Watering and/or other dust mitigation measures will be applied if necessary.	1	1	1	2	R	1
Storm system	N	Not part of maximum emissions scenario						
Sewage system	N							
Pipelines	N							
Water supply dam	N							
Residue storage dams	N							
Power lines	N							
Shipping	N							
Vehicle traffic	N	Watering and/or other dust mitigation measures will be applied if necessary.	1	1	6	4	R	1
Solid waste	N	Not part of maximum emissions scenario						
Temporary power	N							

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

4.5.1 Air Emissions

Nitrogen Oxide (NO_x)

Dispersion modelling predicted elevated levels of NO_x at the Plant construction area, where the bulk of the heavy construction equipment will be operating (SENES 2007a). The 24-hour Newfoundland Air Quality Standard (AQS) of 200 µg/m^3 was not exceeded beyond the property boundary. Annual average NO_x concentrations at the Vale Inco NL property boundary are predicted to be well within the AQS.

Sulphur Dioxide (SO_2)

The maximum one-hour, 24-hour and annual concentrations of SO_2 are predicted to be small fractions of the applicable AQS. Construction activities are not anticipated to cause any elevated levels of SO_2, due to the use of low-sulphur diesel in construction equipment.

Dust

Neither the 24-hour Newfoundland AQS of 120 µg/m^3 nor the annual Newfoundland AQS of 60 µg/m^3 was predicted to be exceeded anywhere off property. Elevated levels of PM at areas with more intense dust-generating activities, namely the plant complex construction site, were identified.

4.5.2 Mitigation

For the Construction Phase, Vale Inco NL has committed to controlling fugitive emissions by following environmental protection procedures:

- Limit any stockpiling of materials to reduce fugitive dust emissions during construction;
- Use air filters and regular maintenance to control emissions;
- Establish and flag Buffer zones prior to any disturbance activities; and
- Leave natural vegetation in place wherever possible.

A detailed Environmental Protection Plan (EPP) will be prepared prior to start of construction.

4.5.3 Residual Effects

As indicated in Table 4.4, residual effects of routine construction activities on air quality are predicted to be *not significant*. Magnitude of effects could potentially range up to *high* in a very limited area (i.e., small areas within the Project Area), but it will be *negligible* to *low* outside the boundary; duration could be *37 to 72 months*, but again the geographic extent is relatively small because any exceedances are limited to the Project Area.

Table 4.4 Significance of Potential Residual Environmental Effects of Construction on Air Quality

Valued Ecosystem Component: Air Quality				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Construction Activities and Physical Works				
Earthworks	NS	3	-	-
Wharf expansion	NS	3	-	-
Dredging	NS	3	-	-
Blasting	NS	3	-	-
Effluent pipeline	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Roads	NS	3	-	-
Storm system	NS	3	-	-
Sewage system	NS	3	-	-
Pipelines	NS	3	-	-
Water supply dam	NS	3	-	-
Residue storage dams	NS	3	-	-
Power lines	NS	3	-	-
Shipping	NS	3	-	-
Vehicle traffic	NS	3	-	-
Solid waste	NS	3	-	-
Temporary power	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect

4.6 Effects of Operations

The predicted discharges from both processing scenarios are characterized in SENES (2007a). The results indicate that when comparing the maximum pollutant concentrations for the Hydromet Plant and Matte Plant scenarios, some contaminants for the Hydromet Plant scenario resulted in higher predicted concentrations (HCl, H_2SO_4, Mn, Fe, PM_{10} and NO_x) and for others the Matte Plant scenario predicted higher concentrations (Co, Ni, Cu, SO_2). While the Hydromet Plant has the potential for a process upset condition that may result in elevated releases of chlorine, this is not an issue for the Matte Plant (see Chapter 11.0, Accidental Events). Modelling for both scenarios predicted no exceedences of any of the air quality criteria outside of the Plant boundary. The criteria are met within the property boundary except occasionally within a very small area beside the facility where the modelling results are not reliable. The potential interactions between the Project and air quality for the Operation Phase are contained in Table 4.5.

The fugitive emissions from offloading of limestone and nickel concentrate (vessel unloading activity) represent less than one per cent of the produced total emissions and are considered to be *negligible* as a contributor to total facility discharges; hence this source was not considered further.

Road dust emissions from truck activity during the Operation Phase are anticipated to be 90 per cent lower than road dust emissions during the Construction Phase. Based on the predicted concentrations of dust during Construction, the impacts of road dust during Operations are anticipated to be *negligible*. Therefore, road sources were not considered further in the assessment for the Operation Phase.

Table 4.5 Potential Interactions between Operations and Air Quality

Valued Ecosystem Component: Air Quality	
Project Activity	**Air Quality**
Operational Activities and Physical Works	
Total footprint	
Material handling & storage	✓
Acid leaching process	✓
Solvent extraction process	✓
Treatment of undesired substances	✓
Residue storage	✓
Shipping	
Offloading	
Dust	✓
Washdowns/runoff	
Water use	
Electricity use	
Diesel use	✓
Fuel oil#2 use	✓
Atmospheric emissions (incl. dust)	✓
Marine effluent	
Site runoff	
Surge pond	
Sewage	
Solid waste	
Vehicle traffic	✓
Noise	
Lighting	
Maintenance	

As detailed in Table 4.6, any effects from the Operation Phase are negligible to *low* in magnitude, extend over a *very small geographic area* within the Project boundary, and generally occur for *short durations*. As stated above, all applicable criteria for all contaminants are met outside of the property boundary.

Table 4.6 Effects Assessment of Operations on Air Quality

Valued Ecosystem Component: Air Quality								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Operational Activities and Physical Works								
Material handling and storage	N	EPP	1	1	2	1	R	1
Acid leaching process	N	EPP, Design	1	1	1	1	R	1
Solvent extraction process	N	EPP, Design	1	1	1	1	R	1
Treatment of undesired substances	N	EPP, Design	1	1	6	5	R	1
Residue storage	N	Design	1	1	6	5	R	1
Offloading								
Dust	N		0-1	1	1	1	R	2
Diesel use	N		1	1	2	1	R	1
Fuel oil #2 use	N		1	1	2	1	R	1
Atmospheric emissions (incl. dust)	N		1	1	6	4	R	1 & 2
Vehicle traffic	N		0	1	6	5	R	1

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

4.6.1 Mitigation

Vale Inco NL is committed to the following design and operational measures to limit the emission and subsequent dispersion of contaminants from the Project.

Design

- Air pollution control systems:
  - Baghouses for hygiene dust control – used predominantly at concentrate and limestone transfer and handling locations;
  - Scrubbers for venting gas streams and copper electro-winning cells – used to reduce aerosol mists, chlorine gas and particulate carryover from entering the environment;
  - Adequate building ventilation to ensure good in-plant air quality; and
  - Water spray dust suppression, when required, for roads and for the Matte Plant residue storage site.
- Instrumentation and monitoring equipment will be provided for maintaining air quality standards within regulatory requirements.

Operations

- All equipment containing potential air contaminants will be routed through air pollution control equipment prior to release to the air.
- All conveyors will be covered and transfer points vented through air cleaning prior to release to air.
- Dust collection systems will be in place at all material transfer points and material will be conveyed between locations in covered conveyors.
- Air emissions will be monitored to ensure that environmental regulations are met.
- Environmental control equipment will be monitored to ensure that operating parameters are met.
- Precautions will be in place to monitor and prevent the release of chlorine gas produced during the process for the Hydromet Plant. Alarm systems and emergency safety procedures will be established to properly manage any accidental event involving chlorine.
- Contingency plans will be in place in the event of unplanned events such as a chlorine release from the Hydromet Plant.

4.6.2 Residual Effects

Of the 17 pollutants modeled in the Air Dispersion Assessment, none resulted in exceedances of the applicable standards within or outside of the property boundary. As indicated in Table 4.7, the residual effects of routine activities during the Operation Phase on air quality are predicted to be *not significant*.

Table 4.7 Significance of Potential Residual Environmental Effects of Operations on Air Quality

Valued Ecosystem Component: Air Quality				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Vessel unloading	NS	3	-	-
Dust	NS	3	-	-
Material handling & residue storage	NS	3	-	-
Acid leaching process	NS	3	-	-
Solvent extraction process	NS	3	-	-
Treatment of undesired substances	NS	3	-	-
Residue storage	NS	3	-	-
Diesel use	NS	3	-	-
Fuel oil#2 use	NS	3	-	-
Vehicle traffic	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect

4.7 Effects of Decommissioning

Details on Decommissioning activities are unknown and will depend upon government requirements current at the time. However, it is logical that air emissions resulting from the Project works and activities associated with the Closure and Post-closure components of the Decommissioning Phase will be less than those associated with the Construction and Operation phases. As the effects of the Construction and Operation phases on the air quality were shown to be relatively small, it is predicted that the Decommissioning Phase will have *no significant effects* on air quality.

4.8 Cumulative Effects

4.8.1 Within Project

The cumulative environmental effects from the Project on air quality are expected to be minimal. The predicted maximum 24-hour incremental concentrations for all pollutants at the closest residential receptors represent a small fraction of the applicable air quality standards under both the Construction and Operation phases. As the phases will not overlap, there will be no cumulative effects on air quality.

No exceedances of air quality standards outside of the property boundary were predicted during the Construction Phase, based upon incremental concentrations. A comparison of cumulative concentrations (project-related concentrations plus existing concentrations) with the air quality standards, while not included in the Air Dispersion Modelling Assessment because of the conservative nature of data on existing concentrations, would also reflect compliance with air quality standards off-property.

No exceedances were predicted during the Operation Phase.

4.8.2 With Other Projects

The Project air quality effects, in general, do not extend beyond the property boundary. As there are no other facilities in close proximity, it is not expected that the Project will affect the air quality at/near other facilities in the area, such as the Port of Argentia, Marystown shipyard, Cow Head, or the Come By Chance area.

4.9 Summary of Effects on Air Quality

The results for the Construction Phase show that the maximum predicted 24-hour and annual concentrations of NO_x and PM exceed the Newfoundland AQSs in small on-site areas in the vicinity of the construction operations, and no exceedances of the AQSs are predicted off-site. Predicted concentrations of SO_2 are well within the AQSs both on-site and off-site.

The results of the analyses of the Operation Phase show none of the contaminants are predicted to exceed the applicable criteria within or outside of the Property Boundary.

5.0 Freshwater Resources Effects Assessment

The Study Area's freshwater resources may be viewed as a pathway that links a project activity to an environmental receptor. For example, a chemical released into the environment from the Project Area may be transported through groundwater and discharged into the aquatic environment resulting in measurable effects on fish. Therefore, effects on such other VECs (e.g., freshwater fish and fish habitat, marine fish) resulting from altered water quality or a disturbance to the natural hydrology of freshwater bodies will be addressed in Chapters 6.0 and 7.0 of this volume. Water quantity is addressed in Chapter 6.0.

Effects directly caused by routine project activities that result in altered freshwater and groundwater quality (i.e., the Freshwater Resources VEC) are examined in this chapter. These effects are assessed with respect to baseline data and criteria established in the *Canadian Environmental Quality Guidelines* (*CEQG*). Predictions on water quality during the life of the project are made based on scientific modelling, as discussed below.

5.1 Impact Significance Criteria

Assessment criteria including boundaries are as described in Chapter 3.0. Significant environmental effects are those considered to be of sufficient magnitude, duration, frequency, and geographic extent to cause a change in the freshwater resources (groundwater and surface water) VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EIS, a *significant* effect is defined as:

> *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2.*

For the physical freshwater resources VEC, *magnitude* is defined in terms of per cent change from its normal ambient condition. For example, a change in groundwater quality resulting from a project activity can be quantified and given a *magnitude* rating of *negligible, low, medium*, or *high* based on the predicted chemical concentrations determined through modeling, and comparing these values against background levels. It is also important to consider the reversibility of an effect.

5.2 Potential Interactions

The freshwater resources VEC may potentially interact with a variety of routine activities during the Construction, Operation, and Decommissioning phases:

- Earthworks;
- Blasting;
- Storm system;

- Sewage system;
- Water supply dam;
- Sewage;
- Construction accommodations; and
- Residue disposal/storage.

5.3 Issues and Concerns

The primary concern associated with potential interactions between freshwater resources and routine activities of the three project phases is the alteration of groundwater and surface water quality.

5.4 Existing Knowledge

5.4.1 Groundwater

Groundwater is found within three hydrostratigaphic units (glacial till, till/upper fractured bedrock, and deep fractured bedrock), and its flow is primarily governed by the hydraulic conductivity (permeability) of these units. Hydraulic gradients generally mimic the overlying topographic gradients, various local freshwater and marine water bodies, and topography.

Based on recent subsurface characterization studies and groundwater modeling (AMEC 2007e,f), shallow groundwater migrates from the proposed Lower Tier I and Upper Tier II sites and ultimately discharges into the marine environment along the southern shoreline of Long Harbour, as shown in Figure 5.1. A component of this flow that originates from the Tier II sites discharges directly into the receiving marine waters: the remainder discharges at the surface into freshwater ponds, streams (typically referred to as 'baseflow'), and down-gradient springs and wetlands, which also ultimately flow into Long Harbour.

AMEC (2007f) has demonstrated through numerical modeling that deep groundwater flow pathways within the Sandy Pond watershed are less influenced by local topographic irregularities than are shallow groundwater flow pathways. Nevertheless, deep groundwater from Sandy Pond ultimately reaches the head of Long Harbour near the mouth of Sandy Brook. This general flow of deep groundwater towards Long Harbour is inferred to occur over other parts of the Project Area.

Major ion geochemistry of the groundwater across the Study Area reflects calcium bicarbonate type water, characterized by slightly acidic pH, and low TDS. With depth, there is a trend towards increasing calcium, bicarbonate, alkalinity, hardness, and pH level (AMEC 2007e). Background concentrations of certain metals are elevated with respect to the freshwater and/or the marine aquatic life criteria of the *Canadian Environmental Quality Guidelines* (CEQG). In particular, iron, arsenic, cadmium, copper, lead, zinc, and aluminum were relatively high. Within the Lower Tier I Area, fluoride, elemental phosphorus, and free cyanide were identified as the primary contaminants of concern, and these are associated with historic activities of the phosphorus plant in Long Harbour. Other chemicals of concern include sulphate, total phosphate, arsenic, iron and manganese, which may be naturally occurring, related to historic activities, or a combination of both.

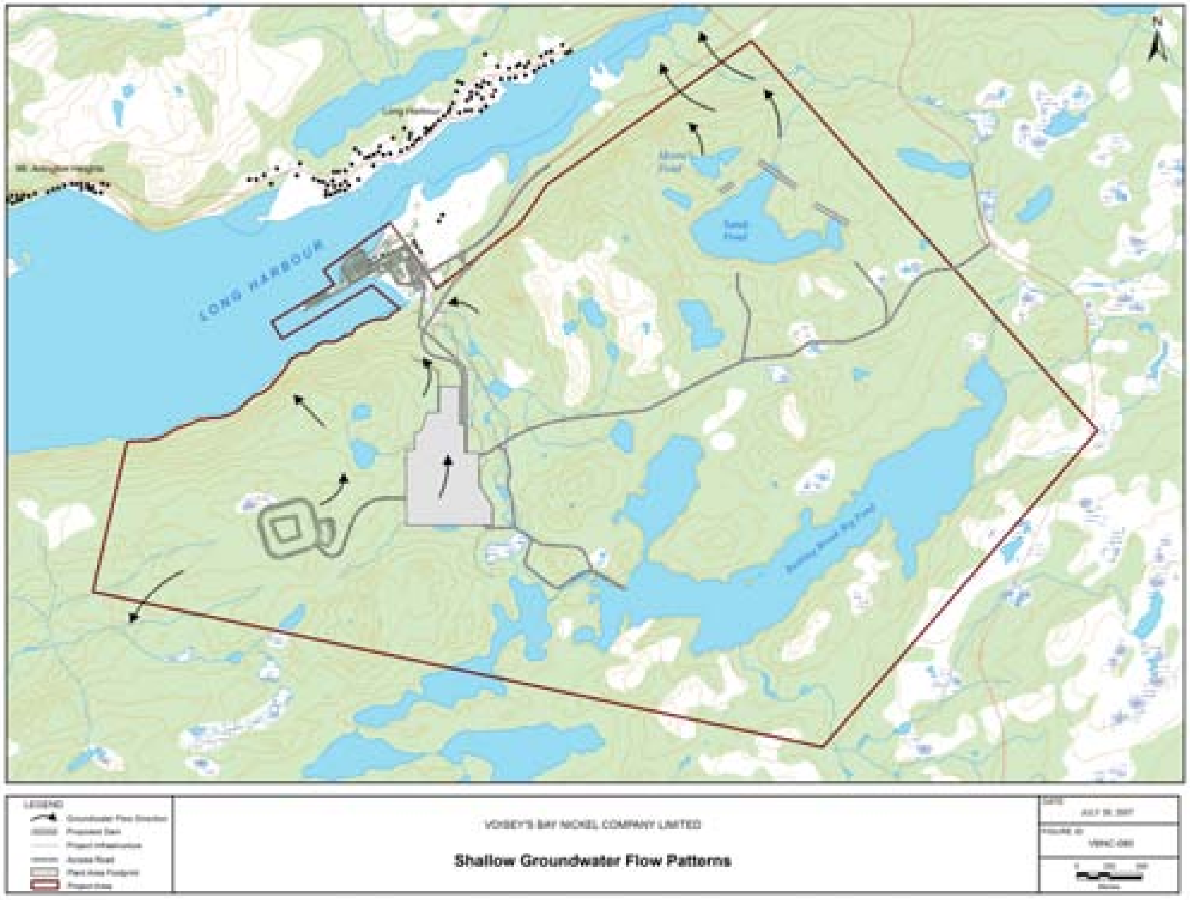

Figure 5.1 Shallow Groundwater Flow Patterns within the Project Area

Given that groundwater flow will potentially be the most important migratory pathway linking the subaqueous disposal facility at Sandy Pond to freshwater and marine aquatic environments, AMEC (2007f) focused its groundwater modeling on this watershed. Important input parameters for the model included several groundwater background concentrations:

- Nickel (0.0017 mg/L);
- Copper (0.004 mg/L);
- Iron (0.5 and 0.05 mg/L, for overburden and bedrock, respectively);
- Selenium (0.001 mg/L);
- Boron (0.020 mg/L);
- TDS (0.060 mg/L); and
- Sulphate (2.7 mg/L).

Groundwater is not known to be in current use within the Project Area or downgradient of it; however, future development down-gradient of the Project Area remains a possibility (M. Pretty, A. Maher, pers. comm.).

The flow of water through the subsurface (i.e., groundwater) can move contaminants from their source (e.g., the residue disposal facility) to environmental receptors (e.g., freshwater fish and marine aquatic life). The groundwater migratory pathways around and down gradient of Sandy Pond, shown in Figure 5.2., depicts generalized flow of shallow groundwater from the residue storage facility towards Long Harbour. Shallow groundwater generally flows in the same direction as surface runoff, whereas deep groundwater flows more consistently in a northwesterly direction from Sandy Pond towards Long Harbour and discharges along its southern shoreline. The three proposed dams at the northern and northwestern sides of Sandy Pond are shown, as are proposed access roads (represented by darker lines).

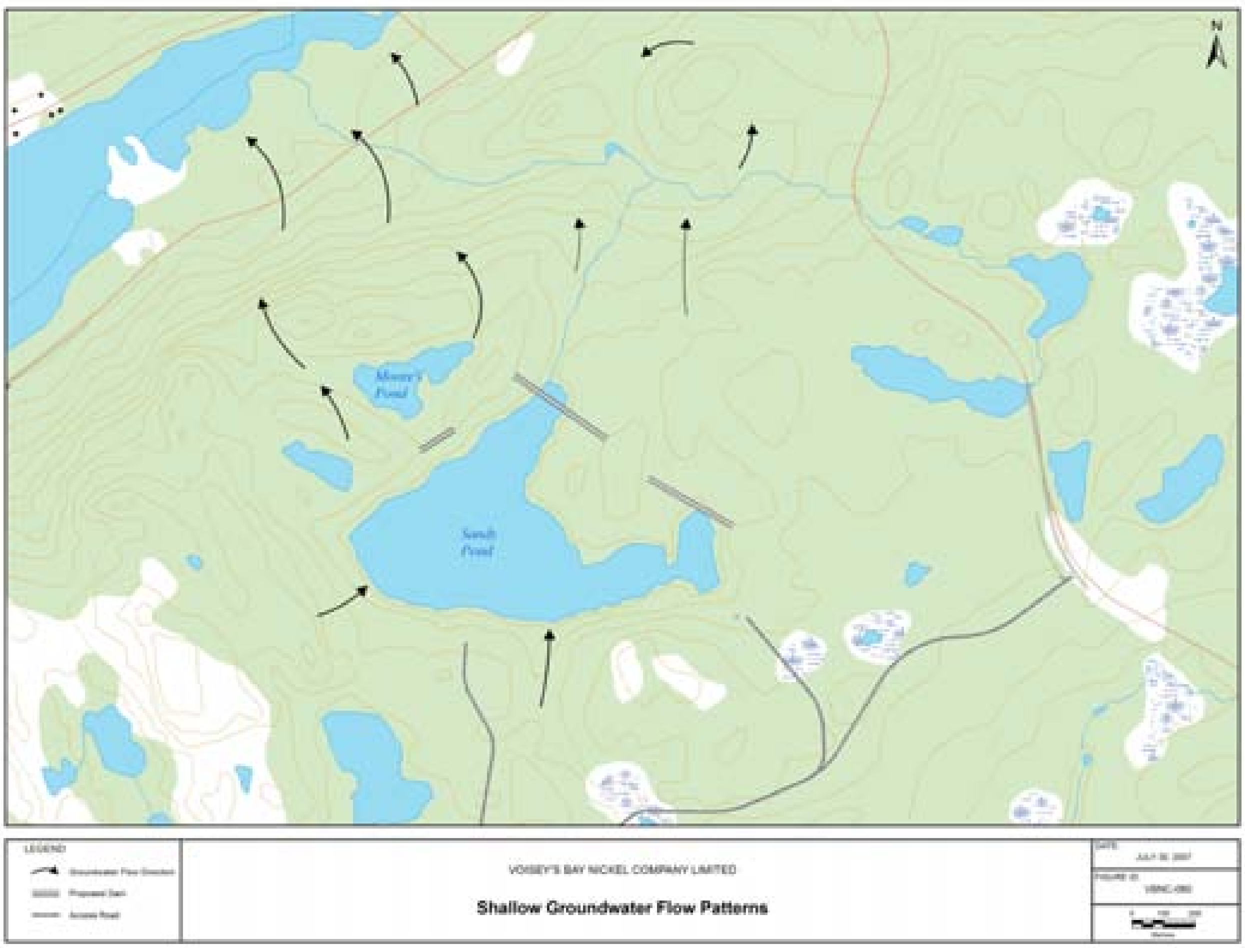

Figure 5.2 General Groundwater Flow Patterns near Sandy Pond

5.4.2 Surface Water

Changes in surface water quality could occur over the life of operations as a result of four possible pathways:

1. Direct residue storage as a result of operations;
2. Site runoff and washdown;
3. Potential groundwater seepage from the Residue Storage Area; and
4. Airborne deposition of contaminants.

Two residue disposal/storage areas have been identified, based on the Hydromet and the Matte processing options. Sub-aqueous residue disposal associated with the Hydromet process will be contained within the Sandy Pond drainage area and will permanently alter this pond's water quality. Sub-aerial residue storage associated with the Matte process would be contained within an area west of the plant footprint in an upper headwater drainage of Little Rattling Brook (see Chapter 2.0).

Site runoff will occur as a result of water accumulation (e.g., rainwater and snowmelt) within the processing plant area. Routine washdown water will be generated as a result of dust suppression at the wharf site. Runoff and washwater, if not properly collected and treated, may leave the site and enter watercourses untreated. Washwater in particular has the potential to be high in dissolved metals such as nickel and copper.

Air emissions from the plant will disperse and may deposit contaminants in or near watercourses, causing alteration of the water quality.

5.4.3 Changes in Water Quality

Nickel and copper are the main constituents of stack emissions that may generate elevated levels of deposition to water. These potential chemical changes are of relevance, as they can cause biological effects as discussed below.

Nickel

Nickel compounds are of medium toxicity to fish. With short periods of exposure, the lethal concentration is between 30 and 75 $\mu g \cdot L^{-1}$ (CCME guideline value is 25 to 150 $\mu g \cdot L^{-1}$). As with the toxicity of other metals, the toxicity of nickel compounds to aquatic organisms is markedly influenced by the physico-chemical properties of water. For example, in soft waters with low calcium concentrations (Stasiunaite 1999; Hoang et al. 2004), the lethal concentrations of nickel compounds for fish are much lower than at high calcium concentrations. Nickel is taken up by fish primarily through the gills; after toxic exposure to nickel compounds, the gill chambers of fish are typically filled with mucus and the lamellae are dark red in colour. It has many sublethal effects on fish, including effects on growth and survival (Donaldson 1990; Tracy et al. 1992), reproduction (Baylock and Frank 1979), metabolism (Bozcaarmutlu and Arinç 2007), genetic defects, and carcinogenicity (Hoang et al. 2004).

Copper

Copper is an essential element needed for many physiological processes (Sloman 2003); however, at high concentrations copper acts as a neurotoxicant and can be lethal. Fish are exposed to copper in both diet and the external environment, where uptake occurs through the gills (Marr et al. 1999). The physical and chemical properties of the water exert a strong influence on the toxicity of copper to fish (Marr et al. 1999). In water containing high concentrations of organic substances, copper can become bound into soluble and insoluble complexes. In very alkaline water it forms hydroxides of low solubility; in waters with a high bicarbonate/carbonate concentration, copper precipitates as poorly soluble or insoluble cupric carbonate (Marr et al. 1999). Compounds that are slow to dissolve or are insoluble are unlikely to be absorbed to any extent into fish, so their toxicity is considered low. The CCME concentrations range between two and four mg/L and vary with $CaCO_3$ concentration.

The characteristic clinical symptoms of fish poisoned by copper ions and copper compounds include laboured breathing and, in cyprinids, gasping for air at the water surface. The typical patho-anatomic appearance includes a large amount of mucus on body surface, under the gill covers and in the gills. Excess levels of copper can cause changes in the fish's ionoregulation, neurological function, swimming ability, and behaviour (Hansen et al. 1999a; 1999b). It also affects olfaction (Baldwin et al. 2003), especially in salmonids, diminishing their ability to locate prey, avoid predators, migrate to natal streams and spawn (Branion 1981; Branion et al. 1984). Exposure to copper also induces a stress response, causing the release of the stress hormone cortisol, which can negatively affect health, reproduction, and growth (Taylor et al. 2000).

5.5 Effects of Construction

Potential interactions between construction routine activities and the freshwater resources VEC are shown in Table 5.1. Table 5.2 presents the effects assessment of construction activities on freshwater resources, and Table 5.3 tabulates the significance of potential effects. Mitigations will be detailed in the EPP; some of the major ones are described in Volume 1 and in the relevant DFO Factsheets.

Table 5.1 Potential Interactions between Construction and Freshwater Resources

Valued Ecosystem Component: Freshwater Resources		
Project Activity	**Groundwater Quality**	**Surface Water Quality**
Construction Activities and Physical Works		
Earthworks[1]	✓	✓
Wharf expansion		
Dredging	✓	✓
Shore and scour protection		
Blasting	✓	✓
Effluent pipeline		
Atmospheric emissions (incl. dust)	✓	✓
Roads	✓	✓
Storm system		
Sewage system		
Pipelines		
Water supply dam		
Residue storage dams		
Power lines		
Shipping		
Vehicle traffic	✓	✓
Sewage	✓	✓
Solid waste	✓	✓
Temporary power		
Lighting		
Noise		
Note: [1] Includes all activities involving earthworks, including grubbing, excavation, grading and levelling.		

Table 5.2 Effects Assessment of Construction on Freshwater Resources VEC

Valued Ecosystem Component: Freshwater Resources								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Construction Activities and Physical Works								
Earthworks	Increased turbidity (N); potential chemical release (N)	EPP	0	1	6	4	R	1 & 2
Dredging	On-land transport and treatment/disposal of potentially contaminated spoils (N)	EPP	0	1	1	4	R	2
Blasting	Increased turbidity (N); potential chemical release (N)	EPP	0	1	6	4	R	1 & 2
Atmospheric emissions	Deposition of airborne contaminants and dust on surface water bodies (N)	EPP	0-1	2	6	4	R	1 & 2
Roads	Increased turbidity (N); potential chemical release (N)	EPP	0	1	6	4	R	1 & 2
Vehicle traffic	Dust deposition on or potential release of other contaminants into freshwater bodies (N)	EPP	0-1	1	6	4	R	1 & 2
Sewage	Release of untreated sewage and effluent to the receiving environment (N)	EPP	0	1	6	4	R	1 & 2
Solid waste	Release of solid waste leachate to environment (N)	EPP	0	1	6	4	R	1 & 2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 5.3 Significance of Potential Residual Environmental Effects of Construction on Freshwater Resources VEC

Valued Ecosystem Component: Freshwater Resources				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Construction Activities and Physical Works				
Earthworks	NS	3	-	-
Dredging	NS	3	-	-
Blasting	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Roads	NS	3	-	-
Vehicle traffic	NS	3	-	-
Sewage	NS	3	-	-
Solid waste	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

5.5.1 Earthworks

All earthworks over the Project Area such as dam, road, and pipeline construction, site grading, excavation, blasting, and levelling could potentially introduce chemicals (fuels, oils, etc.) to the ground surface that can flow to freshwater bodies or seep into the subsurface and alter groundwater quality. In addition, these activities will likely generate dust that can be blown and deposited into freshwater bodies. Given that there will be mitigation measures such as dust control (to be detailed in the EPP) to prevent this from occurring, this effect is not likely during routine construction activities.

The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality associated with earthworks during construction are *negligible*, *<1 km^2*, and *37 to 72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.5.2 Dredging

Dredging in Long Harbour will generate about 26,600 m^3 of sediment that may have become contaminated historically. This material will be collected and transported by a licensed and experienced contractor for treatment/disposal at an approved on-land waste disposal site. An EPP will provide details on disposal options for this material.

The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality associated with managing spoils dredged during construction are *negligible, <1 km^2,* and *37 to 72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.5.3 Atmospheric Emissions

Deposition of airborne contaminants such as dust and vehicle emissions on water bodies could alter the quality of surface water during construction. This effect is expected to be temporary and is not considered to cause a measurable effect over the long term. Mitigation measures to reduce this effect will include water spray as a dust suppressant on gravel roadways, and maintenance of vehicle emission-control systems.

The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality associated with atmospheric emissions during construction are *negligible to low, 1 to 10 km^2,* and *37 to 72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.5.4 Sewage

During construction activities, sanitary wastes at the site and accommodations will be disposed of through an approved on-site sewage treatment system or trucked off-site by a licensed waste management firm for treatment and disposal. Under routine conditions, this is not considered to result in any significant alteration of the groundwater or surface water quality.

The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality associated with sewage management during construction are *negligible, <1 km^2,* and *37 to 72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.5.5 Solid Waste

Solid wastes generated during construction activities will be collected, stored, and disposed of at an approved off-site disposal facility in accordance with regulatory requirements, the EPP, and the facility's waste management plan.

The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality associated with solid waste management during construction are *negligible*, *<1 km*^{2}, and *37 to 72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.5.6 Construction Accommodations

All activities and facilities related to the construction accommodations will be designed and constructed in accordance with regulatory requirements. No on-site disposal or discharge of untreated effluents will occur. The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality associated with the construction accommodations are *negligible*, *<1 km*^{2}, and *37 to 72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6 Effects of Operations

Potential interactions between the freshwater resources VEC and routine activities during the Operation Phase of the Project are shown in Table 5.4. Effects assessments of project activities are presented in Table 5.5 and the significance of residual environmental effects of these activities are rated in Table 5.6. The following sections elaborate on the effects.

Table 5.4 Potential Interactions between Operations and Freshwater Resources VEC

Valued Ecosystem Component: Freshwater Resources		
Project Activity	**Groundwater Quality**	**Surface Water Quality**
Operational Activities and Physical Works		
Total footprint	✓	✓
Residue storage	✓	✓
Ships		
Offloading		
Dust	✓	✓
Washdowns/runoff	✓	✓
Water use		
Electricity use		
Diesel use		
Fuel oil#2 use		
Atmospheric emissions (incl. dust)	✓	✓
Marine effluent		
Site runoff	✓	✓
Surge pond	✓	✓
Sewage	✓	✓
Solid waste	✓	✓
Vehicle traffic	✓	✓
Noise		
Lighting		
Maintenance	✓	✓

Table 5.5 Environmental Effects Assessment of Operations on Freshwater Resources

Valued Ecosystem Component: Freshwater Resources								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Operational Activities and Physical Works								
Total footprint	Potential contaminant release (N)	EPP	0	2	6	5	I	1 & 2
Residue storage	Predicted contaminant release (N)	Environmental engineering controls, EPP	3	2	6	5	I	1
Offloading								
Dust	Airborne deposition (N)	Environmental management system, EPP	1	1	2	1	R	2
Washdowns/runoff	N	Environmental management system, EPP	1	1	2	1	R	2
Atmospheric emissions (incl. dust)	Airborne deposition (N)	Environmental engineering controls, environmental management system, EPP	3	2	6	5	R	1 & 2
Site runoff	N	Environmental engineering controls, environmental management system, EPP	0	1	3	1	R	1 & 2
Surge pond	N	Environmental engineering controls, EPP	0	1	6	5	R	1
Sewage	Potential leakage or discharge (N)	Environmental engineering controls, environmental management system, EPP	0	1	6	5	R	1 & 2
Solid waste	Potential leachate generation and release (N)	Waste management plan, environmental management system, EPP	0	1	6	5	R	1 & 2
Vehicle traffic	Air emissions and potential leaks (N)	Environmental management system, vehicle maintenance program, EPP	0	1	6	5	R	1 & 2
Maintenance	Potential contaminant emissions and discharges (N)	Environmental management system, EPP	0	1	6	5	R	1 & 2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
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(refers to population)

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Table 5.6 Significance of Potential Residual Environmental Effects of Operations on Freshwater Resources VEC

Valued Ecosystem Component: Freshwater Resources				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Operational Activities and Physical Works				
Total footprint	NS	3	-	-
Residue storage	NS	2	-	-
Offloading				
Dust	NS	3	-	-
Washdowns/runoff	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Site runoff	NS	3	-	-
Surge pond	NS	3	-	-
Sewage	NS	3	-	-
Solid waste	NS	2	-	-
Vehicle traffic	NS	3	-	-
Maintenance	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

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3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
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2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

5.6.1 Total Footprint

The effect of the total footprint on freshwater resources, as it relates to freshwater fish and fish habitat, is assessed in Chapter 6.0. Freshwater resources affected during the Construction Phase have been assessed in previous sections.

The existence of the Plant, pipelines, residue disposal and storage facilities, roads, etc., of the Tier 2 site, and wharf loading/unloading facility, storage areas, and pipelines of the Tier 1 portion of the Project Area during the Operation Phase will not have a significant adverse effect on the environment. Mitigation measures, such as described in the EPP, will be implemented to ensure that no significant residual effects will arise.

The magnitude, geographic extent and duration of the predicted *irreversible* residual effects on surface water and groundwater quality caused by the total footprint are *negligible, 1 to 10* km^2, and *>72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6.2 Residue Storage

During the Operation Phase and with increasing amounts of disposed residue, the water quality of the residue pond will progressively worsen. This deterioration is brought on by two things: effluent discharge during the operational phase, and chemical reactions that take place within the disposed residue. The latter will persist indefinitely as long as oxygen is available to react with elemental sulphur and sulphide minerals contained in the residue (AMEC 2007f).

Water quality in the residue facility will be greatly impaired at Closure when sulphate and iron levels are at their highest, and when nickel and copper are near their maximum concentrations. Following Closure, both iron and sulphate levels will decrease significantly and rapidly, whereas nickel and copper concentrations will rise slightly and gradually. During the first 10 to 15 years following Closure, the concentrations of these four parameters are expected to become stable and to remain so indefinitely (AMEC 2007f).

During Operation and after Closure, water levels in the facility will remain relatively constant, and groundwater flow patterns through shallow overburden tills and fractured bedrock are also expected to remain relatively unchanged. Based on groundwater modeling, there is the potential that some seepage of impacted water will occur from the residue disposal facility. Shallow groundwater flow will be reduced, but not eliminated by grouting. This seepage will eventually discharge downgradient to the streambed 700-800 m north of Sandy Pond. The remaining groundwater plume discharging to Long Harbour is expected to migrate primarily in the deep rock system. Thus, groundwater transport to Long Harbour is very slow, in the order of 1,500 years, before any discharge to the marine environment occurs (Figure 5.2).

Groundwater contaminant plumes are expected to reach equilibrium after many years following Closure; for example, copper is predicted to reach a steady-state condition in about 1,500 years (AMEC 2007f).

Surface water quality modeling and groundwater contaminant transport modeling conducted by AMEC based on 2007 data (AMEC 2007f) predicted mass loadings to Sandy Brook as shown in Table 5.7. Predicted long-term chemical concentrations are shown, together with groundwater background concentrations and CEQG criteria.

The area over which altered surface water and groundwater may occur consists of that portion of land located hydraulically downgradient of Sandy Pond, which includes the northern corner of the Project Area and the relatively small portion of land between it and Long Harbour, collectively less than about two km^2 (see Figure 5.1 and Figure 5.2).

Table 5.7 Model Predicted Long-Term Contaminant Concentrations and Loading Rates

Chemicals of Concern	Mass loading into Sandy Brook (g/day)[1]	Predicted levels in Sandy Brook (during low flow conditions) (µg/L)	Background levels in groundwater (µg/L)	Guidelines for Canadian Drinking Water Quality (µg/L)	CEQG freshwater aquatic life criteria (µg/L)
Copper	9.3	5.5	4	<1,000	2-4
Nickel	27.5	7.5	1.7	ne	25-150
Iron	22.0	497	500	<300	300
Selenium	1	1.1	1.0	10	1.0
Boron	13.6	20.4	20	5,000	ne
TDS	59,306	6.53×10^4	6.0×10^4	$<0.5 \times 10^6$	ne
Sulphate	nm	nm	2,700	<500,000	ne

Notes:
- ne: value not established
- nm: contaminant not modeled
- freshwater aquatic life criteria for copper depends on water hardness
- drinking water criteria are considered aesthetic objectives

[1] projected to steady-state, not simulated

Source: AMEC (2007f).

The magnitude of residual effects on surface and groundwater quality from residue storage (Sandy Pond) are predicted to range from *negligible* for the freshwater Study Area as a whole to *high* (and potentially *irreversible*) in a localized area down-gradient of Sandy Pond. (Note: The affected area includes Moores Pond, a fishless water body.) The level of confidence in this prediction is low, as indicated by the potential range in the magnitude. The reason for this uncertainty in the modeling is the extremely long time it would take any potential contaminants to reach Sandy Brook. In addition, mitigation measures such as drilled wells could be instituted to capture any contaminated groundwater that may filter out of Sandy Pond.

While the duration of effects will be long, the geographic extent (i.e., at the low end of the 1-to-10 km^2 scale) is restricted, and thus the effect is considered to be *not significant*.

5.6.3 Offloading

Bulk nickel concentrate, limestone and sulphuric acid will be unloaded at the wharf on Tier 1 during operations.

Dust

Dust generated during offloading will be contained and captured by the dust collection systems and baghouses. Any dust that is not captured (released to the environment and transported landward) is expected to have a negative effect on freshwater resources where deposition occurs.

Detailed mitigation measures to reduce the effect of offloading dust will be detailed in the EPP. The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality caused by dust generation during offloading are *low*, *<1 km^2*, and *<1 month*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

Washdowns/Runoff

The conveyor and ship's hold washdown water will be directed into the concentrate preparation process except during winter, when glycol will be used for washdown. The spent washdown liquids containing glycol will be collected and stored in drums for off-site disposal by an approved waste management firm. Wharf storm-water, container area storm-water, and port level storm-water will be diverted to the Tier 1 settling pond and the clarified effluent subsequently discharged into Long Harbour via the effluent pipe. As with dust, any washdown liquids that are not contained will either run overland towards the marine environment or seep into the ground and recharge the local water table.

Mitigation measures to reduce the effect of offloading washdown liquids will be detailed in the EPP, and management of these liquids will be part of the facility's environmental management system. The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality caused by dust generation during offloading are *low*, *<1 km^2*, and *<1 month*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6.4 Atmospheric Emissions

The effect on air quality is covered in Chapter 4.0. Water quality modelling carried out by AMEC (2007f) predicts worst-case concentrations in pond water located near the proposed plant during Operations and resulting from atmospheric emissions. The concentrations of various parameters in water from pond P28 are predicted to increase as shown in Table 5.8.

At the end of the Operation Phase, the concentrations are predicted to decrease steadily. The concentrations of all modelled parameters will return to background levels within two years.

Table 5.8 Predicted Parameter Concentrations in Pond P28 during Operations

Parameter	Initial Concentration in Pond (mg/L)	Maximum Pond Concentration (mg/L)	CEQG Freshwater Aquatic Life Criteria (mg/L)	Guidelines for Canadian Drinking Water Quality (mg/L)	Maximum Increase Above Initial Concentrations During Operations
Cu	0.0012	0.0014	0.002	<1	16.67%
Co	0.001	0.00105			5.00%
Fe	0.991	0.9959	0.300	<0.3	0.49%
Pb	0.001	0.00105	0.001	0.01	5.00%
Mn	0.49	0.4901		<0.05	0.02%
Ni	0.001	0.0035	0.025		250.00%
SO_4	1.66	1.665			0.30%

During operations, however, concentrations of lead are predicted to increase marginally by (5%) to levels above the CEQG's Freshwater Aquatic Life (FAL) criteria. Lead is the only one of the modelled parameters that has a human health-based *maximum acceptable concentration* listed in the *Guidelines for Canadian Drinking Water Quality*, and its predicted concentrations in the raw, untreated water are below this acceptable level.

Concentrations of copper and nickel are predicted to increase by 17 per cent and 250 per cent, respectively, above baseline levels, although these will always remain within the FAL criteria. Concentrations of iron, which under baseline conditions already exceed the FAL criteria, and manganese will increase marginally by 0.5 per cent and 0.02 per cent. Colbalt and sulphate (SO_4) will increase marginally above background levels, by five per cent and 0.3 per cent respectively.

The magnitude of residual effects on surface and groundwater quality from air emissions are predicted to range from *negligible* for the freshwater Study Area as a whole to *high* (for several parameters) in very localized small water bodies within the Project Area (e.g., Pond P28) over a long period of deposition. The level of confidence in this prediction is low as indicated by the potential range in the magnitude. The reason for this uncertainty at the high end of the scale stems from uncertainty in the modeling.

While the duration of effects will be long (i.e., *>72 months*), the geographic extent will be much localized (i.e., at the low end of the *1 to 10 km^2* scale) and thus *not significant*.

5.6.5 Site Runoff

Site runoff will be diverted to containment ponds for treatment prior to release. There is the potential that this may affect freshwater fish and fish habitat, and this issue is addressed in Chapter 6.0. Mitigation measures contained in the EPP will be in place to prevent surface water and groundwater quality alteration as a result of surface water runoff.

The predicted magnitude, geographic extent, and duration of the *reversible* residual effects on surface water and groundwater quality caused by surface runoff during operations are *negligible, <1 km*^{2}*,* and *<1 month*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6.6 Surge Pond

A surge pond associated with the Matte Plant's residue storage site would receive gypsum stack drainage, including decant water and rain/snow melt runoff. Water in this surge pond will be pumped back to the process plant for re-pulping gypsum cake. The excess solution will be sent to Process Effluent Neutralization. No discharge to the environment should occur.

The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality caused by use of the surge pond during operations are *negligible, <1 km*^{2}*,* and *>72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6.7 Sewage

A sanitary sewage collection and treatment facility will receive sanitary wastes from the Tier 2 site. Sludge generated by this system will be periodically removed for approved off-site disposal, and treated effluent will be discharged to the effluent pipeline for marine disposal. A septic system will be installed for the Tier 1 site, with sludge periodically collected for approved off-site disposal, and clarified effluent will be discharged into an engineered leaching field. Mitigation measures will involve proper engineering design and construction of these systems, and an EPP.

The predicted magnitude, geographic extent and duration of the *reversible* residual effects on surface water and groundwater quality caused by sanitary waste management during operations are *negligible, <1 km*^{2}*,* and *>72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6.8 Solid Waste

Solid wastes generated during operations (e.g., domestic wastes, and process waste solids) will be disposed of off-site by approved waste management firms. Any stockpiling of trash debris will be covered to prevent dust and debris from being blown. All solid waste streams will be identified and handled in accordance with the facility's waste management plan.

The predicted magnitude, geographic extent, and duration of the *reversible* residual effects on surface water and groundwater quality associated with solid wastes generated during operations are *negligible, <1 km*^{2}*,* and *>72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6.9 Vehicle Traffic

Vehicles used by plant staff, contractors, and other visitors to the facility will generate air emissions and may be the source of leaks and spills of fuels and other hazardous chemicals. The EPP will identify mitigation measures to deal with possible leaks and spills. Accidental events are discussed in Chapter 11.0 of this volume.

The predicted magnitude, geographic extent, and duration of the *reversible* residual effects on surface water and groundwater quality associated with vehicle traffic during operations are *negligible, <1 km^2,* and *>72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.6.10 Maintenance

Maintenance activities will be conducted around the facility as required to ensure that equipment, infrastructure, and processes are fully functional, and to reduce or eliminate the release of contaminants to the environment. Some of these maintenance activities will involve the handling of hazardous materials, such as oils, lubricants, and waste oils. Mitigations to reduce the effect of maintenance activities on freshwater resources will be detailed in the EPP.

The predicted magnitude, geographic extent, and duration of the *reversible* residual effects on surface water and groundwater quality associated with maintenance during operations are *negligible, <1 km^2,* and *<72 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.7 Effects of Decommissioning

The residue disposal facility, dams, and pipelines from the pond to Long Harbour will be inspected and the water quality in the area will be monitored following Closure. Activities related to Closure may have temporary negative effects on freshwater resources within the Project Area, but these are expected to be similar to (but no worse than) those associated with construction activities and thus *not significant*. Activities associated with Closure include draining/cleaning of pipelines, demolition and removal of infrastructure, and environmental monitoring.

Mitigation measures aimed at reducing the effect of these activities on the environment will be detailed in a decommissioning and closure plan. The predicted magnitude, geographic extent, and duration of the *reversible* residual effects on surface water and groundwater quality associated with Closure activities are *low, <1 km^2*, and *13 to 36 months*, respectively. These residual effects on the freshwater resources VEC are considered *not significant*.

5.8 Cumulative Environmental Effects

5.8.1 Within-Project

The within-project cumulative effects are integrated into the effects assessment of the individual routine activities of the various phases of the Project. Since the residual effects of all routine activities with potential to interact with freshwater resources were predicted to be *not significant*, the within-project cumulative effect is also *not significant*.

5.8.2 With Other Projects

There will be no overlap or interaction with the activities and projects identified for cumulative effects assessment with respect to freshwater resources. Project activities have the potential to negatively affect water resources, but only within the Project Area, and these are predicted to be *not significant*. No significant effects from other projects are predicted on the freshwater resources within the Study Area. Therefore, the cumulative effect of the Project in association with the effects of other projects and activities in the Study Area is predicted to be *not significant*.

5.9 Summary of Effects on Freshwater Resources

The primary issue related to potential effects of routine activities during Construction, Operation, and Decommissioning phases on freshwater resources relate to alteration of surface water and groundwater quality.

The geographic area over which negative effects are predicted to occur is quite restricted and generally limited to the Project boundaries. All groundwater effects are restricted geographically, and the modelled flow rate is such that interactions only occur over time spans of hundreds to thousands of years, allowing ample opportunity to monitor progress and to implement control measures, if necessary. Accordingly the predicted overall residual effect of routine activities on freshwater resources will be *not significant*.

6.0 Freshwater Fish and Fish Habitat Effects Assessment

The section predicts effects of routine project activities on freshwater fish and fish habitat. Water quality effects have been addressed in Chapter 5.0.

6.1 Existing Conditions

VBNC conducted intensive surveys of the freshwater environment in the Long Harbour area (AMEC 2005; 2007a). The freshwater environment of the Project Area and surrounding Study Area, and its utilization by the species present, are described in detail in Chapter 2.0. Relevant portions have been provided in the following assessment sections where appropriate.

Fish species recorded within the Project Area include brook trout (*Salvelinus fontinalis*), Arctic char (*Salvelinus alpinus*), rainbow smelt (*Osmerus mordax*) and American eel (*Anguilla rostrata*). There are five watersheds within the Long Harbour area, two of them directly within the footprint of the Project site. If the Matte Plant were to be built, a third watershed would also be within the footprint area.

The boundaries associated with the potential interactions and assessment of fish and fish habitat are the watershed limits of the Study Area.

6.2 Impact Significance Criteria

Assessment criteria including boundaries are described in Chapter 3.0. Significant environmental effects are those considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the freshwater fish and fish habitat VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EIS, a significant effect is defined as:

> *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2.*

It is also important to consider the reversibility of an effect.

6.3 Potential Interactions

The freshwater fish and fish habitat VEC could potentially interact with a variety of routine activities associated with the Construction, Operation, and Decommissioning phases. Some of the major ones include:

- Earthworks;
- Blasting;

- Roads;
- Storm system;
- Pipelines;
- Water supply dam;
- Residue storage dams; and
- Vehicle traffic.

The effects of routine activities on freshwater fish and fish habitat area are assessed in this chapter.

6.4 Issues and Concerns

The primary concerns associated with the potential interactions between routine activities of the three phases of the Project and freshwater fish and fish habitat include the following:

- Loss and/or alteration of freshwater fish habitat;
- Siltation, erosion and dust;
- Blasting and noise;
- Changes in water quantity; and
- Changes in water quality (addressed in Section 5.0).

The potential concerns identified are those interactions that have a reasonable probability of occurring. Each potential concern is described below as well as a description of the activity with which they may be associated. In this way, similar concerns for numerous activities are identified and described without unneeded duplication.

6.5 Existing Knowledge

The following sections briefly summarize existing knowledge in regard to freshwater fish and fish habitat issues and concerns identified in Section 6.4. Note that changes in water quality have been addressed in Section 5.0. Water quantity is discussed in Section 2.3.

6.5.1 Loss and/or Alteration of Freshwater Fish Habitat

The freshwater fish habitat within and near the Project has been surveyed and quantified with the results provided in the Freshwater Ecosystem Component Study (AMEC 2007a) and summarized in Section 2.3 of this volume. A portion of the identified fish habitat will be lost as a result of the direct footprints of the processing plant, water supply dam, and residue dams (as shown in Figure 4.1 of Volume 1). Habitat will also be altered as a consequence of diversions and extractions that reduce flow volumes. Final habitat quantification of the lost habitat is completed; either processing facility would destroy at least a portion of the fish habitat within Beaver Brook, a sub-tributary of Rattling Brook, as a result of the plant footprint (see Figures 2.2 and 2.3 in Volume 1). This would include a portion of the stream itself and ponds P24 and P25 (see Figure 2.6). Both processing facilities would also require a water control structure (a dam) on the outflow of Rattling Brook Big Pond to supply water. It should be noted that the water control structure is designed to release water to maintain fish habitat and to provide fish passage. In the case of the Hydromet process, Sandy Pond as well as Sandy Brook would also be lost to residue storage and de-watering.

The Fisheries Act contains a prohibition with respect to the "harmful alteration, disruption or destruction" (HADD) of fish habitat (Section 35). The Act permits a HADD of fish habitat to occur if authorized by the Minister or under regulations made by the Governor in Council. Authorizations are issued in accordance with the Policy for the Management of Fish Habitat, which has has an objective of achieving a net gain in the productive capacity of fish habitat in Canada. The policy has a guiding principle of "No Net Loss": existing fish habitat will be protected, while unavoidable habitat alterations are to be balanced by development of new habitat or the increased productive capacity of existing habitat.

The total amount of habitat directly within the Project Area and its utilization has been quantified and has been submitted to DFO. Once it has been reviewed by DFO, a HADD determination can be made; i.e., a formal statement identifying the quantity of habitat which will be lost following the application of all reasonable mitigation measures. This determination establishes the basis for fish habitat compensation. Vale Inco NL will then develop a Compensation Plan, which upon acceptance by DFO becomes a binding condition of any authorization issued. This Compensation Plan also requires that public consultations occur prior to finalization.

6.5.2 Siltation, Erosion and Dust

Siltation and erosion of fish habitat due to earthworks, culvert/bridge installation, and poor water management can occur throughout the Construction Phase of the Project. Increased erosion of stream bank soils or uncontrolled transportation of fine material from exposed areas can be deposited into freshwater habitat. Excess siltation can have a negative effect on the health of freshwater biota and can cause the loss or avoidance of productive freshwater habitat. A potential pathway can also include airborne deposition (dust). Fine material can settle on substrates, particularly areas with lower water velocities, affecting physical processes, structural attributes and ecological conditions such as water clarity, overall habitat suitability, and food supply. Infilling occurring during spawning, incubation, and hatching periods can smother eggs and alevins. Suspended sediment can also reduce water clarity and cause damage to gills (Gosse et al. 1998).

This pathway can be associated with activities such as earthworks, atmospheric emissions, road construction, and pipeline installations as well as water supply and residue dam construction. Therefore, there is the potential for within project cumulative effects for this pathway, as all activities could occur simultaneously. As such, the cumulative or "worst-case scenario" has been assumed and assessed.

6.5.3 Blasting and Noise

Blasting will be associated with construction activities such as earthworks around the processing plant footprint. The detonation of explosives can result in a number of adverse effects on fish and marine mammals and their habitats (Wright and Hopky 1998). Two main variables determine how sound and vibrations can affect aquatic species: shock pressure, represented and measured in Peak Particle Velocity (PPV), and compressional seismic waves, measured as a pressure force (kPa). These phenomena can lead to disturbance or damage to fish by affecting their internal organs (Hawkins and Johnstone 1978; Whalberg and Westerberg 2005).

Wright and Hopky (1998) describe several potential pathways that include the production of post-detonation compressive shock waves and vibrations. The effects can affect many life stages, the degree depending upon many factors such as type of explosive, size and pattern of the charge(s), method of detonation, distance from the point of detonation, water depth, and species of fish. Potential effects on fish include damage to swim bladders, rupture/haemorrhage of kidney, liver, spleen, and sinus venous, as well as damage to incubating eggs.

In addition to direct damage, both wild and aquacultured species also display avoidance behaviour to noise (Chapman and Hawkins 1969; Schwartz and Greer 1984; Pearson et al. 1992) and can be negatively affected by intense sounds (such as those from blasting) or from prolonged exposure to certain types of acoustic disturbances (McCauley et al. 2003).

6.6 Effects of Construction

Potential interactions between construction routine activities and the freshwater fish and fish habitat VEC are shown in Table 6.1. Construction interactions with freshwater fish and fish habitat relate primarily to those activities that could cause siltation, erosion, dust and blasting, as well as those activities that will permanently affect existing fish habitat as a result of the Project footprint. Construction mitigations have been described in Section 6 of the Project Description (Volume 1). DFO-recommended guidelines for construction activities will be utilized in developing the EPP (as per relevant DFO Factsheets). Provided below is a brief description of each pathway.

6.6.1 Earthworks

Site clearing, grubbing and leveling, and construction of the processing facility at Tier 2 could potentially result in the introduction of sediment-laden water to the freshwater environment, especially when these activities are conducted in areas proximate to existing freshwater fish and fish habitat. Earthworks will also potentially result in the direct loss of freshwater fish habitat.

Turbidity and Sedimentation

Sediment entering fresh water will result in increased turbidity and sedimentation, potentially causing negative effects on the freshwater fish and fish habitat. There are potential interactions between earthworks activities and all components of the freshwater fish and fish habitat VEC (Table 6.1).

All fish species within the freshwater environment could be potentially affected by increased turbidity and sedimentation. All freshwater spawning species would have eggs and larvae particularly sensitive to excess sedimentation during egg incubation. Since most life-cycle stages are mobile once hatched, the degree of effect on juvenile and adult life-cycle stages would be dependent upon the quantity of sediment, the duration of the release/disturbance, and the overall extent of habitat affected.

The control of siltation, erosion and runoff from construction sites is addressed in many standard practices and guidelines such as the *Guidelines for Protection for Freshwater Fish Habitat* (Gosse et al. 1998), *Land Development Guidelines for the Protection of Aquatic Habitat* (Chilibeck et al. 1993) and the *Environmental Guidelines for General Construction Practices* (Water Resources Management Division 1997).

Table 6.1 Potential Interactions between Construction and Freshwater Fish and Fish Habitat VEC

Valued Ecosystem Component: Freshwater Fish and Fish Habitat				
Project Activity	Freshwater Fish and Fish Habitat Component			
	Egg Incubation	Juveniles	Adult	Habitat
Construction Activities & Physical Works				
Earthworks[1]	✓	✓	✓	✓
Wharf expansion				
Dredging				
Shore and scour protection				
Blasting	✓	✓	✓	✓
Effluent pipeline				
Atmospheric emissions (incl. dust)	✓	✓	✓	✓
Roads	✓	✓	✓	✓
Storm system	✓	✓	✓	✓
Sewage system	✓	✓	✓	✓
Pipelines	✓	✓	✓	✓
Water supply dam		✓	✓	✓
Residue storage dams		✓	✓	✓
Power lines	✓	✓	✓	✓
Shipping				
Vehicle traffic				✓
Sewage				
Solid waste				
Temporary power				
Lighting				
Noise		✓	✓	
Note: [1] Includes all activities involving earthworks, including grubbing, excavation, grading and levelling.				

Special consideration is needed when working in or near freshwater fish habitat. Construction activities that will encroach on freshwater habitat include: process plant footprint clearing/construction, water supply and residue dam installations, installation of culverts and fording associated with pipeline construction. The reader is referred to Sections 6.0 and 7.0 of Volume 1, which describe designed-in construction and operation mitigations respectively. In addition, DFO also provides several guideline publications including:

- The National Policy for the Management of Fish Habitat;
- Land Development Guidelines for the Protection of Aquatic Habitat;
- *The Fisheries Act* - Habitat Protection and Pollution Prevention Provisions – Compliance and Enforcement Policy;
- Guidelines for the Use of Explosives In or Near Canadian Waters;
- National Factsheets – Brook Trout (Specifically);
- Newfoundland Factsheets for:
    - Effects of Silt on Fish and Fish Habitat,
    - Blasting - Fish and Fish Habitat Protection,
    - Forwarder Trails,
    - Temporary Bridges,
    - Resource Road Construction,
    - Instream Work in the Dry Cofferdams,
    - Streambank Stabilization, and
    - Instream Work in the Dry – Temporary Diversion and Elevated Pipes (see Volume 1);
- Freshwater Salmonid Habitat Requirements; and
- Freshwater Intake End-of-Pipe Fish Screen.

Specific mitigative measures can be drawn from these documents to help minimize construction affects and all necessary mitigation measures to reduce the effect of turbidity and sedimentation will be detailed in the EPP. For example, siltation control structures (i.e., silt curtains, cofferdams, and/or sediment fences) will be constructed prior to beginning any activities involving disturbance of the soil, work along the shoreline or near areas of high runoff potential. Construction activities will be coordinated to avoid periods of heavy precipitation and not coincide with sensitive periods for fish. Mitigative measures will be implemented prior to any grubbing or excavation to direct any natural drainage around work areas, avoiding sediments above ambient suspended particle concentration in runoff waters.

Soil disturbance will be minimized by limiting the area exposed at any one time, stabilizing exposed soil with anti-erosion devices (i.e., riprap, filter fabrics, gravel, or wood chips) and revegetation of disturbed areas. Grubbing of the organic vegetation mat and/or the upper soil horizons will be restricted to the minimum area required. The organic vegetation mat and upper soil horizon material that has been grubbed will be spread to cover inactive exposed areas. In addition, a 50-m buffer zone of undisturbed natural vegetation between construction areas and all waterbodies outside the Project site will be maintained to prevent sediments from entering local waterways.

No runoff will be allowed to freely flow into any waterbody. Runoff during construction will be directed to adequate vegetated areas or settling ponds within the Project boundaries to slow flow and allow particles to settle out. Any natural vegetated areas receiving runoff will first be assessed to ensure they can adequately handle anticipated volumes and do not constitute habitat for any species of concern.

Settling Ponds will be designed according to DFO's Land Development Guidelines for the Protection of Aquatic Habitat (Chilibeck et al. 1993). The number and size of ponds required during construction will be based on final area of disturbance and calculations of maximum runoff anticipated. Ponds both for construction and operations will be built with required safety factors, adhering to guidelines with respect to such design standards as the accommodation of storms (1:5, 1:10, and 1:100 years storms), effective capacity, retention times and location. Their operation and maintenance will include regular inspection and assessment of accumulated sediment load, removing it when required.

Residual Effects

With the incorporation of all mitigation measures, the effects of sedimentation as a result of construction earthworks are anticipated to be of a *low* magnitude. While the structures will be permanent and activities will be relatively *continuous* throughout construction, the duration is considered intermediate (*13 to 36 months* during construction), the geographic extent is limited (*1 to 10 km^2*) with effects being *reversible* once the structures are constructed (Table 6.2). The residual sedimentation effects associated with earthworks activities on the freshwater fish and fish habitat VEC are *not significant* (Table 6.3).

Loss or Alteration of Fish Habitat

The habitat survey with respect to a freshwater HADD determination was conducted using the *Standard Methods Guide for the Classification/Quantification of Lacustrine Habitat in Newfoundland and Labrador* (Bradbury et al. 2001a) and the *Classification and Quantification of Fish Habitat in Rivers of Newfoundland and Labrador* (McCarthy et al. 2007). Results are detailed in the Freshwater Habitat Component Study (AMEC 2007a).

The plant site will be located within the watershed of Beaver Brook (Tributary T1-1), a tributary to Rattling Brook. It has a total drainage basin of 2.1 km^2 and extends inland to the west from the main stem approximately 1.8 km. Its headwaters empty two small ponds. An additional sub-tributary drains a second set of small ponds (P22 and P23) into Beaver Brook from the west (see Figure 2.6). The fish species in Beaver Brook is brook trout. Sections of stream within the plant site footprint will be lost and may be deemed to be a HADD since the affected reaches are productive fish habitat.

Upon making a HADD Determination, DFO will require Vale Inco NL to develop and implement a Compensation Plan that will achieve "no net loss" of productive fish habitat. Preferred actions ("like for like" options) would occur within the same ecological unit and address the affected fish species. Since the Rattling Brook watershed has been affected by previous industrial activity, opportunities can be anticipated for habitat improvements or rehabilitation measures that will increase productivity. In the context of an EIS, such compensation measures are regarded as mitigation measures and will ensure that residual environmental effects are at an acceptable level.

Residual Effects

The residual effects of habitat loss will be *continuous*, of long duration (*>72 months*) and *irreversible*, but of *low* magnitude and small geographic extent (<*1* km^2) (Table 6.2). With standard construction mitigations and the Compensation Plan, all residual adverse environmental effects of the earthworks associated with the Project footprint are considered *not significant* (Table 6.3).

6.6.2 Blasting

Blasting will be required during construction to remove areas of bedrock, primarily in the location of the processing plant. Detonation of explosives during construction activities will produce vibrational and acoustic noise in the surrounding environment, potentially causing negative effects on freshwater fish and fish habitat. There are potential interactions between blasting activities and all components of this VEC (Table 6.1).

All fish species within the freshwater environment could be potentially affected by blasting. All freshwater spawning species have eggs and larvae particularly sensitive to excess vibration during egg incubation. The degree of effect on juvenile and adult life-cycle stages will be dependent upon the size, proximity, and duration of blasts.

Blasting will be required during construction to remove areas of bedrock, primarily in the location of the processing plant. Detonation of explosives during construction activities will produce vibrational and acoustic noise in the surrounding environment. Blasting protocols have been designed to be as efficient and effective as possible, using publications such as: Wright and Hopky's (1998) *Technical Report for the Use of Explosives Near Canadian Fisheries Water*, *Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador* (Gosse et al. 1998) and DFO's *Mitigation of Seismic Noise in the Marine Environment - Statement of Canadian Practice*.

Guidance on blasting activities in or near the freshwater environment is provided in the *Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador* (Gosse et al. 1998):

- Large charges should be subdivided into a series of small charges and time delayed to reduce the overall detonation to a series of small detonations;

Table 6.2 Effects Assessment of Construction on Freshwater Fish and Fish Habitat VEC

Valued Ecosystem Component: Freshwater Fish and Fish Habitat								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Construction Activities								
Earthworks	Increased Turbidity (N) Sedimentation (N) Blasting (N) Habitat Loss (N)	Turbidity Barriers Settling Ponds Blast Controls Habitat Compensation	1	2	6	3	R	1
Loss or alteration of fish habitat	Dam Footprints (N) Altered Flows (N)	Habitat Compensation	1	1	6	5	I	1
Atmospheric emissions (dust)	Increased Turbidity (N) Sedimentation (N)	Turbidity Barriers Settling Ponds	1	2	6	3	R	1
Blasting	Vibration (N) Shock (N)	Appropriate Charges Blast Mats Guidelines	0	2	2	3	R	1
Water Supply Dam	Increased Turbidity (N) Sedimentation (N) Habitat Loss (N) Loss of Fish Passage (N)	Turbidity Barriers Settling Ponds Habitat Compensation Construction of Fish Passage	0	1	1	3	R	2 (ERCO)
Residue storage dams	Increased Turbidity (N) Sedimentation (N) Habitat Loss (N)	Turbidity Barriers Settling Ponds Habitat Compensation	0	1	6	5	I	1
Power lines (fording)	Increased Turbidity (N) Sedimentation (N)	Turbidity Barriers Settling Ponds	0	1	1	1	R	1
Roads (culverts/bridges)	Increased Turbidity (N) Sedimentation (N)	Turbidity Barriers Settling Ponds	0	1	1	1	R	1
Pipelines (culverts)	Increased Turbidity (N) Sedimentation (N)	Turbidity Barriers Settling Ponds	0	1	1	1	R	1
Vehicle traffic	Increased Turbidity (N) Sedimentation (N)	Turbidity Barriers Settling Ponds	1	2	6	3	R	1

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

*N/A = Not Applicable

Table 6.3 Significance of Potential Residual Environmental Effects of Construction on Freshwater Fish and Fish Habitat VEC

Valued Environmental Component: Freshwater Fish Habitat				
	Significance Rating	Level of Confidence	Likelihood[a]	
Project Activity	Significance of Predicted Residual Environmental Effects		Probability of Occurrence	Scientific Certainty
Earthworks	NS	3		
Atmospheric emissions (dust)	NS	3		
Loss or alteration of fish habitat	NS	3		
Blasting	NS	3		
Water supply dam	NS	3		
Residue storage dams	NS	3		
Power lines	NS	3		
Roads	NS	3		
Pipelines (culverts)	NS	3		
Vehicle traffic	NS	3		

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence
N/A = Not Applicable

[a] Only applicable to significant effect.

- For multiple charges, time-delay (e.g., blasting caps) should be used to reduce the overall detonation to a series of single explosions separated by a minimum of 25 millisecond delay between charge detonation;
- The on-land set-back distance from the blast site to the watercourse and the set-back distance (zone) around the blast site in the watercourse are based on the maximum weight of the charge to be detonated at one instant in time and the type of fish and fish habitat in the area of the blast;
- Blasting activities are to take place at a minimum set distance from the watercourse as indicated in Table 6.4;
- If on-land blasts are required nearer to the watercourse than indicated above, then additional mitigative measures should be initiated which include the following:
  - Installation of bubble/air curtains to disrupt the shockwave. When bubble curtains are used, the curtain should surround the blast site and be started up only after fish have been moved outside the surrounded area,
  - Blasting should be undertaken at the time of least biological activity or biological sensitivity,
  - Isolation of the work area from fish movement,

  - o Detonation of small scaring charges set off one minute prior to the main charge to scare fish away from the site, and
  - o The use of noise generators to move fish out of the area;
- To confine the blast, sand or gravel should be used to backfill blast hoses to grade or to streambed/water interface;
- Blasting mats should be placed atop the blasting holes to minimize the scattering of blast debris;
- Ammonium nitrate based explosives (i.e., Ammonium Nitrate Fuel Oil mixtures or ANFO) should not be used in or near water due to the production of toxic by-products (ammonia); and
- All blasting and other associated equipment and products are to be removed from the blast area, including any debris that may have entered the aquatic environment.

Specific mitigation measures to reduce the effect of blasting will be detailed in the EPP. Blasting is a highly regulated construction activity subject to very prescriptive guidelines and best-practices. Blasting protocols have been designed to be efficient and effective as possible, while producing minimal unintended effects. Vale Inco NL will contract licensed blasters and require seismograph recordings during blasting as considered appropriate.

Table 6.4 Minimum Required Distances from a Watercourse for Blasting (Confined Charges)

Habitat	Weight of Explosive Charge (kg)					
	0.5	1	5	10	25	50
H1	7 m	10 m	15 m	20 m	35 m	50 m
H2	15 m	20 m	45 m	65 m	100 m	143 m

Notes: H1 – rearing/general fish habitat
H2 – spawning habitat where egg or early fry development is occurring

Residual Effects

With the incorporation of all mitigation measures, the effects of blasting during construction are anticipated to have a *low* magnitude, a low frequency (*11 to 50* blasts per year), intermediate duration (*13 to 36 months* during Construction) and a small geographic extent (*1 to 10* km^2) with effects being *reversible* once blasting is completed (Table 6.2). The residual effects associated with blasting construction are predicted to be *not significant* (Table 6.3).

6.6.3 Atmospheric Emissions (Dust)

Atmospheric dust from clearing, grubbing and excavation activities can result in aerial deposition of fine particles, potentially causing negative effects on the freshwater fish and fish habitat. There are potential interactions between atmospheric emissions of dust and all components of the freshwater fish and fish habitat VEC.

All fish species within the freshwater environment could be potentially affected by instream deposition of dust. All freshwater spawning species have eggs and larvae particularly sensitive to excess deposition during egg incubation. Since most life-cycle stages are mobile once hatched, the degree of effect on juvenile and adult life-cycle stages would be dependent upon the quantity of dust, the duration of the release/deposition, and the overall extent of habitat affected.

Mitigation measures to reduce the effect of atmospheric dust will be detailed in the EPP. Dust emission during the Construction Phase will be localized to the areas where overburden is being cleared to allow for construction of all permanent structures and road construction. Any areas with a high dust potential will be sprayed with water. Where and when applicable (e.g., during a dry summer), calcium chloride may be used for dust suppression on operational roads. The use of calcium chloride will be in accordance with the guidelines outlined in Environment Canada's *Best Practices for the Use and Storage of Chloride-Based Dust Suppressants* (EC 2007b), referring to how, when and quantity to apply. Once construction is completed, the potential for dusting will be minimal.

Residual Effects

With the incorporation of all mitigation measures, the effects of dust deposition during construction are anticipated to be *negligible*. While activities will be relatively *continuous* throughout construction, the duration is considered intermediate (*13 to 36 months* during construction), the geographic extent is small (*1 to 10* km^2) with effects being *reversible* (Table 6.2). The residual effects of dust associated with clearing, grubbing and excavation activities on the freshwater fish and fish habitat VEC are *not significant* (Table 6.3).

6.6.4 Supporting Infrastructure (Roads, Storm System, Pipelines and Powerlines)

Construction of supporting infrastructure will include similar activities and mitigations to those described for earthworks of the Plant footprint (see Section 6.6.1). Site clearing, grubbing, and leveling could potentially result in the introduction of sediment-laden water to the freshwater environment, especially when these activities are conducted in areas proximate to fish habitat.

The upgrading and construction of roads and the construction and installation of pipelines and powerlines will include culvert installations, temporary stream crossings and associated activities near watercourses.

Design parameters of supporting infrastructure will adhere to all relevant guidelines and recommendations outlined in the NL Department of Works, Services and Transportation *Specifications Book* (2003).

Mitigative measure will be implemented prior to grubbing or excavation to direct natural drainage around work areas (e.g., silt curtains, cofferdams, and sediment fences), avoiding sediments above allowable suspended particle concentration in runoff waters. Soil disturbance will be minimized by limiting the area exposed at any one time, stabilizing exposed soil with anti-erosion devices (e.g., riprap, filter fabrics, gravel, or wood chips), and revegetating disturbed areas as necessary.

The use of heavy equipment near watercourses will be minimized, restricting the use of machinery within a waterbody. Construction activities will be coordinated to avoid periods of heavy precipitation and not coincide with sensitive periods for fish (e.g., spawning). Excavation, embankment, and grading in the vicinity of stream crossings will be done in a manner that ensures erosion and sedimentation of watercourses and waterbodies is minimized and is done in strict compliance with the NL Department of Environment and Conservation and DFO guidelines and requirements. All stream bank sections that contain loose or erodible materials are to be stabilized. No material is to be deposited within the watercourse.

Work in or near water courses will include water crossings. One crossing will employ a bottomless arch culvert; the rest will employ corrugated iron pipe culverts. In locations where culverts are required, application will be made to NDOE. The culverts used will be sized to handle the 1-in-25-year return period flood and will be constructed in accordance with the *Environmental Guidelines for Culverts* from the NDOE, Water Resources Division, 1992. The following measures will also be implemented:

- Culverts will be installed in accordance with good engineering and environmental practices.
- Unless otherwise indicated, all work should take place in dry conditions, either by the use of cofferdams or by diverting the stream.
- Installation of cylindrical culverts shall be counter-sunk only where necessary to protect fish habitat such that the culvert bottom is 1/3 the diameter below the streambed in the case of culverts less than 750 mm outside the diameter; for culverts greater than 750 mm outside diameter, the culvert bottom shall be installed a minimum of 300 mm below the streambed.
- In multiple (gang) culvert installations, install culverts at graduated elevations.
- Ensure that the natural low flow regime of the watercourse is not altered.
- A culvert will not be installed before site-specific information such as localized stream gradient, fish habitat type and species present have been evaluated.
- Riprap outlets and inlets to prevent erosion of fill slopes.
- Use culverts of sufficient length to extend a short distance beyond the toe of the fill material.
- Use backfilling material that is of texture that shall support the culvert and limit seepage and subsequent washing out.
- Align culverts so that the original direction of stream flow is not significantly altered.
- Remove fill and construction debris from the culvert area to a location above the peak flow level to prevent its entry into the stream.
- Confine construction activity to the immediate area of the culvert.
- Fill material shall not be removed from streambeds or banks, except when installing a culvert, when removal of material is necessary to ensure a flat foundation.
- Minimize and restrict the use of heavy equipment in and near watercourses; where possible, an excavator will be used from shore rather than a bulldozer in the watercourse. Where it is

absolutely necessary to do so, instream work will be performed by rubber-tired vehicles only, and will only be done in compliance with NDOE and DFO guidelines/conditions.

- As required, cofferdams of non-erodible material shall be used to separate work areas from the watercourse when excavating for culverts and footings.
- Cofferdams shall be removed upon completion of construction and the streambed returned as closely as possible to its original condition.

When fording any watercourse, the *Environmental Guidelines for Fording* from NDOE, Water Resources Division (1992) will be applied in conjunction with the following:

- Areas of spawning habitat will be avoided.
- Crossings shall be restricted to a single location and crossings made at right angles to the watercourse.
- Equipment activity within the watercourse shall be minimized by limiting the number of crossings.
- Ensure that all equipment is mechanically sound to avoid leaks of oil, gasoline and hydraulic fluids.
- Ensure that no servicing or washing of heavy equipment occurs adjacent to watercourses; temporary fueling, services or washing of equipment in areas other than the main fuel storage site shall not be allowed within 30 m of a watercourse except within a refueling site approved by Newfoundland Hydro, where conditions allow for containment of accidentally spilled fuels; remove from the work area and properly dispose of all waste oil, filters, containers or other such debris in an approved waste disposal site.
- Stabilize the entire fording area using vegetation mats, corduroy roads or coarse material (125 mm diameter or greater) when such material is available from a reasonably close location within the right-of-way, and the ford area is not natural bedrock, or is easily disturbed by fording; when the substrate of the ford area is not subject to easy disturbance by fording, or coarse material is not easily available within the right-of-way, fording under existing substrate conditions may occur under the direction of the Environmental Field Coordinator.
- Ensure that fording activities shall not decrease the depth of the watercourses to less than 20 cm; where the existing depth is less than 20 cm, that depth shall be maintained.
- Ensure that fording activities are halted during high flow periods.
- Stabilize all bank sections that contain loose or erodible materials; if banks must be sloped for stabilization, no material shall be deposited within the watercourse; sloping shall be accomplished by back-blading and the material removed shall be deposited above the high-water mark of the watercourse.
- All fording activities will comply with the required approvals from the NDOE and DFO guidelines (as per the DFO *Factsheet on Fording*).

- The flow of water must be diverted around the work area during the installation of a culvert to ensure dry conditions for construction activities.
- Culverts must be marked to indicate their position under the snow.

Residual Effects

With the incorporation of all mitigation measures, the effects of sedimentation during construction of supporting infrastructure are anticipated to have a *negligible* magnitude. While the structures will be permanent, construction will have a very low frequency (*<11* culverts/bridges), a short duration (*<1* month per installation), a very small geographic extent (*<1* km^2) with effects being *reversible* once the structures are in place (Table 6.2). The residual effects associated with the construction of roads are predicted to be *not significant* (Table 6.3).

6.6.5 Water Supply

Water required for Plant operations will be extracted from Rattling Brook Big Pond using a pumphouse and pipeline configuration.

The water supply facilities will include replacement of the existing pipeline in Rattling Brook Big Pond from past operations. It also includes a berm on the outflow of Rattling Brook Big Pond to ensure adequate water supply at all anticipated base flows (see Volume 1 for design rationale). The design of the water supply is such that maximum water levels will be as close as possible to normal high water levels for Rattling Brook Big Pond. Current design indicates that the spill elevation will be 109.1 m based on Project demand. This would compare to an existing maximum water level of 108.6 m. The calculation of the storage volume in Rattling Brook has taken into account the volume of water required to provide maintenance flows to Rattling Brook. The facility will also be designed to allow for upstream and downstream fish passage.

Standard mitigation as outlined in Section 6.6.1 will apply to all construction activities associated with the water supply. Fish passage will be maintained for the species identified in the upper portion of Rattling Brook (brook trout and Arctic char). Final passage design will be incorporated in the Habitat Compensation Plan but will include provision for passage at all typical seasonal times and at all flows. Recent swim speed data on Arctic char and brook trout indicates that culvert velocities of 0.40 to 0.65 m/s and 0.30 to 0.50 m/s respectively would allow successful passage (Peake 2004) through the existing structures. If these velocities are shown to be exceeded during the Compensation Planning process, an additional culvert will be added to the structure at a slightly higher elevation to provide the preferred passage velocities.

Residual Effects

With the incorporation of all mitigation measures, the effects of water supply construction will have a *negligible* magnitude. While the structures will be permanent, construction will have a very low frequency (*<11* dams/berms), an intermediate duration (*13 to 36 months)*, a very small geographic extent (*<1 km*^{2}) with effects being *reversible* once the structure is in place (Table 6.2). The residual effects associated with the construction of the water supply are predicted to be *not significant* (Table 6.3).

6.6.6 Residue Storage

The residue from the Hydromet process will be stored in Sandy Pond. The existing outflow of the pond will be dammed and all water within the pond contained. Any process water requiring discharge from Sandy Pond will be re-circulated back to the Plant, treated and discharged through the marine effluent diffuser. Thus, the flows to Sandy Brook from Sandy Pond will be eliminated.

Vale Inco NL will institute discussion with DFO on handling and disposition of fish from Sandy Pond and Sandy Brook.

Residual Effects

With the incorporation of a Habitat Compensation Plan, the effects of habitat loss associated with the alteration of Sandy Pond to a residue storage facility are anticipated to be of negligible magnitude. While the structures will be permanent (frequency *continuous* and duration greater than 72 months) and *irreversible*, the geographic extent is very small (*<1 km*^{2}) (Table 6.2). As a result, the residual effects are predicted to be *not significant* (Table 6.3).

6.6.7 Vehicle Traffic

Vehicle-related dust from the access roads will be largely confined to the Construction Phase, when traffic levels will be relatively high. The potential effects of dust and deposition into the environment as well as standard mitigations are described in Volume 1 Chapter 6.0, and Volume 2 sections 4.5.1, 5.5.3, and 6.5.2. Wet conditions common to the region greatly decrease the amount of dust that will be generated.

Residual Effects

With the incorporation of dust suppression measures, vehicle traffic effects are anticipated to be of a *low* magnitude. While vehicle traffic will be relatively *continuous* throughout construction, the duration is considered intermediate (*13 to 36 months* during construction), the geographic extent is small (*1 to 10 km*^{2}) with effects being *reversible* (Table 6.2). The residual dust effects associated with vehicle traffic on the freshwater fish and fish habitat VEC are *not significant* (Table 6.3).

6.7 Effects of Operations

Potential interactions between operations and the freshwater fish and fish habitat VEC are shown in Table 6.5. Mitigations related to operations are discussed in Chapter 7.0 of Volume 1.

6.7.1 Residue Storage

Residue slurry will be contained within the residue storage area. The total amount of habitat directly within Sandy Pond has been quantified (see Section 2.3 and AMEC 2007a) as per DFO guidelines and direction (see Bradbury et al. 2001a). The loss of Sandy Pond fish habitat will require the creation of a Habitat Compensation Plan by DFO prior to any undertakings directly affecting the habitat in question.

Residual Effects

With the incorporation of a Habitat Compensation Plan, a fully effective mitigation measure will be in place so that the effects of residue storage will be of a *negligible* magnitude. The structure will be permanent (frequency *continuous* and duration *>72 months*) and the effect *irreversible*. The geographic extent is small (*1 to 10* km^2) (Table 6.6). The residual effects associated with residue storage are predicted to be *not significant* (Table 6.7).

6.7.2 Water Use

Water required for Operations will be extracted from Rattling Brook Big Pond.

An assessment of the minimum flows required to maintain adequate fish habitat downstream of the dam has been conducted and (AMEC 2007a) results indicate that a minimum flow of 0.30 to 0.35 m^3/s will be required to protect and maintain downstream fish habitat. This requirement has been implemented in dam design and water storage and will be used as an operational requirement.

Residual Effects

With the incorporation of all mitigations, the effects of water withdrawal are anticipated to be of a *negligible* magnitude. Water withdrawal is anticipated to be *continuous* and continued for the life of the project (duration *>72 months*). The geographic extent is low (*1 to 10* km^2) with the effects being *reversible* (Table 6.6). The residual effects associated with water withdrawal are predicted to be *not significant* (Table 6.7).

Table 6.5 Potential Interactions between Operations and Freshwater Fish and Fish Habitat VEC

Valued Environmental Component: Freshwater Fish and Fish Habitat						
Project Activity	**Freshwater Fish and Fish Habitat Component**					
	Egg Incubation	**Young-of-Year**	**Juvenile**	**Adult**	**Reduced Water Quality**	**Reduced Water Quantity**
Operational Activities & Physical Works						
Total footprint						
Residue storage	✓	✓	✓	✓	✓	
Shipping						
Offloading						
Dust						
Washdowns/runoff	✓	✓	✓	✓	✓	
Water use	✓	✓	✓	✓		✓
Electricity use						
Diesel use						
Fuel oil#2 use						
Atmospheric emissions (incl. dust)	✓	✓	✓	✓	✓	
Marine effluent						
Site runoff	✓	✓	✓	✓	✓	
Surge pond						
Sewage						
Solid waste						
Vehicle traffic						
Noise						
Lighting						
Maintenance	✓	✓	✓	✓	✓	

Table 6.6 Effects Assessment of Operations on Freshwater Fish and Fish Habitat VEC

Valued Ecosystem Component: Freshwater Fish and Fish Habitat								
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Operational Activities								
Residue storage	N	Habitat Compensation	0	1-2	6	5	I	1
Water use	N	Flow Maintenance	0	2	6	5	R	2 (ERCO)
Atmospheric emissions (incl. dust)	N	Emission and Dust Controls Monitoring	0-1	1-2	6	3-5	R	2 (ERCO)
Site runoff	N	Controls	0	1	2	5	R	2 (ERCO)
Washdowns	N	Containment	0	1	2	5	R	2 (ERCO)
Maintenance (roads)	N	EPP	0	1	1	5	R	2 (ERCO)
Fuelling (see Accidental Events)		EPP						

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

*N/A = Not Applicable

Table 6.7 Significance of Potential Residual Environmental Effects of Operations on Freshwater Fish and Fish Habitat VEC

Valued Environmental Component: Freshwater Fish and Fish Habitat				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Operational Activities and Physical Works				
Residue storage	NS	3	-	-
Offloading	NS	2	-	-
Washdowns	NS	3	-	-
Water use	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Site runoff	NS	3	-	-
Maintenance (roads)	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

6.7.3 Atmospheric Emissions and Dust

Air emissions from the Plant will disperse and, depending on actual emission concentrations and stack/dispersion design, may deposit in or near watercourses, entering freshwater fish habitat. The effect on water quality has been considered in Chapter 5.0.

If deposition is at a rate or concentration that accumulation can occur (i.e., in substrates, food sources or fish), it can have a negative effect on fish and fish habitat. Atmospheric deposition (see Table 5.8) will result in increased concentrations of metals in water within a small area close to the plant site. Based on modeling of maximum bioaccumulation factors (BAF) of metals levels in fish tissue (Intrinsik 2007, 2008) metals levels in fish will not be a concern for the metals examined (cobalt, copper, lead, nickel, iron and manganese).

Residual Effects

With the incorporation of mitigation measures, the effects of airborne deposition during operation are anticipated to be of a *negligible* magnitude. While Operations will continue for 15 years (frequency *continuous* and duration *>72 months*), the geographic extent is low (*1 to 10* km^2) and would be *reversible* upon decommissioning (Table 6.6). The residual effects associated with airborne deposition are predicted to be *not significant* (Table 6.7). Uncertainties associated with modeling result in a medium level of confidence. Monitoring of deposition in nearby ponds can be conducted as a means to confirm predictions.

6.7.4 Site Runoff

Site runoff will occur as a result of water accumulation (e.g., rainwater and snow melt) within the processing plant area. Routine washdown water will be generated as a result of dust suppression at the wharf site. Runoff and washwater, if not properly collected and treated, may leave the site and enter watercourses untreated. Washwater in particular has the potential to be high in dissolved metals such as nickel and copper.

Site runoff will be collected by a series of drains and directed to on-site settling ponds. Settling ponds will be connected to the overall water treatment system for treatment and discharge and will be designed to handle anticipated site runoff. A secondary containment system is available in the residue storage area, where excess site runoff and effluent that does not meet discharge criteria can be re-routed to for further settling and treatment.

Residual Effects

With the incorporation of all mitigation measures, the effects of site runoff on fish and fish habitat are anticipated to be of a *negligible* magnitude. Activities will be of low frequency (*11 to 50 times per year*) but will be continued for the life of the Project's (duration *>72 months*). The geographic extent is very small (*<1 km*^{2}) with the effects being *reversible* (Table 6.6). The residual effects are predicted to be *not significant* (Table 6.7).

6.7.5 Washdowns

Routine washdown of the wharf area and infrastructure will be conducted to control dust during transfer. The washdown water will be maintained in a closed system and circulated to a settling system. Accumulated concentrate in the settling system will be periodically collected and excess water will be delivered to the processing plant water treatment system for treatment and discharge. All washdown areas are at the wharf site and are not located near freshwater fish or fish habitat.

During operations, the ship loader will be fed by covered conveyor belts. Dust suppression procedures will be implemented in these areas to comply with the NL *Criteria for Acceptable Air Quality* (which allows a total suspended particulate concentration of 80 $\mu g/m^3$ and 120 $\mu g/m^3$ for one-hour and 24-hour exposure, respectively).

Residual Effects

With the incorporation of all mitigation measures, the effects of washdowns on fish and fish habitat are anticipated to be of a *negligible* magnitude. Activities will be of low frequency (*11 to 50 times per year*) but will be continued for the life of the Project (duration *>72 months*). The geographic extent is very small (*<1 km²*) with the effects being *reversible* (Table 6.6). The residual effects associated with site washdowns are predicted to be *not significant* (Table 6.7).

6.7.6 Maintenance (Roads)

The maintenance of roads associated with the Project will include surface regrading of any gravel roads.

Residual Effects

With the incorporation of standard operating procedures, the effects of road maintenance are anticipated to be of a *negligible* magnitude. Activities will be of low frequency (*11 to 50 times per year*) but will be continued for the life of the Project (duration *>72 months*). The geographic extent is very small (*<1 km²*) with the effects being *reversible* (Table 6.6). The residual effects associated with the operation of roads are predicted to be *not significant* (Table 6.7).

6.8 Effects of Decommissioning Activities

Decommissioning interactions with freshwater fish and fish habitat relate primarily to pathways such as siltation, erosion and dust as a result of removal of material and infrastructure from the Project Area. These would be similar in nature but much reduced from those considered during Construction (Section 6.6) and would be *not significant*.

6.9 Cumulative Environmental Effects

The accumulation of within-Project activities during each phase will have the potential to result in an effect that, in total, exceeds individual predictions. The small footprint of the Project, the phasing of activities, and the modest (*not significant*) nature of the predicted effects will together diminish any within-Project cumulative effect.

The other planned or ongoing projects and activities identified for cumulative effects consideration do not overlap directly with the freshwater fish and fish habitat associated with this Project. In any case, the even and consistent application of the DFO policy for the Management of Fish Habitat will mean that there will be no net loss of productive fish habitat, and therefore no cumulative effects generated with respect to freshwater fish and fish habitat.

6.10 Summary of Effects on Freshwater Fish and Fish Habitat

Five primary issues are related to the potential effect of routine activities of the Construction, Operation, and Decommissioning phases on freshwater fish and fish habitat:

- Loss and/or alteration of freshwater fish habitat;
- Siltation, erosion and dust;
- Blasting and noise;
- Changes in water quantity; and
- Changes in water quality (addressed in Section 5.0).

Construction, Operation, and Decommissioning of the proposed facility does not present unique challenges in terms of mitigations required to protect freshwater fish and fish habitat. The potential effects of siltation, erosion, dust, and blasting are typical of most large-scale construction projects and have been the focus of regulators and industry. In this respect, appropriate mitigations are available and standardized so that their implementation is not difficult and, in most cases, is required under regulation. Many of these have been described in the appropriate sections above and throughout the Project Description (Volume 1) where warranted. These as well as more project-specific mitigations will also be presented in the EPP, which will be available to all workers on the site so that the mitigations are known and implemented.

The more project-specific effects (i.e., habitat loss) require site-specific mitigations such as minimum flow maintenance and fish passage design. Habitat loss, both direct as a result of structure placement, and indirect from dewatering, will also require compensation under the *Fisheries Act* and thus will ensure no net loss of fish habitat and hence no significant residual effect.

The predicted residual effects associated with the Project on freshwater fish and fish habitat are *not significant*.

7.0 Marine Fish and Fish Habitat Effects Assessment

Marine fish habitat is very broadly defined here to include components such as water and sediment quality, plankton, and benthos. The marine stages of anadromous (e.g., sea run salmonids) and catadromous fish (e.g., American eel) are also considered where relevant. Fish VECs are of prime concern from both a public and a scientific perspective, locally, nationally, and internationally. Individual species were selected to represent this VEC, as it is impossible to individually assess the hundreds of species that potentially occur in Placentia Bay. In most cases, species can be grouped according to life cycle needs and sensitivities. Flounder and blue mussel are two relatively immobile species found in the Project Area year-round and likely to interact with the marine activities; they provide a conservative basis for effects predictions for marine species in general. The main potential for effects on these species and the marine environment in general stem from marine construction activities, marine effluent, shipping, and marine accidents (Chapter 11.0).

7.1 Existing Conditions

The existing marine environment is described in detail in Section 2.4. During the marine ecology baseline study (LGL 2007) at Long Harbour, blue mussels and winter flounder were sampled as bio-indicators of baseline conditions. Blue mussels have direct contact with the suspended sediments and feed by filtering sea water through gills. In Long Harbour they tend to occur in the lower part of the water column immediately above the substrate. Thus, the blue mussel can provide indications of the water and sediment quality by measuring the levels of bioaccumulated substances and general health indices (e.g., condition index). Also, it is a particularly relevant species in the present case because blue mussels are currently being grown at an aquaculture operation in Long Harbour.

The winter flounder is also a good indicator of environmental health because it is essentially in contact with the bottom substrate at all times (sometimes buried), and feeds on small organisms that live either on or in the substrate. This flatfish species can also provide some indication of sediment quality by measured levels of bioaccumulated substances and overall health.

The blue mussel and the winter flounder serve as important prey for a variety of higher level ecosystem consumers including other macroinvertebrates, fish, birds, marine mammals, and man. Both animals have life stages that occur throughout the habitat (i.e., upper and lower water column, and on bottom substrates). These marine species were used as focal species in the assessment of the effects of routine activities on the marine fish and fish habitat VEC.

7.2 Assessment Criteria

Assessment criteria, including boundaries, are described in Chapter 3.0. Significant environmental effects are those considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the marine fish and fish habitat VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EIS, a *significant* effect is defined as:

> *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2.*

Reversibility is also an important consideration.

7.3 Issues and Concerns

Three primary concerns are associated with the potential interactions between routine activities of the three phases of the Project and marine fish and fish habitat:

1. Loss and/or alteration of marine fish habitat;
2. Increased suspended sediments; and
3. Discharge of marine effluent into Long Harbour.

The marine fish and fish habitat VEC could potentially interact with a variety of routine activities associated with the Construction, Operation, and Decommissioning phases. There are five primary marine works activities that will interact with marine fish and fish habitat:

1. Dredging;
2. Wharf expansion;
3. Shore and scour protection;
4. Marine effluent pipeline; and
5. Marine effluent.

The effects of these and some other routine activities on marine fish and fish habitat are assessed in the following sections.

7.4 Existing Knowledge

The following sections briefly summarize existing knowledge in regard to the focal species, marine habitat, metal contamination, and disturbance. Also presented is a summary of the modeling results from the Environmental Risk Assessment (ERA) (Intrinsik 2007, 2008).

7.4.1 Blue Mussel

Throughout its circumpolar distribution in boreal and temperate waters, the blue mussel can be found in habitats ranging from slightly brackish shallow estuaries to highly saline offshore environments. In Newfoundland and Labrador, the blue mussel is most commonly found in the intertidal and shallow subtidal zones (<30 m) (DFO 1996).

Spawning typically occurs from May to August, peaking sometime between mid-May and late June. Spawning time appears to be closely linked to environmental triggers, including sufficiently high water temperatures, suitable planktonic food supply, spring tidal currents, and even sudden physical disturbance during storm events (Bayne 1976; Starr et al. 1990). External fertilization results in benthic fertilized eggs, followed by the larval hatch. In Atlantic Canada, blue mussel veliger larvae (second larval stage) are often among the first marine invertebrate larvae caught during spring plankton tows (Mallet and Myrand 1995). The free-swimming larvae remain planktonic for three to four weeks prior to settlement (mid-June to late September in Atlantic Canada). Settlement appears to be most successful on hard substrate with surface irregularities and in areas with some protection from strong wave action. Once the larvae settle, crawl along a substrate and attach to the substrate by byssal threads, they metamorphose into young juveniles commonly referred to as spat, which in turn develop to adult stage, ingesting small phytoplankton organic detritus suspended in the water column (DFO 1996).

Over the years, adult blue mussels have often been used as bioindicator species for marine environmental quality (Freeman and Dickie 1979). Being a sessile filter feeder makes this mollusc an ideal candidate as a bioindicator. Mussel species, including the blue mussel, have been used as bioindicator species in numerous studies conducted in the Atlantic Ocean, including marine areas in Newfoundland and Labrador (Christian 1993; Christian and Lee 1998; Christian and Buchanan 1998). The blue mussel is a popular aquaculture species, especially in parts of eastern Canada, and is in relatively high demand in the food market.

7.4.2 Winter Flounder

The winter flounder occurs in the northwest Atlantic from southern Labrador to Georgia. It is a coastal flatfish that inhabits depths ranging from five to 100 m, but typically less than 40 m, and is most often associated with soft or moderately hard bottoms (Scott and Scott 1988; DFO 2005b).

In Newfoundland, this flatfish typically spawns in shallow coastal areas with sand or mud bottom during spring (March to June), peaking in June. The winter flounder is unique among Atlantic flatfishes in that its fertilized eggs are demersal and adhesive. Time to larval hatch varies from one to four weeks after fertilization, depending primarily on water temperature. The larvae are planktonic in the surface waters until they metamorphose and seek out the bottom. Juvenile and adult winter flounder are found on a variety of substrate types in Newfoundland waters (e.g., soft bottom with eelgrass, hard bottom dominated by cobble, rock and boulder) (DFO 2005b).

Winter flounder is primarily a daytime feeder, preying on benthic organisms including algae, polychaetes, crabs, amphipods, shrimps, sea urchins, molluscs, and fish eggs (e.g., capelin, herring) (Scott and Scott 1988; DFO 2005b; Fish Base 2007, http://www.fishbase.org).

The winter flounder has often been used as a bioindicator species in studies conducted in Placentia Bay and other marine areas in Newfoundland (Barker et al. 1994; Khan et al. 1994; Khan 1995, 1997, 1998, 1999, 2003a,b, 2004a,b, 2006; Khan and Hooper 2000; Khan and Payne 2002a,b, 2004).

The winter flounder is fished commercially in some areas of eastern Canada (e.g., NAFO Division 4T in the Gulf of St. Lawrence) for bait and limited food markets (DFO 2005b).

7.4.3 Harmful Alteration, Disruption and/or Destruction (HADD)

Habitat destruction is always considered harmful, at least temporarily. Alteration, disruption and destruction of marine fish habitat immediately affect the productive capacity of an area, but the return to the pre-impact productive capacity level can be relatively rapid, depending on the nature of the habitat affected. Some alterations and disruptions can result in an increase in productive capacity of an area. For example, habitat alteration and disruption for the Project includes covering existing natural bottom habitat with introduced objects such as armour stone and a pipeline. Biota living at the surface of the covered natural habitat would likely be displaced. If the habitat being covered is hard (i.e., substrate predominantly comprised of coarse particles), the surface of the introduced object would likely serve as habitat substrate. There could even be an increase in available surface area for attachment/colonization. Examples of activities that cause habitat destruction include dredging and installation of wharf pilings; in each of these cases, an amount of sediment is actually removed from a habitat area, which can then no longer serve as habitat for certain biota. The sediment exposed as a result of dredging would eventually become the surface substrate for epibenthic species. The ultimate change in the benthic community would depend somewhat on the physical and chemical similarity of the exposed sediment to that removed by dredging.

Some marine activities associated with the proposed Project will result in a HADD to marine fish habitat.

7.4.4 Chemicals of Potential Concern

The ERA of the Vale Inco NL commercial nickel processing plant (Intrinsik 2007, 2008) identified chemicals of potential concern (COPC) for the marine environment associated with both the Hydromet and Matte plant processing options. A comprehensive list of the identified COPCs includes:

- Arsenic;
- Barium;
- Boron;
- Cadmium;
- Chromium;
- Cobalt;
- Copper;
- Iron;
- Lead;
- Manganese;
- Nickel;

- Selenium;
- Zinc;
- TSS; and
- TDS.

All of the COPCs listed above are associated with the Matte Plant processing option, whereas all but arsenic and chromium are associated with the Hydromet processing option. All but arsenic, boron, and selenium are metals.

Elements in trace amounts are normal chemical constituents of marine organisms. Some, including zinc, copper, and cobalt, are essential for normal growth and development. In coastal regions, elements are typically supplied to the marine system by river water or wind-blown material following rock weathering. Additional quantities of metals are being added to estuaries and other developed coastal regions from industrial effluents, sewage and atmospheric pollution. At sufficiently high concentrations, elements can be toxic to marine organisms (Bryan 1971).

One factor that affects the bioavailability of elements is 'chemical speciation'. Elements exist in sea water in equilibrium between soluble forms (either free ions or polar complexes) and forms bound to particulate matter. The forms most available to biota are the dissolved polar species (Bryan 1971). Generally, early developmental stages of marine invertebrates and fish are often most sensitive to exposure to elements.

Arsenic

Arsenic is a ubiquitous element with metalloid properties. In water, arsenic is typically found in the form of arsenate (under well-oxygenated conditions) or arsenite (under reducing conditions such as deep water). The most important commercial compound, arsenic (III) oxide, is produced as a by-product in the smelting of copper and lead ores (U.K. Marine SACs Project: http://www.ukmarinesac.org.uk /activities/water-quality /wq8_9.htm).

The ambient level of arsenic in seawater is generally accepted as being in the range two to three µg/L (Mance et al.1984). Mance et al. (1984) reviewed information relating to the aquatic toxicity of arsenic to marine organisms and derived an environmental quality standard (EQS) of 25 µg/L. The authors concluded that invertebrate species appear to be more sensitive to arsenic than vertebrate species, particularly in larval stages. Algae also appear to be as sensitive as marine invertebrates. Grimwood and Dixon (1997) recommended that the EQS derived by Mance et al. (1984) was appropriate. Smith and Edwards (1992) suggested that a lower guideline for arsenic concentration in seawater (e.g., 7 µg/L) be used where particularly sensitive algal species occur. According to the Canadian Interim Marine Sediment Quality Guidelines, arsenic concentrations in marine sediment exceeding 7.24 mg/kg might pose a hazard to infauna. Arsenic bioaccumulates in marine organisms (e.g., bivalves, flatworms, algae) but does not appear to biomagnify in food chains.

Barium

Barium is one of the alkaline earth metals. In nature, barium occurs only in a combined state, the principal mineral forms being barite (barium sulfate) and witherite (barium carbonate). Certain barium compounds (e.g., acetate, nitrate, chloride) are relatively water-soluble while others (e.g., fluoride, carbonate, phosphate) are not. The water solubility of barium salts typically increases with decreasing pH (International Programme on Chemical Safety, http://www.inchem.org/documents/ehc/ehc/ehc107.htm).

Few data are available for evaluating the risk of exposure to barium to marine organisms. Barium is known to have a variety of specific effects on different microorganisms (e.g., physico-chemical properties, spore germination, general inhibition of cellular processes). Some data indicate no effects on fish survival following 30 days of exposure. However, some effects on invertebrates (e.g., daphnids) have been reported after multiple-day exposure to a barium concentration of 5,800 µg/L. Exposure to large amounts of barite could potentially adversely affect colonization by benthic animals. The Canadian marine water quality guideline (MQG) for barium is 500 µg/L.

Boron

The environmental chemistry of this non-metal element in sea water is not well understood but the predominant boron species in sea water is boric acid (76%), while the borate anion accounts for approximately another 13 per cent (CCREM 1987).

Mance et al. (1988) reviewed the toxicity of boron to marine organisms and found that data were very limited. Based on LC_{50} experimentation on a species of fish (dab, *Limanda limanda*), the authors derived a conservative seawater boron standard for protection of marine organisms of 7,000 µg/L. There is some evidence that boron accumulates in marine zooplankton and algae (CCREM 1987). Furuta et al. (2007) found that the 96 h LC_{50} of boron for the Japanese flounder (*Paralichthys olivaceus*) increased with increasing fish size (108,000 to 252,000 µg/L) and increasing water temperature (108,000 to 350,000 µg/L). These differences might partially reflect the variability of boron acute toxicity between fish species.

Cadmium

The accepted average concentration of this metal in seawater is approximately 0.1 µg/L or less (Korte 1983). Cadmium uptake by marine organisms is extremely variable and depends on species and environmental conditions including water hardness (notably calcium ion and zinc concentrations), salinity, temperature, pH, and organic matter content. For example, increased temperatures tend to increase cadmium uptake and toxic impact, while increasing salinity, water hardness, and organic content have the opposite effect. An increase in cadmium toxicity has also been noted when water temperatures increase and salinity decreases (Rosenberg and Costlow 1976). Acute lethal effects for marine organisms have been noted with cadmium concentrations as low as 16 µg/L (WHO 1992a,b).

Cadmium toxicity can affect growth and reproduction in marine invertebrates and fish (and formation of the spine). As with other contaminants, the most susceptible life stages of fish appear to be embryos and early larvae. Bioaccumulation in marine organisms appears to occur primarily as a result of intake of dissolved cadmium in seawater and cadmium in prey (WHO 1992a,b).

Chromium

Chromium is ubiquitous in nature. Its natural level in uncontaminated seawater is typically less than one µg/L, but the chemical forms of chromium in seawater are unclear. Theoretically, chromium likely occurs in both trivalent and hexavalent states. Almost all the hexavalent chromium in the environment arises from human activities. This state is reduced to the trivalent state when it comes in contact with organic matter in biota, air and water. The ultimate repository for chromium is ocean sediment (U.K. Marine SACs Project: http://www.ukmarinesac.org.uk/activities/water-quality/wq8_9.htm).

The solubility of trivalent chromium in seawater varies with salinity and complexes present in the seawater. Mance et al. (1984) reviewed information relating to the aquatic toxicity of chromium to marine organisms and found considerable variability in acute toxicity. The authors concluded that invertebrate species appear to be more sensitive to chromium than vertebrate species, particularly in larval stages. They proposed an EQS for chromium in seawater of 15 µg/L. Hunt and Hedgecott (1992a) later proposed a more stringent EQS of five µg/L. According to the Canadian Interim Marine Sediment Quality Guidelines, chromium concentrations in marine sediment exceeding 52.3 mg/kg might pose a hazard to infauna. Chromium is not expected to bioaccumulate under natural conditions (Hunt and Hedgecott 1992a).

Cobalt

Since it is an integral component of vitamin B_{12}, a dietary intake of cobalt is required. The cobalt-cobalamine complex is required by fish (Droop 1957 *in* Nolan et al. 1992). It has been suggested that cobalt concentrations could play a role in limiting biological growth in the marine environment (Bruland 1983 *in* Nolan et al. 1992). In seawater, cobalt is present primarily as the CO^{++} ion and its chloro-, sulfato-, and carbonato-complexes (Ahrland 1975 *in* Nolan et al. 1992) and is rapidly removed from seawater, probably in association with MNO_2 phases (Knauer et al. 1982 *in* Nolan et al. 1992). In shallow waters, 98 per cent of the metal can be found in the sediments and in suspended particulate matter (Robertson et al. 1973 *in* Nolan et al. 1992); the remainder is the soluble fraction. Typical concentrations of cobalt in sea water vary with distance from the continental margin, the higher concentrations typically occurring closer to shore (e.g., 0.002 to 0.1 µg/L). Cobalt will accumulate in plants and in the bodies of animals that eat these plants, but it is not known to biomagnify up the food chain. Therefore, fish and other animals that humans eat will usually not contain high amounts of cobalt.

There is no water quality guideline for cobalt relating to the protection of marine aquatic life due to lack of data (BC MOE website, http://www.gov.bc.ca/wat/wq/BCguidelines/cobalt/update.html).

Copper

This metal may exist in the marine environment either in dissolved form as the cupric ion (Cu^{2+}), complexed with inorganics and organics, or as suspended particles when present as a precipitate or adsorbed to organic matter (Mance et al. 1984). Copper can also be adsorbed to bottom sediments or exist as settled precipitates. The concentrations of each of these forms depend on many variables including pH, salinity, and water hardness. Next to mercury and silver, copper is the most toxic metal to a wide spectrum of marine life (Ansari et al. 2004). There is experimental evidence to suggest that a number of aquatic species are sensitive to copper in the concentration range of 1 to 10 µg/L of sea water. Copper concentrations within this range have been shown to have effects on young bay scallops (Nelson et al. 1988 *in* Ansari et al. 2004) and young surf clams (Nelson et al. 1988 *in* Ansari et al. 2004). Rygg (1985 *in* Morrisey et al. 1996) concluded that the most sensitive benthic animals in Norwegian fjords were missing from areas where sediment copper concentrations exceeded 200 ppm. Morrisey et al. (1996) found that sediment concentrations of copper ranging from 140 to 1,200 mg/kg, compared to background levels of 29 to 40 mg/kg, had an impact on abundance and taxonomic composition of a soft-sediment fauna community. The apparent effects varied between species.

Using matching biological and chemical data compiled from numerous modeling, laboratory and field studies performed with estuarine and marine sediments, Long et al. (1995) derived two guideline values for some of the trace metals, including copper. The two guideline values are 'effects range low' (ERL) and 'effects range median' (ERM). The ERL is the lower 10^{th} percentile of the effects data and the ERM is the median (50^{th} percentile) of the effects data for each trace metal. The derived ERL and ERM for copper were 34 and 270 ppm, respectively. Incidences of effects when sediment copper concentrations were <ERL, ERL-ERM, and >ERM were 9.4 per cent, 29.1 per cent, and 83.7 per cent, respectively.

Iron

Iron is a vital component of plant and animal life. The highest concentrations of iron are found in the liver, spleen, kidney and heart. Excessive intake of soluble iron salts may cause injury to the alimentary canal and liver (Ansari et al. 2004). Upon contact with seawater, suspended iron oxyhydroxides are rapidly precipitated, meaning that at salinities greater than 10 ppt the vast majority of iron present occurs in particulate form and is effectively removed from solution. In anoxic marine waters, ferrous iron is mobilized from sediments and diffuses into the water column (U.K. Marine SACs Project website, http://www.ukmarinesac.org.uk/activities/water-quality/wq8_12.htm).

Mance and Campbell (1988) reviewed data on the toxicity of iron to marine biota and proposed environmental quality standard (EQS) guidelines of 10,000 and 25,000 g of total iron/L in less turbulent areas and more turbulent estuaries with higher suspended solids content, respectively. In terms of a dissolved annual average concentration, an EQS of 1,000 µg/L has been adopted in the UK.

Marine organisms accumulate iron but also rapidly excrete it in clean water conditions. Typically, tissue concentrations are related to the water and sediment concentrations but there is considerable variability (Mance and Campbell 1988).

Lead

The fate and behaviour of lead in the marine environment is complex because of its many compounds and the variability of natural systems. Much of this metal in the marine environment is strongly adsorbed onto sediment and suspended particles, reducing its availability to marine organisms. The low solubility of most of its salts tends to result in lead precipitating out of complex solutions (U.K. Marine SACs Project website, http://www.ukmarinesac.org.uk/activities/water-quality/wq8_4.htm).

The most accepted environmental quality standard concentration for lead in seawater appropriate for the protection of most marine invertebrates and fish is 10 µg/L (Grimwood and Dixon 1997). Typical symptoms of lead toxicity in marine fish include spinal deformity and other developmental irregularities. As is the case with many metals, earlier life stages appear to be most susceptible to lead. Organisms living on or in the bottom sediment can be susceptible to high levels of lead in the sediment. Canadian interim sediment quality guidelines indicate that lead concentrations in sediment exceeding 30.2 mg/kg may pose a hazard to benthos (CCME 2002). Environmental factors that affect lead toxicity include temperature, salinity, and pH. Bioaccumulation of lead in the food chain can pose a hazard to higher-level predators.

Manganese

This metal is a naturally occurring substance that is typically present in surface waters and biota. Some aquatic organisms have exhibited toxic responses to manganese in surface waters. The Government of British Columbia established a freshwater guideline of 100 µg/L, despite the scarcity of data. Acute manganese concentrations ranged from 600 to 3,800 µg/L for exposures of less than 96 hours. Chronic manganese concentrations ranged from 600 to 1,900 µg/L for exposures exceeding 96 hours. Water hardness appears to affect manganese toxicity (BC MOE website, (http://www.env.gov.bc.ca/wat/wq/BCguidelines/manganese/update.html).

Nickel

Nickel occurs in the marine environment as soluble salts adsorbed on clay particles or organic matter (e.g., detritus, algae), or associated with organic particles such as proteins. The fate of nickel in seawater is affected by several factors including pH, ionic strength, types and concentrations or organic and inorganic ligands, and the presence of solid surfaces for adsorption (U.K. Marine SACs Project website, http://www.ukmarinesac.org.uk/activities/water-quality/wq8_8.htm).

Laboratory studies have shown that nickel has little capacity for accumulation in the fish studied. Accumulation factors in different trophic levels of aquatic food chains suggest that the biomagnification of nickel along the food chain does not occur (WHO 1991).

Using matching biological and chemical data compiled from numerous modeling, laboratory, and field studies performed with estuarine and marine sediments, Long et al. (1995) derived two guideline values for the marine sediment concentrations of some trace metals, including nickel. The two guideline values are 'effects range low' (ERL) and 'effects range median' (ERM). The ERL is the lower 10^{th} percentile of the effects data and the ERM is the median (50^{th} percentile) of the effects data for each trace metal. The derived ERL and ERM for nickel were 20.9 and 51.6 ppm, respectively. Incidences of effects when sediment nickel concentrations were <ERL, ERL-ERM, and >ERM were 1.9 per cent, 16.7 per cent, and 16.9 per cent, respectively.

Selenium

Selenium chemistry is complex. In seawater, selenites (Se^{+4}) are the dominant chemical species under certain conditions (Cappon and Smith 1981 *in* Eisler 1985). The range of selenium concentrations in seawater presented by Eisler (1985) was 0.009 to 0.8 ppb.

Among sensitive species of aquatic organisms, acute mortality has been observed at selenium concentrations ranging from 60 to 600 ppb. Early life stages accounted for most of these mortalities. Chronic mortality after exposure has also been observed but not as frequently as acute mortality.

LC_{50} concentrations of selenium for various marine organisms were presented by Eisler (1985). Marine organisms included oyster larvae, copepods, crab larvae, mysid shrimp eggs, juveniles and adults, various fish larvae, and minnow eggs and adults. The LC_{50} concentrations ranged from 600 ppb for haddock larvae to over 67,000 ppb for adult minnows, and in winter flounder larvae ranged from 14,250 to 15,100 ppb.

Zinc

This is one of the most ubiquitous and mobile metals in the marine environment. Zinc is transported in natural waters in dissolved forms and in association with suspended particles (Mance and Yates 1984). In estuaries, a large proportion of zinc is adsorbed to suspended particles. In seawater of higher salinity, much of the zinc is found in its dissolved forms as inorganic and organic complexes.

Mance and Yates (1984) found that marine invertebrates are generally more sensitive to zinc than are fish, at least based on studies they reviewed. Hunt and Hedgecott (1992b) reported that both the toxicity and bioaccumulation of zinc is greater at lower salinity. Grimwood and Dixon (1997) recommended an environmental quality standard guideline for zinc in seawater of 10 µg/L (dissolved annual average). Canadian Interim Sediment Quality Guidelines indicate that zinc concentrations in sediment exceeding 124 mg/kg can pose a hazard to benthos.

7.4.5 Ecological Risk Assessment Summary

The ERA (Intrinsik 2007, 2008) is largely based on static or flow-through laboratory toxicity testing where mobile (pelagic) species are placed in containers with contaminated seawater and continuously exposed for set periods of time. It should be noted that near-bottom marine species have more potential to be affected by effluent discharge than true pelagic species due to their close association with the bottom water where the effluent emerges. Considering the depth of the diffuser end of the pipeline and the bottom water currents, it is likely that any effect of the effluent on the water column will occur in the water directly above the substrate, thereby potentially affecting benthic biota more than other biota. Sediment modeling by AMEC concluded that there would be little or no build-up of contaminants in marine sediments from the effluent.

Intrinsik (2007, 2008) present a marine sediment assessment in Section 5.7.3.2 of the ERA. The outfall effluent will contain stable soil ferrihydrite particles, which are predicted to settle within a maximum of 1.5 km from the effluent release point. The ERA concluded that the likelihood of effects occurring in benthic species as a result of incremental increase of iron in the surficial sediments due to the marine effluent is low. The conclusion is based on the high energy environment present in the vicinity of the effluent diffuser, and the large margin of safety between baseline sediment iron concentrations and the U.S. National Oceanographic and Atmospheric Administration (NOAA) sediment guideline.

The major findings of the ERA as they relate to the marine environment are provided below. The pelagic results are applicable to the benthos as extrapolated from the research on a variety of invertebrate and fish species.

Based on baseline and predicted seawater concentrations of arsenic at approximately 10 m and 250 m from the diffuser for the Matte scenario, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of exposure to arsenic releases in the marine effluent on pelagic marine life is negligible.

Based on baseline and predicted seawater concentrations of barium at approximately 10 m and 250 m from the diffuser for both the Hydromet and Matte scenarios, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of exposure to barium releases in the marine effluent on pelagic marine life is negligible.

Based on baseline and predicted seawater concentrations of boron at approximately 10 m and 250 m from the diffuser for both proposed facility types, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of boron on pelagic marine biota during the Project is low.

Based on baseline and predicted seawater concentrations of cadmium at approximately 10 m and 250 m from the diffuser for both the Hydromet and Matte scenarios, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of exposure to cadmium releases in the marine effluent on pelagic marine life is negligible.

Based on baseline and predicted seawater concentrations of chromium at approximately 10 m and 250 m from the diffuser for the Matte scenario, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of exposure to chromium releases in the marine effluent on pelagic marine life is negligible.

Based on baseline and Hydromet scenario seawater concentrations of cobalt at approximately 10 m and 250 m from the diffuser, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of cobalt on pelagic marine biota during the Project is negligible.

Based on baseline and predicted seawater concentrations of copper at approximately 10 m and 250 m from the diffuser for both the Hydromet and Matte scenarios, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of exposure to copper releases in the marine effluent on pelagic marine life is higher than that predicted for other metals. However, the affected area is in the near-field of the diffuser and, therefore, exposure potential for marine species is limited. The likelihood of copper in the effluent resulting in adverse effects is considered to be low.

Based on Baseline and Hydromet scenarios, predicted seawater concentrations of iron at approximately 10 m and 250 m from the diffuser, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of iron on pelagic marine biota during the Project is negligible. Intrinsik (2007, 2008) also predicted incremental increases of stable forms of iron in the sediments in the vicinity of the marine effluent diffuser. However, considering the relatively low baseline levels of iron in the surficial sediments, incremental increases of stable forms of iron associated with the effluent is not expected to result in any direct toxic effects to benthic species. None of the other COPCs are predicted to have incremental change in the sediments due to effluent discharge.

Based on baseline and predicted seawater concentrations of lead at approximately 10 m and 250 m from the diffuser for both the Hydromet and Matte scenarios, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of exposure to lead releases in the marine effluent on pelagic marine life is negligible.

Based on baseline and Hydromet scenario seawater concentrations of nickel at approximately 10 m and 250 m from the diffuser, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of nickel on pelagic marine biota during the Project is negligible.

Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of concentrations of selenium at approximately 10 m and 250 m from the diffuser for either the Hydromet or Matte scenarios on pelagic marine life is negligible. It should be noted that this conclusion has considerable uncertainty associated with it due to the lack of site-specific ambient baseline selenium data, and actual estimates of release concentrations from the diffuser.

TSS is identified as one of the constituents of the marine effluent. Increases in suspended sediments are likely to occur during dredging, piling installation, marine effluent pipeline installation, shore and scour protection activities, and possibly during on-land earthworks activities at Tier 1. Based on available data, Intrinsik (2007, 2008) concluded that it is unlikely that future predicted increases in TSS due to the marine effluent would result in adverse effects on pelagic marine life.

Based on baseline and predicted seawater concentrations of TDS at approximately 10 m and 250 m from the diffuser for both the Hydromet and Matte scenarios, Intrinsik (2007, 2008) concluded that the likelihood of adverse effects of exposure to increased TDS concentrations on pelagic marine life is negligible.

7.4.6 Total Suspended Solids

Suspended sediments are typically silt and clay particles measuring two to 60 µm in diameter. They are often measured directly as TSS in mg/L or indirectly as turbidity. Turbidity is the optical property of water resulting in a loss of light transmission caused by absorption and scattering. While suspended sediments are often the primary contributors to turbidity, non-sediment sources that also affect light transmission include natural tannins and algae. An increase in TSS can occur as a result of natural phenomena such as storms or tides and anthropogenic activities such as dredging (U.K. Marine SACs Project website, http://www.ukmarinesac.org.uk/activities/water-quality/wq9_9.htm).

Elevated TSS conditions have been reported to cause physiological stresses, growth reduction, and lower survival. It is important to consider the frequency and duration of exposure to increased TSS and not just the TSS concentration. The effects of elevated TSS conditions also vary depending on the species and its life history stage being affected (Wilber and Clarke 2001; USACE 2004). Elevated TSS conditions can affect marine invertebrates and/or fish in three ways:

1. Behavioural effects including avoidance, attraction, reduced feeding success, and increased ‘gill flaring’;
2. Physical effects including stress, tissue damage, reduced growth, and mortality; and
3. Habitat effects including increased sedimentation, filling of gravel interstitial spaces, decrease in gravel inter-particle dissolved oxygen concentration.

Wilber and Clarke (2001) conducted a review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. Unlike the attention that has been given to suspended sediment effects on salmonid fish, relatively little is known about the effects on estuarine fish and invertebrates. However, studies of the effects on various marine species have been conducted. The biota studied includes bivalve eggs, larvae, and adults (Davis 1960, Davis and Hidu 1969, Mulholland 1984, and Hawkins et al. 1996 *in* Wilber and Clarke 2001). Primary mechanisms used by bivalves to deal with higher than usual concentrations of suspended sediment include reduction of net pumping rates (Foster-Smith 1976 *in* Wilber and Clarke 2001), rejection of excess filtered material as pseudofeces (Hawkins et al. 1996 *in* Wilber and Clarke 2001), and reduced growth and survival (Kirby 1994 *in* Wilber and Clarke 2001). Eggs and larvae of nonsalmonid estuarine fish exhibit some of the most sensitive responses to suspended sediment exposure. Behavioural responses to, and sub-lethal and lethal physical effects of suspended sediment has also been observed for several estuarine fish species (Wilber and Clarke 2001).

7.4.7 Total Dissolved Solids

TDS is an expression for the combined content of all inorganic and organic substances contained in a liquid, whether in a molecular, ionized, or micro-granular (colloidal sol) suspended form. Solids are typically less than two µm in diameter. It was found that TDS concentrations of 350 mg/L reduced spawning of striped bass in the San Francisco-Delta region but concentrations less than 200 mg/L did not appear to affect spawning (Kaiser Engineers 1969).

7.4.8 Noise

The sea is a naturally noisy environment. Natural ambient noise is often related to sea state, increasing with wind speed and wave height. Disturbance related to underwater and air-borne noise could also be caused by non-natural sources such as a dredging vessel, a pile driver, or marine vessels. The acoustic assessment for the Construction and Operation phases (SENES 2007b) of the Long Harbour facility considered only airborne noise and its sources. For the marine fish and fish habitat, underwater noise is of more concern than airborne noise. Underwater noise will be introduced during the Project and it could potentially affect all six components of the marine fish and fish habitat VEC.

The various types of potential effects of exposure to noise on fish and invertebrates can be considered in three categories: pathological, physiological, and behavioural. Pathological effects include lethal and sub-lethal damage to the animals; physiological effects include temporary primary and secondary stress responses, and behavioural effects refer to changes in exhibited behaviours of the fish and invertebrate animals. The three categories should not be considered as independent of each other. They are certainly interrelated in complex ways. For example, it is possible that certain physiological and behavioural changes could potentially lead to the ultimate pathological effect on individual animals (i.e., mortality). However, it appears that fish and invertebrates have to be exposed to high sound pressure levels for extended period of time before physical and physiological effects become apparent. Behavioural effects are another issue. There are suggestions that horizontal and vertical distributions might be affected by exposure to sound; however, any apparent effect seems to be temporary.

Fish vary widely in their ability to hear sounds. Some fish have very good auditory capabilities; in many of these species, such as certain herring-like fishes, the swim bladder is connected directly to the inner ear. In contrast, cod do not have this direct connection and are less sensitive to sound.

Little is known about invertebrate reactions to sound. It has been generally believed that strong sounds such as those produced during seismic exploration have little effect on important marine invertebrates such as lobster, shrimp, and crab because these animals do not have hearing organs. Nonetheless, they are able to detect certain vibrations.

Articles on the impacts of pile driving on fish have recently been published (Nedwell et al. 2003, 2006; Hawkins 2005; Popper et al. 2006). Nedwell et al. (2003) measured the underwater noise produced by vibratory and impact pile drivers and observed its effect on caged fish. They found that caged brown trout neither appeared to react to either type of pile driving nor suffered gross physical injury at a distance of 400 m from the source. The caged fish did not show any behavioural reactions when exposed as close as 50 m from the vibropiling equipment. Source level of the impact pile driver was determined to be 194 dB re 1 µPa at 1-m. Hawkins (2005) pointed out that the typical source levels associated with both vibratory and impact pile drivers exceed the known hearing thresholds of certain fish. It is likely that the hearing of those species with thresholds below the pile driver source levels could be affected when exposed to enough percussive sound. Popper et al. (2006) presented interim criteria for injury of fish exposed to pile driving operations. Based on the best available science, they concluded that is reasonable to use a combined interim single-strike criterion for pile driving received level exposure: a sound exposure level (SEL) of 187 dB re: 1 $\mu Pa^2 \cdot s$, and a peak sound pressure level (SPL) of 208 dB re: 1 μPa_{peak} measured 10 m from source. The important issue of cumulative effects of multiple exposures could not be properly accounted for due to paucity of data.

Underwater recordings of both vibratory and impact pile-driving sounds during recent dock modifications in Alaska were made (HDR Alaska et al. 2006). The mean SPL_{rms} at 56 m (average of several 8.5 second samples) from the vibratory pile driver was 164 dB re: 1 µPa at a depth of 10 m and 162 dB re: 1 µPa at a depth of 1.5 m. The mean SPL_{rms} at 62 m (average of several individual pulses) from the impact pile driver was 189 dB re: 1 µPa at a depth of 10 m and 190 dB re: 1 µPa at a depth of 1.5 m. With respect to the impact pile driving, the distances at which the mean $SPLs_{rms}$ decreased below 180 dB were 250 m (10 m depth) and 195 m (1.5 m depth), and the distances at which the maximum $SPLs_{rms}$ decreased below 180 dB were 650 m (10 m depth) and 330 m (1.5 m depth). The mean SEL at 62 m (average of several individual pulses) associated with impact pile driving was 178 dB re: 1 $\mu Pa^2 \cdot s$ at a 10 m depth, and 180 dB re: 1 $\mu Pa^2 \cdot s$ at a 1.5 m depth. The dominant frequency ranges for vibratory and impact pile driving were 400 to 2,000 Hz and 100 to 2,000 Hz, respectively (HDR Alaska et al. 2006).

7.4.9 Lighting

Some marine species (e.g., squid) are known to be attracted to light. This interaction is acknowledged here but considered so small scale and intermittent as to be negligible and not assessed further.

7.4.10 Atmospheric Emissions

Air dispersion modeling (SENES 2007a) indicated that Construction Phase activities such as clearing and grubbing, overburden removal, excavating, stockpiling, and transport of uncrushed and crushed material have the potential to generate relatively high levels of dust. The air dispersion modeling results also indicated that there would likely not be any chemical emissions of concern for the marine environment in the vicinity of the Project Area. Particulate matter and NO_2 were shown to reach the marine environment but at levels below the Air Quality Standards predicted off-site.

7.5 Effects of Construction

Potential interactions between construction routine activities and the marine fish and fish habitat VEC are shown in Table 7.1.

7.5.1 Earthworks

There are potential interactions between earthworks and all components of the marine fish and fish habitat VEC (Table 7.1). Site grading and leveling on Tier 1 could potentially result in the introduction of silt and dust to the marine environment, especially when these activities are conducted in areas proximate to the shoreline. Sediment entering the sea water will result in increased turbidity and sedimentation, potentially causing negative effects on the marine fish and fish habitat.

Blue mussels and winter flounder, the focal species of the marine fish and fish habitat VEC, could potentially be affected by increased turbidity and sedimentation. Both species might alter their feeding behaviours in response to increased turbidity. Excessive sedimentation has the potential to affect the reproduction of both, particularly since flounder eggs are demersal.

Mitigations intended to reduce the effects of earthworks on marine fish and fish habitat will be detailed in the Construction Environmental Protection Plan (EPP) (see Section 6.1 of Volume 1). Candidate mitigations include water-spray dust suppression and the use of silt curtains, sediment traps and sediment basins (Table 7.2) but these measures will be finalized in the EPP. Regardless of continuous earthworks throughout the Construction Phase, appropriate mitigation measures would minimize the potential effects of this activity on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of earthworks on the marine fish and fish habitat VEC are *negligible to low*, *<1* km^2, and *37 to 72 months*, respectively (Table 7.2). Based on these criteria ratings, the residual effects of the Construction Phase earthworks on the marine fish and fish habitat VEC are *not significant* (Table 7.3).

7.5.2 Wharf Expansion

There are potential interactions between wharf expansion and four components of the marine fish and fish habitat VEC (Table 7.1). The primary sources of effects of wharf expansion (including conveyor system) on the marine fish and fish habitat of Long Harbour relate to piling installation and increased turbidity/sedimentation. Installation of the pilings will result in the loss of bottom habitat while increased turbidity/sedimentation has the potential to negatively affect marine biota (e.g., blue mussels and winter flounder and their habitat). The effects of both loss of habitat and increased TSS/sedimentation are reversible from a ‘population’ perspective.

Table 7.1 Potential Interactions between Construction and Marine Fish and Fish Habitat VEC

Valued Ecosystem Component: Marine Fish and Fish Habitat						
Project Activity	**Feeding**		**Reproduction**		**Adult Stage**	
	Plankton	**Benthos**	**Eggs/Larvae**	**Juveniles[1]**	**Pelagic Fish**	**Groundfish**
Construction Activities and Physical Works						
Earthworks[2]	✓	✓	✓	✓	✓	✓
Wharf expansion		✓		✓	✓	✓
Dredging	✓	✓	✓	✓	✓	✓
Shore and scour protection		✓	✓	✓		✓
Blasting						
Effluent pipeline		✓		✓		✓
Atmospheric emissions (incl. dust)						
Roads						
Storm system						
Sewage system						
Pipelines						
Water supply dam						
Residue storage dams						
Power lines						
Shipping						
Vehicle traffic						
Sewage						
Solid waste						
Temporary power						
Lighting	✓				✓	
Noise	✓	✓	✓	✓	✓	✓

Notes: [1] Juveniles are young fish that have left the plankton and are often found closely associated with substrates.
[2] Includes all activities involving earthworks, including grubbing, excavation, grading, and levelling.

Table 7.2 Effects Assessment of Construction on Marine Fish and Fish Habitat VEC

Valued Ecosystem Component: Marine Fish and Fish Habitat								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigations**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Construction Activities and Physical Works								
Earthworks	Increased turbidity (N); Sedimentation (N)	Water spray dust suppression; Silt curtains; Sediment traps; Sediment basins	0-1	1	6	4	R	2
Wharf expansion (piling installation)and presence	Loss of bottom habitat (N); Increased turbidity (N); Sedimentation (N)	Habitat Compensation Plan; Silt curtains; Bubble curtains	1-2	1	6	4	R	2
Dredging	Loss of bottom habitat (N); Increased turbidity (N); Sedimentation (N)	Habitat Compensation Plan; Silt curtains; Removal of existing manmade waste	1-2	1	1	4	R	2
Shore and scour protection (installation and presence)	Loss of bottom habitat (N); Increased turbidity (N); Sedimentation (N)	Habitat Compensation Plan; Silt curtains;	1-2	1	6	4	R	2
Effluent pipeline (installation and presence)	Alteration of bottom habitat (N); Increased turbidity (N); Sedimentation (N)	Habitat Compensation Plan; Silt curtains	1-2	1	6	4	R	2
Atmospheric emissions (incl. dust)	-	-	-	-	-	-	-	-
Lighting	Attraction	-	-	-	-	-	-	-
Noise	Disturbance (N)	Muffling to minimize noise level	1-2	2	6	4	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 7.3 Significance of Potential Residual Environmental Effects of Construction on Marine Fish and Fish Habitat VEC

Valued Ecosystem Component: Marine Fish and Fish Habitat				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood[a]	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Construction Activities and Physical Works				
Earthworks	NS	3	-	-
Wharf expansion	NS	3	-	-
Dredging	NS	3	-	-
Shore and scour protection	NS	3	-	-
Effluent pipeline	NS	3	-	-
Atmospheric emissions	NS	3	-	-
Lighting	NS		-	-
Noise	NS	3	-	-

Key:
Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect

During expansion of the existing wharf in Long Harbour, an estimated 60 pilings will be installed 20 m to 25 m into the sediment. The pilings will displace approximately 30 m^2. Displaced sediment will be pumped from inside the pile and disposed of on land in accordance with regulatory requirements.

Since blue mussels and winter flounder are benthic species, the loss of bottom habitat has the potential to affect them both. However, the amount of habitat lost due to piling installation is relatively small compared to the similar habitat in the surrounding area. After wharf expansion is complete, there would actually be an increase in hard surface area for blue mussel larval attachment. Any short-term increase in turbidity and sedimentation might also have temporary and minimal effects on both focal species.

Mitigations intended to reduce the effects of wharf expansion on marine fish and fish habitat will be detailed in the EPP (see Section 6.1 of Volume 1). Mitigations will include a Habitat Compensation Plan and the use of silt curtains (Table 7.2) but these measures will be finalized in the EPP. Wharf expansion may be continuous for 1.5 to two years during the Construction Phase, but the piling installation component will require only two to three months for completion. Appropriate mitigation measures would minimize the potential effects of this activity on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of wharf expansion on the marine fish and fish habitat VEC are *low to medium*, *<1 km^2*, and *37 to 72* *months* (duration rating includes presence of expanded wharf after construction completed), respectively (Figure 7.2). Based on these criteria ratings, the residual effects of the Construction Phase wharf expansion on the marine fish and fish habitat VEC are *not significant* (Table 7.3).

7.5.3 Dredging

There are potential interactions between dredging and all components of the marine fish and fish habitat VEC (Table 7.1). The primary sources of effects of dredging on the north side of the wharf are the removal of substrate and increased turbidity/sedimentation. The dredging is expected to be conducted only once and will result in the removal of approximately 26,600 m^3 of sediment to a maximum depth of 1.5 m below the existing substrate over an area of ~2.6 ha. Increased turbidity/sedimentation is likely to occur during dredging. The removal of substrate and increased turbidity/sedimentation can negatively affect fish and fish habitat, including species such as blue mussels and winter flounder. Water will be monitored for contaminants. Displaced sediment will be collected and disposed of on land in accordance with regulatory requirements. It is anticipated that dredging would occur for 45 to 60 days, weather permitting.

As with the piling installation, dredging will alter habitat suitable for both blue mussels and winter flounder. Although the area of habitat affected is substantially greater than the area affected by piling installation, it still represents a relatively small proportion of similar habitat in the immediate area. Therefore, the effects of this activity on marine fish and fish habitat are reversible from a 'population' perspective. While winter flounder would likely move out of the dredging area, blue mussels would not be able to and would therefore be removed along with the dredged sea bottom. However, the number of individual fish disturbed and mussels removed would quickly be replaced after cessation of dredging. The removal of contaminated sediment, scrap metal and other debris during dredging will likely improve habitat quality for both winter flounder and blue mussels. Any short-term increase in turbidity and sedimentation might also have some effects on both focal species but they would likely be temporary and minimal.

Mitigations intended to reduce the effects of dredging on marine fish and fish habitat will be detailed in the EPP (see Section 6.1 of Volume 1). Mitigations will include a Habitat Compensation Plan, the use of silt curtains, and the removal of existing manmade waste (Table 7.2) but these measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of dredging on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of dredging on the marine fish and fish habitat VEC are *low to medium*, *<1* km^2, and *37 to 72 months* (duration rating includes presence of dredged area after dredging completed), respectively (Table 7.2). Based on these criteria ratings, the residual effects of the Construction Phase dredging on the marine fish and fish habitat VEC are *not significant* (Table 7.3).

7.5.4 Shore and Scour Protection

There are potential interactions between shore and scour protection and four components of the marine fish and fish habitat VEC (Table 7.1). Substantial sections of reclaim area foreshore and wharf toe will be armoured to provide better shore and scour protection. Existing shoreline along much of the reclaim area is being eroded. Riprap will be placed along approximately 800 m of shoreline. The placed rock will range in size between 73 to 208 cm for armour stone and eight to 40 cm for the underlining filter stone. Scour protection to control propeller wash will also be provided by armour stone ranging in size from 30 to 202 cm) and extending approximately 30 m beyond the face of the wharf. The minimum total surface area of existing bottom habitat that will be covered by armourstone/filter stone is 13,300 m^2. At the same time, the armour stone/filter stone will introduce additional hard-surface habitat for benthic species. The armour stone installed for scour protection will occur in an area already affected by dredging.

Mitigations intended to reduce the effects of installation and presence of shore and scour protection on marine fish and fish habitat will be detailed in the EPP (see Section 6.1 of Volume 1). Mitigations will include a Habitat Compensation Plan and the use of silt curtains (Table 7.2) but these measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of this activity on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of shore and scour protection on the marine fish and fish habitat VEC are *low to medium*, *<1 km*^{2}, and *37 to 72 months* (duration rating includes presence of armour stone/filter stone after installation completed) respectively (Table 7.2). Based on these criteria ratings, the residual effects of the Construction Phase shore and scour protection on the marine fish and fish habitat VEC are *not significant* (Table 7.3).

7.5.5 Effluent Pipeline

There are potential interactions between the marine effluent pipeline and three components of the marine fish and fish habitat VEC (Table 7.1). The marine effluent pipeline that will run from Rattling Brook Cove to an area between Crawley Island and Shag Rocks will result in the potential alteration of 0.34 ha of marine bottom habitat. No trenching will be involved. The pipeline and associated infrastructure will be placed on the seabed. Physical characteristics of the affected habitat range from hard substrate composed primarily of sand and gravel to soft substrate composed primarily of silt and mud. The transition between hard and soft substrate is gradual along the pipeline route from shore to the offshore end of pipe. The pipeline and associated infrastructure will provide a three-fold increase in surface area for biota colonization. Although the epifauna and epiflora will be affected, the infauna likely will not. Considering the relatively small area of bottom habitat being affected, and the additional surface area/hard substrate being provided, the effects of installation will be minimal.

About half of the habitat along the marine effluent pipeline is suitable for blue mussels and winter flounder. The inshore portion of the route is characterized by harder substrate while the outer portion has much softer substrate. Any short-term increase in turbidity and sedimentation might have some transient effects on both focal species, but they would likely be temporary and minimal.

Mitigations intended to reduce the effects of installation and presence of the marine effluent pipeline on marine fish and fish habitat will be detailed in the Construction EPP (see Section 6.1 of Volume 1). Mitigations will include a Habitat Compensation Plan and the use of silt curtains (Table 7.2) but these measures will be finalized in the EPP. As previously mentioned, the pipeline will provide an increase in hard, stable substrate. Appropriate mitigation measures would minimize the potential effects of this activity on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of the marine effluent pipeline on the marine fish and fish habitat VEC are *low to medium*, *<1 km*^{2}, and *37 to 72 months* (duration rating includes presence of effluent pipeline after installation completed) respectively (Table 7.2). Based on these criteria ratings, the residual effects of the Construction Phase marine effluent pipeline on the marine fish and fish habitat VEC are *not significant* (Table 7.3).

7.5.6 Noise

There are potential interactions between noise and all components of the marine fish and fish habitat VEC (Table 7.1). Numerous noise sources will occur in the Project Area during the Construction Phase: marine vessels, dredging, pipelaying, piling installation, and heavy equipment associated with work at Tier 1. It is likely that the most intrusive noise source from the perspective of marine fish and fish habitat will be the equipment used to install the wharf pilings. Section 7.4.8 above discusses recent publications on the topic of effects of pile driving noise on fish. The effects of exposure to noise on the marine fish and fish habitat VEC are likely to be negative but minimal.

There is some evidence that prolonged exposure to sound with relatively high sound pressure levels (SPL) (e.g., pile driving) could potentially cause injury to fish; however, the most likely effect will be the displacement of fish in the proximity of the noise source. In the case of sedentary animals such as the blue mussel, behavioural changes are the most likely effects of prolonged exposure to high SPLs (e.g., change in filtering rate). Both animals might also become habituated to the underwater noises introduced during the Construction Phase.

Mitigations intended to reduce the effects of noise on marine fish and fish habitat will be detailed in the Construction EPP (see Section 6.1 of Volume 1). Candidate mitigations include bubble curtains and well-maintained equipment mufflers (Table 7.2) but these measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of noise on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of noise on the marine fish and fish habitat VEC are *low to medium*, *1 to 10 km*^{2}, and *37 to 72 months*, respectively (Table 7.2). Based on these criteria ratings, the residual effects of Construction Phase noise on the marine fish and fish habitat VEC are *not significant* (Table 7.3).

7.5.7 Mitigation

Mitigation measures for routine activities during Construction will be described in the EPP (see Section 6.1 of Volume 1). Candidate mitigation measures may include the following and will be finalized in the EPP:

- Water spray dust suppression;
- Silt curtains;
- Sediment traps;
- Sediment basins;
- A Habitat Compensation Plan;
- Bubble curtains; and
- Equipment muffling.

7.5.8 Residual Effects

After implementation of appropriate mitigation measures, all predicted residual environmental effects of routine activities during the Construction Phase on marine fish and fish habitat are assessed as negative but *not significant*.

7.6 Effects of Operations

Potential interactions between the Operation Phase's routine activities and the marine fish and fish habitat VEC are shown in Table 7.4.

7.6.1 Total Footprint

The total footprint of the marine portion of the Project Area has already been assessed in Section 7.5 although duration reflected the length of the Construction Phase only. There are potential interactions between total footprint and four components of the marine fish and fish habitat VEC (Table 7.4). The mitigation measures already discussed remain relevant to total footprint during the Operation Phase (Table 7.5), particularly a Habitat Compensation Plan. Considering that the maximum magnitude (*low to medium*) and geographic extent (*<1 km^2*) ratings provided in Section 7.5 still apply to the total footprint (i.e., dredge area + wharf expansion area + shore and scour protection area + marine effluent pipeline area), and the duration increases to *>72 months*, the residual effects of Operation Phase total footprint on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

Table 7.4 Potential Interactions between Operations and Marine Fish and Fish Habitat VEC

Valued Ecosystem Component: Marine Fish and Fish Habitat						
Project Activity	**Feeding**		**Reproduction**		**Adult Stage**	
	Plankton	**Benthos**	**Eggs/Larvae**	**Juveniles[1]**	**Pelagic Fish**	**Groundfish**
Operational Activities and Physical Works						
Total footprint		✓		✓	✓	✓
Residue storage	✓	✓	✓	✓	✓	✓
Ships						
Offloading dust	✓	✓	✓	✓	✓	✓
Offloading Washdowns/runoff	✓	✓	✓	✓	✓	✓
Water use						
Electricity use						
Diesel use						
Fuel oil#2 use						
Atmospheric emissions (incl. dust)	✓	✓	✓	✓	✓	✓
Marine effluent	✓	✓	✓	✓	✓	✓
Site runoff	✓	✓	✓	✓	✓	✓
Surge pond						
Sewage						
Solid waste						
Vehicle traffic						
Noise	✓	✓	✓	✓	✓	✓
Lighting	✓				✓	
Maintenance		✓	✓	✓	✓	✓
Note: [1]Juveniles are young fish that have left the plankton and are often found closely associated with substrates.						

Table 7.5 Environmental Effects Assessment of Operations on Marine Fish and Fish Habitat VEC

Valued Ecosystem Component: Marine Fish and Fish Habitat								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Operational Activities and Physical Works								
Total footprint	See "Construction" (N)	See "Construction"	1-2	1	6	5	R	2
Residue storage	Contamination	Minimize leakage from Sandy Pond	0	1	6	5	R	2
Offloading dust	Contamination (N)	Dust collection systems	1	1	2	1	R	2
Offloading washdowns/ runoff	Contamination (N)	Collected in sumps and used in plant site process water	1	1	2	1	R	2
Atmospheric emissions	Contamination (N); Increased turbidity (N); Sedimentation (N)	Scrubbers to reduce aerosol mists, chlorine gas and particulate carry over; Air pollution control equipment; Air quality monitoring	0-1	2	6	5	R	2
Marine effluent	Contamination (N); Sedimentation (N); Increased BOD (N)	Effluent monitoring and treatment; Diffuser end of effluent pipe positioned in area to maximize dispersion by mixing	1-2	2	6	5	R	2
Site runoff	Contamination (N)	Collected in Tier 1 settling pond before discharge to marine environment	1	1	1	1	R	2
Noise	Disturbance (N)	Well-maintained mufflers	1	2	6	5	R	2
Lighting	Attraction	-	-	-	-	-	-	-
Maintenance	Disturbance (N)	Maximize efficiency	0-1	2	1	1	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 7.6 Significance of Potential Residual Environmental Effects of Operations on Marine Fish and Fish Habitat VEC

Valued Ecosystem Component: Marine Fish and Fish Habitat				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Operational Activities and Physical Works				
Total footprint	NS	3	-	-
Residue storage			-	-
Offloading			-	-
Dust	NS	3	-	-
Washdowns/runoff	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Marine effluent	NS	3	-	-
Site runoff	NS	3	-	-
Noise	NS	3	-	-
Lighting	NS	3	-	-
Maintenance	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

7.6.2 Residue Storage

While it is theoretically possible for contaminated groundwater from residue stored in Sandy Pond to reach the marine environment, groundwater modeling by AMEC suggests that this is unlikely, at least within the 1,500-year time frame of the model (see Section 5.6.2.). Groundwater seepage, even on eventually reaching the marine environment, would be subject to mixing. Thus it is predicted that there will be no interaction between residue storage and marine fish and fish habitat. This issue is therefore not considered further in this assessment.

7.6.3 Offloading

Bulk nickel concentrate, limestone, and sulphuric acid will be unloaded at the wharf on Tier 1 during the Operation Phase. It is anticipated that there will be a maximum of approximately 25 shipments per year into Long Harbour, 10 with nickel concentrate. There are potential interactions between offloading and all components of the marine fish and fish habitat VEC (Table 7.4).

Dust

The limestone will be offloaded into two hoppers at the wharf. Each hopper will have a self-contained dust collection system and a retractable dribble tray that rotates to a horizontal position to cover the area between the wharf and the vessel. The hoppers discharge onto a common conveyor for transport to a storage building. The conveyor will be enclosed in a tube and have dust collection at the transfer and sampling locations. Baghouses will collect nickel concentrate dust at transfer points and return it to either the roll crusher feed conveyor or the ball mill feed conveyor. Any dust from the offloading that reaches the marine environment would likely have negative contamination effects.

Dust from either limestone or nickel concentrate entering the marine environment at the wharf area could potentially affect blue mussels and winter flounder via introduced contaminants and increased TSS. The planktonic larvae of each of the focal species would be most at risk compared to the other life stages; however, large quantities of dust would have to enter the marine system in order to have any measurable effect on the biota, and the Vale Inco NL mitigative measures will prevent this from happening. Intrinsik (2007, 2008) concluded that the overall contribution of fugitive dust releases to wharf area sediment COPC loadings would be low and that chemical effects would be unlikely given the low solubility of the sulphide-based ores. Physical smothering of some existing bottom habitat could occur but only occur if dust releases were extreme.

A mitigation intended to reduce the effects of offloading dust on marine fish and fish habitat is a dust collection system (Table 7.5). However, mitigative measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of offloading dust on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of offloading dust on the marine fish and fish habitat VEC are *low*, *<1 km^2*, and *<1 month*, respectively (Table 7.5). Based on these criteria ratings, the residual effects of Operation Phase offloading dust on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

Washdowns/Runoff

The conveyor and ship's hold washdown water will be directed into the concentrate preparation process except in winter, when glycol is used. Wharf storm-water, container area storm-water, and port level storm-water will be collected in the Tier 1 settling pond. Washdown and runoff water could potentially interact with blue mussels and winter flounder, but these events are highly unlikely. Any effects of washdown and runoff water on the marine fish and fish habitat VEC would likely be negative.

Glycol is not used to clean the conveyor; the conveyor will be cleaned with a double belt scraper arrangement at the head pulley and a V-plough on the return side. This arrangement is an industry standard and is very effective when maintained correctly on a planned maintenance schedule.

Glycol is used during winter to clean the vessel's hold; this is required to avoid a possible build-up of ice in the hold, which could lead to health and safety problems during the cleaning operation and potentially to stability problems for the ship on the open ocean. The glycol is provided from a tanker truck on the wharf and is continually recycled in a closed loop during the cleaning process. After cleaning, the contaminated glycol is removed from site in the tanker truck for off-site disposal. This complete procedure will be carried out by a third-party registered waste removal company. A similar service is currently provided to the St. John's International Airport.

During other seasons, mitigation intended to reduce the effects of offloading washdown/runoff on marine fish and fish habitat is to collect it in sumps and recycle it in plant site process water (Table 7.5). However, mitigative measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of offloading washdown/runoff on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of offloading washdown/runoff on the marine fish and fish habitat VEC are *low*, *<1 km^2*, and *<1 month*, respectively (Table 7.5). Based on these criteria ratings, the residual effects of Operation Phase offloading washdown/runoff on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

7.6.4 Atmospheric Emissions

There are potential interactions between atmospheric emissions and all components of the marine fish and fish habitat VEC (Table 7.4). As indicated in Chapter 4.0, modeling predicted deposition of NO_2 and total suspended particulates (TSP) will be limited to a small area and no exceedances of the AQSs were predicted off-site, including into the marine environment. Intrinsik (2007, 2008) concluded that atmospheric emissions would have minimal effect on the marine environment within and proximate to the Project Area. However, any effect of atmospheric emissions on the marine fish and fish habitat VEC, regardless of how small, would likely be negative.

Mitigations intended to reduce the effects of atmospheric emissions on marine fish and fish habitat include scrubbers to reduce aerosol mists, chlorine gas and particulate carry-over, air pollution control equipment, and air quality monitoring (Table 7.5). However, mitigative measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of atmospheric emissions on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of atmospheric emissions on the marine fish and fish habitat VEC are *negligible to low*, *1 to 10 km^2*, and *>72 months*, respectively (Table 7.5). Based on these criteria ratings, the residual effects of Operation Phase atmospheric emissions on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

7.6.5 Marine Effluent

There are potential interactions between marine effluent and all components of the marine fish and fish habitat VEC (Table 7.4). The marine outfall is the Project's main source of contaminant input to the marine environment. Generally, however, modeling results (Intrinsik 2007, 2008) show that the releases are limited in effect and the size of influence confined to a small area adjacent to the diffuser outfall.

Four types of marine effluent will be discharged into Long Harbour via the marine effluent diffuser:

1. Decant water from residue pond (Sandy Pond) (Hydromet only);
2. Treated process effluent neutralization solution (both Hydromet and Matte);
3. Gypsum stack return (Matte only); and
4. Plant site water (i.e., treated sanitary waste and storm-water).

Over a fifteen-year period, the sediment dispersion modeling by AMEC (2007b,c) predicted the range of 0 to 2.1 kg/m^2 solid particle bottom accumulation (i.e., 0 to 0.54 mm thickness) over an area of approximately 1.4 km^2.

Oceans (2007) conducted a predictive modeling study to estimate levels of dilution associated with the effluent released from the diffuser. Effluent concentration is estimated to be 1/100 of the starting concentration at approximately 10 m from the diffuser.

The Environmental Risk Assessment conducted by Intrinsik (2007, 2008) used the sediment deposition and dilution rates, along with contaminant concentrations in the effluent, to predict the long term effects of the contaminants on subject marine receptors. Where data were limited, it was assumed that the constituents in the effluent would comply with applicable regulations. It was generally concluded that estimated future concentrations of the metals examined in seawater would not be expected to result in adverse effects in pelagic marine aquatic life, based on the assumed release rates, dilution factors, and available toxicity date used in the assessment.

Uptake of metals into fish and benthos from deposited sediments is estimated to be limited, in large measure because the deposited material is often in a form not available for uptake. Therefore, the potential for adverse effects in bivalves is considered to be low.

Mitigations intended to reduce the effects of marine effluent on marine fish and fish habitat include effluent treatment and monitoring and maximization of effluent mixing with seawater at pipeline diffuser (Table 7.5). However, mitigative measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of marine effluent on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of marine effluent on the marine fish and fish habitat VEC are *low to medium*, *1 to 10 km^2*, and *>72 months*, respectively (Table 7.5). Based on these criteria ratings, the residual effects of Operation Phase marine effluent on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

7.6.6 Site Runoff

There are potential interactions between site runoff and all components of the marine fish and fish habitat VEC (Table 7.4). Site runoff will be diverted to containment ponds for treatment prior to release to Long Harbour (see Volume 1). Site runoff has the potential to cause negative effects on marine fish and fish habitat. Blue mussels and winter flounder in and proximate to the Project Area will not likely be affected by site runoff, especially after application of mitigation measures.

Mitigations intended to reduce the effects of site runoff on marine fish and fish habitat include collection and treatment prior to discharge (Table 7.5). However, mitigative measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of site runoff on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of site runoff on the marine fish and fish habitat VEC are *low*, *<1 km^2*, and *<1 month*, respectively (Table 7.5). Based on these criteria ratings, the residual effects of Operation Phase site runoff on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

7.6.7 Noise

There are potential interactions between noise and all components of the marine fish and fish habitat VEC (Table 7.4). Compared to Construction, underwater noise during Operations will be of less concern for marine fish and fish habitat. Most of the noise produced during Operation Phase will be from land-based sources (see SENES 2007b). It is likely that the primary source of underwater noise during the Operation Phase will be marine vessels. While the effects of exposure to underwater noise on marine fish and fish habitat (i.e., blue mussels and winter flounder) during the Operation Phase might be considered negative, they are likely to be minimal, and certainly within the range of present and past marine activities in Long Harbour.

A mitigation to reduce the effects of noise on marine fish and fish habitat is use of well-maintained mufflers on equipment and vessels (Table 7.5). However, mitigative measures will be finalized in the EPP. Appropriate mitigation measures would minimize the potential effects of noise on the marine fish and fish habitat VEC. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of noise on the marine fish and fish habitat VEC are *low*, *1 to 10 km^2*, and *>72 months*, respectively (Table 7.5). Based on these criteria ratings, the residual effects of Operation Phase noise on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

7.6.8 Maintenance

It is anticipated that the abrasive wear on the pipeline due to the process fluid will not be significant during the life of the Project; however, regular maintenance will be needed to check the condition of diffuser ports and the placement of the line on the seabed. A small ROV will be used on a planned schedule to carry out external condition monitoring. Pressure monitoring at the headworks of the line will provide a historical record, which can be used to assess the condition of the pipe.

There is capacity at the effluent treatment pond to hold effluent during short-term regular maintenance functions. For any lengthy maintenance or process upset condition, all effluent would be directed to Sandy Pond, where it can be safely stored for a prolonged period.

There is sufficient time between vessel shipments for dust collector maintenance. Limestone vessels are planned to be received approximately three times per year and concentrate vessels eight to 10 times per year, allowing ample time for maintenance after every shipment as required.

Maintenance activities that have potential to negatively affect marine fish and fish habitat (i.e., blue mussels and winter flounder) include those associated with the inspection and repair of equipment/infrastructure located either in or proximate to the marine environment. However, proper mitigation measures reduce these potential effects substantially. Potential mitigations include such measures as careful selection of procedures and materials (e.g., lower toxicity chemicals and paints, where applicable) and proper collection and disposal of waste generated during maintenance. Mitigation actions will be detailed in the EPP and may include measures already described for Construction Phase activities. The overall goal of the EPP will be to reduce or eliminate release of any potentially harmful substances to the marine environment. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of Operation Phase maintenance on marine fish and fish habitat are *negligible* to *low*, *1 to 10* km^2, and *<1 month*, respectively (Table 7.5). The residual effects of maintenance activities during the Operation Phase on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

7.6.9 Mitigation

Mitigation measures for routine activities during Project Operations will be described in the EPP. Primary mitigation measures may include the following and will be finalized in the Operations EPP:

- Dust collection systems;
- Atmospheric emission control systems;
- Monitoring and treatment of marine effluent; and
- Reduced duration and controlled timing for each activity.

7.6.10 Residual Effects

After implementation of appropriate mitigation measures, all predicted residual environmental effects of routine activities during the Operation Phase on marine fish and fish habitat are assessed as negative but *not significant*.

7.7 Effects of Decommissioning

The residue storage pond, the dams, and the pipeline to Long Harbour will be subject to ongoing environmental monitoring, inspection, and maintenance for a number of years Post-closure. The following sections outline the basic elements of the proposed Rehabilitation and Closure Plan.

7.7.1 Closure

While some of the activities associated with Closure might have temporary negative effects on the marine fish and fish habitat, the end result of these activities will be beneficial to the VEC. Activities associated with Closure include:

- Drainage and cleaning of pipeline;
- Demolition and removal of infrastructure including wharf (except phosphorus encapsulated area) and marine effluent pipeline;
- Assessment of areas subject to chronic exposure; and
- Implementation of appropriate measures to remediate identified contaminated areas.

The predicted magnitude, geographic extent and duration of the potential reversible residual effects of Closure activities on marine fish and fish habitat are *low*, *1 to 10* km^2, and *13 to 36 months*, respectively (Table 7.5). The residual effects of Closure activities during the Decommissioning Phase on the marine fish and fish habitat VEC are *not significant* (Table 7.6).

7.7.2 Post-closure

Post-closure activities such as the long-term monitoring, care, and maintenance of the phorphorus encapsulated in the wharf, and the implementation of a monitoring program to determine the effectiveness of decommissioning, would have positive effects on marine fish and fish habitat.

7.7.3 Mitigation

Mitigation measures for the Decommissioning Phase are outlined in Volume 1 and will be described in detail in the Decommissioning EPP, which can only be conceptualized at this point as it will depend upon regulations in place at the time of Decommissioning. Many of the mitigations such as use of silt curtains and proper maintenance of equipment will be common to those used during construction as many of the activities (e.g., use of heavy equipment, earth-moving, etc.) will be similar.

7.7.4 Residual Effects

After implementation of appropriate mitigation measures, all predicted residual environmental effects of Decommissioning on marine fish and fish habitat are assessed as negative but *not significant*.

7.8 Cumulative Environmental Effects

7.8.1 Within-Project

The within-project cumulative effects are integrated into the effects assessment of the individual activities that comprise the various phases of the Project. The residual effects of all routine activities with potential to interact with marine fish and fish habitat were predicted to be *not significant*, the within-project cumulative effects are also predicted to be *not significant*.

7.8.2 With Other Projects

With the exception of marine shipping and commercial fisheries, there is essentially no overlap or interaction with the various activities and projects identified for cumulative effects assessment with respect to marine fish and fish habitat. The estimated additional maximum of 25 vessel round trips per year into Long Harbour are well within historical activity for the area and represent only a very small percentage of Placentia Bay vessel traffic. With respect to the commercial fishery, no utilized habitat loss or displacement will occur. Any fish mortalities caused by the Project would most likely be caused by an accidental event as opposed to routine activities (see Chapter 11.0). At present, the largest source of fish mortality in Placentia Bay is the commercial fishery (see Volume 3), an activity that is licensed and managed by DFO.

Any added effects on the ecosystem from routine activities associated with the proposed nickel processing plant at Long Harbour will likely not change the effects predictions when viewed on a cumulative basis. Therefore, the cumulative effect of the Project, in association with the effects of other projects and activities in Placentia Bay, is predicted to be *not significant*.

7.9 Summary of Effects on Marine Fish and Fish Habitat

The primary issues related to the potential effects of routine activities of the Construction, Operation, and Decommissioning phases on marine fish and fish habitat are:

- Loss and/or alteration of marine fish habitat;
- Effects of discharged marine effluent into Long Harbour; and
- Increased suspended sediments.

Habitat losses are predicted to occur as a result of dredging, installation of shore and scour protection, and installation of the marine effluent pipeline but an acceptable marine fish Habitat Compensation Plan will mitigate these HADD effects. Installation and presence of the marine effluent pipeline will likely displace some epibenthos but only minimally affect infauna. Increased physical diversity will provide more settlement surface area for blue mussels and other sessile epifauna. With respect to the discharge of marine effluent and increased suspended sediments, appropriate mitigation measures will minimize effects associated with these events. The environmental risk assessment indicated that contaminant effects on marine fish and fish habitat will be minimal.

Overall, the predicted residual effects of routine activities on the marine fish and fish habitat are *not significant*. Based on this prediction, the residual effects of routine activities on the commercial fisheries and aquaculture operations (Volume 3) will also be *not significant*.

8.0 Avifauna Effects Assessment

Many species of terrestrial, freshwater, and marine avifauna may occur in or near the Project Area. Selected species of marine avifauna were chosen as focal species for this VEC. While Vale Inco NL recognizes that some terrestrial species or their habitat may be sensitive to disturbance, survey results suggest that there is no critical habitat in the Project Area and no shortage of similar habitat in the Regional Study Area. Similarly, directed surveys for waterfowl broods suggest that there is little or no breeding in the Project Area, no critical habitat, and no shortage of suitable adjacent habitat. In addition, the Intrinsik ecological risk assessment did not identify any risks to terrestrial avifauna (Intrinsik 2007, 2008). Nevertheless, effects on Red Crossbill are assessed under the Species at Risk VEC. In addition, some birds such as waterfowl may be attracted to artificial impoundments (e.g., sewage lagoons). This will not be the case with the residue storage pond as there will be little or no food to attract birds. Pond water will be of pH eight to 10; if birds happen to land there, they will not be harmed unless they chronically ingest the water over some period of time. Thus, the decision was made to focus on marine avifauna using two species known to be sensitive to the types of disturbance the Project may create.

Newfoundland supports some of the largest seabird colonies in the world and Newfoundland waters host large populations during all seasons. Shorebirds, waterfowl, and raptors (Bald Eagle and Osprey) may be abundant at certain places and times. They are important socially, culturally, economically, aesthetically, ecologically, and scientifically. Seabirds are a key component near the top of the food chain and are an important resource for bird-watching (one of the fastest growing outdoor activities in North America), the tourist industry, local hunting, and scientific study. In addition, this VEC is often more sensitive to contaminants in or on water than other VECs, and is of prime concern from a public and a scientific perspective, locally, nationally, and internationally. There is potential for effects on the marine-related avifauna (represented in the EIS by Bald Eagle and cormorant) from marine effluents and shipping and unloading/loading accidents.

8.1 Existing Conditions

Cormorants (either Double-crested or Great Cormorant) and Bald Eagle are focal species for the avifauna VEC. Cormorants live in the marine environment, eating a wide range of fish species, and are present year-round in Placentia Bay. Double-crested Cormorant occurs in all seasons except winter; the Great Cormorant is present year-round and thus probably is the better focal species. Cormorants use Long Harbour all year. Although they do not nest there, they roost at Shag Island and King's Island and regularly feed in Long Harbour.

Placentia Bay has one of the highest densities of nesting Bald Eagles in eastern North America. The population is estimated at approximately 30 active nests and 125 individuals. In 2006, LGL observers confirmed active nests near Long Harbour Head, Bald Head adjacent to the Brine Islands, and on Merchant's Island and Burke's Island off the mouth of Long Harbour. Relatively large numbers are observed in spring during the herring spawn at Rattling Brook Cove and to the north of Rattling Brook

Point. The availability of herring in spring is likely an important high-energy supplement to the diet of eagles; it could ensure adults attain optimal body condition for nesting.

8.2 Assessment Criteria

Assessment criteria including boundaries are as described in Chapter 3.0. Significant environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the avifauna VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EIS, a *significant* effect is defined as:

> *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2.*

8.3 Potential Interactions

The avifauna VEC could potentially interact with a variety of routine activities associated with the Construction, Operation, and Decommissioning phases. The primary potential interactions involve the following sources:

- Dredging;
- Wharf expansion;
- Marine effluent pipeline;
- Marine effluent;
- Shore and scour protection;
- Ship and boat traffic;
- Lighting;
- Noise; and
- Air emissions.

The effects of these and some other routine activities on marine-associated birds are assessed in the following sections.

8.4 Issues and Concerns

Four primary concerns are associated with the potential interactions between routine activities of the three phases of the Project and marine-associated birds:

1. Decline in prey abundance;
2. Loss or alteration of foraging habitat;

3. Discharge of marine effluent into Long Harbour; and
4. Displacement or injury caused by noise or ship traffic.

8.5 Existing Knowledge

The following sections briefly summarize existing knowledge on mechanisms for potential effects on avifauna.

8.5.1 Decline in Prey Abundance

Declines in the abundance of prey fish species have the potential for negative effects on Great Cormorant and Bald Eagle populations. However, large declines in prey abundance would be necessary for large effects because of the great mobility of birds and the widespread nature of prey distributions in marine ecosystems.

8.5.2 Foraging Habitat Loss

Loss of foraging habitat for fish-eating birds could potentially have negative effects; however, the lost habitat would have to be large (e.g., >100 km^2) in order to have a significant effect. Displacement of fish-eating birds from important foraging habitat by construction activities and ship traffic could potentially have negative effects on populations if large numbers of birds were affected and if the habitat was limiting.

8.5.3 Chemicals of Potential Concern

As discussed in the effects assessment for marine fish and fish habitat, the ERA of the nickel processing plant (Intrinsik 2007, 2008) identified a final COPC list for the marine environment. This list consists of boron, cadmium, cobalt, copper, iron, lead, manganese, nickel, selenium, arsenic, barium, chromium, and zinc. All of these elements are present in marine organisms as a normal part of their biochemistry but may be toxic in high concentrations. Iron and lead precipitate out in sea water and therefore tend to be unavailable to marine life.

In the adult Mallard (*Anas platyrhynchos*) high concentrations of boron (450 to 900 ppm in diet) have been reported to cause adult weight loss and decreased hemoglobin production, egg weight, and egg fertility (Stanley et al. 1996). In the embryo and duckling, toxic effects of boron include reduced hatching success and reduced duckling weight, growth, and production.

At toxic levels, the effects of selenium on wild aquatic birds have been reported to consist of mortality, impaired reproduction with teratogenesis, reduced growth, histopathological lesions, and altered hepatic glutathione metabolism (Hoffman 2002).

As in other animals, the bioavailability and toxicity of arsenic in birds varies greatly due to a wide range of biotic and abiotic factors (Eisler 1988). Single oral LD-50 doses range from 17 mg/kg of body weight (BW) (3-Nitro-4-hydroxy phenylarsonic acid in Turkey *Meleagris gallopavo*) to >2,400 mg/kg BW (Silvisar 510 in Mallard) (Eisler 1988).

Chromium is a powerful toxin, particularly in its hexavalent form, affecting bird development and the nervous system (Eisler 1986; Burger and Gochfeld 2002). The LD-50 value for the hexavalent form in chicken embryo is 1.7 mg/kg BW (Eisler 1986). Teratogenic effects on chicken embryo occur at 25 µg per egg (Asmatullah and Shakoori 1998).

Barium appears to have relatively low toxicity to avifauna, although it has been reported that three micromoles injected into chicken eggs has teratogenic effects on 50 per cent of embryos (Ridgway and Karnofsky 1952).

8.5.4 Total Suspended Solids and Total Dissolved Solids

If TSS and TDS were to have negative effects on marine fish and fish habitat, this in turn could affect fish-eating birds by reducing abundance of prey species or by reducing visibility during foraging, thus reducing foraging efficiency. Since no residual effects were identified for fish and fish habitat, it appears unlikely there would be any interaction with the avifauna VEC.

8.5.5 Atmospheric Emissions

Dust will be generated during the Construction Phase, but neither particulate matter nor NO_2 would reach the marine environment at levels exceeding Air Quality Standards.

8.5.6 Noise

Underwater noise caused by construction-related sources such as a dredging, pile driving, or marine vessels may affect marine fauna. There are few data on the effects of underwater sound on birds. A study on the effects of underwater seismic surveys on moulting Long-tailed Ducks in the Beaufort Sea showed little effect on the movement or diving behaviour (Lacroix et al. 2003). However, the study did not monitor physical effects. The authors suggested caution in interpretation of the data because they were limited in their ability to detect subtle disturbance effects and recommended studies on other species to examine the potential effects of seismic testing.

Most species of marine birds that are expected to occur in Long Harbour, (e.g., Bald Eagle) feed at the surface or at less than one metre below the surface of the ocean. Some of these species are plunge-divers either exclusively or occasionally (e.g., skuas, jaegers, gulls, terns and Northern Gannet) and are under the surface for only a few seconds during each dive so would have minimal exposure to underwater sound. Cormorants and the Alcidae (Dovekie, Common Murre, Thick-billed Murre, Razorbill and Atlantic Puffin) dive from the surface and pursue their prey, spending longer periods under water. Alcids in particular are capable of spending considerable time under water (Gaston and

Jones 1998). The average duration of dive times for the five species of Alcidae is 25 to 40 seconds, reaching an average depth of 20 to 60 m, but murres are capable of diving to 120 m and have been recorded underwater for up to 202 seconds (Gaston and Jones 1998). The Great Cormorant makes shorter dives to shallower depths, with average dive times ranging from 21 to 51 seconds depending partly upon the depth and location (summarized in Hatch et al. 2000).

The Great Cormorant and other diving birds may be disturbed by construction-related noise, and this may cause cormorants to avoid the construction area. If exposed to loud underwater noise, diving birds could sustain damage to their auditory organs.

8.5.7 Lighting

Leach's Storm-Petrel and the Greater Shearwater feed at night and are attracted to artificial light sources. They may be injured by flying directly into sources of light. Storm-petrels are known to land on ships at night and become stranded; even when not injured, they have great difficulty becoming airborne from a solid, flat surface. Storm-petrels are very rare in Long Harbour; shearwaters summer in large numbers in eastern Placentia Bay south of Long Harbour and but rarely venture into Long Harbour.

Some migratory birds are known to become disoriented by light under certain conditions; however, Long Harbour is not on any known important migration routes.

8.6 Effects of Construction

Potential interactions between Construction Activities and avifauna are shown in Table 8.1.

8.6.1 Earthworks

Site grading and leveling on Tier 1 could potentially result in the introduction of silt and dust to the marine environment, especially when these activities are conducted in areas proximate to the shoreline. Sediment entering the bay will result in increased turbidity potentially, causing negative effects on Great Cormorant and Bald Eagle prey populations and potentially causing negative effects on Great Cormorant foraging efficiency.

Appropriate mitigation will result in minimal occurrence of sediment entering the marine system as a result of these activities. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of earthworks activities on the avifauna VEC are *negligible to low*, *<1 km*^{2}, and *37 to 72 months*, respectively (Table 8.2). The residual effects of earthworks activities on the avifauna VEC are *not significant* (Table 8.3).

Table 8.1 Potential Interactions between Construction and Avifauna VEC

Valued Ecosystem Component: Avifauna	
Construction Activities and Physical Works	
Earthworks[1]	✓
Wharf expansion	✓
Dredging	✓
Shore and scour protection	✓
Blasting	
Effluent pipeline	✓
Atmospheric emissions (incl. dust)	✓
Roads	
Storm system	
Sewage system	
Pipelines	
Water supply dam	
Residue storage dams	
Power lines	
Shipping	✓
Vehicle traffic	
Sewage	
Solid waste	
Temporary power	
Lighting	✓
Noise	✓
Note: [1] Includes all activities involving earthworks, including grubbing, excavation, grading, and levelling.	

8.6.2 Wharf Expansion

The installation of wharf pilings will result in the loss of bottom habitat for marine benthos, and increased turbidity/sedimentation has the potential to negatively affect marine biota. These effects have the potential to affect abundance of fish prey for Great Cormorant and Bald Eagle. In addition, turbidity has the potential to directly affect marine-associated birds by negatively affecting foraging efficiency. Effects on the marine fish and fish habitat VEC are expected to be temporary and minimal, and therefore not significant. The use of armour stone to protect the bottom habitat in the ship berthing area is predicted to increase marine fish diversity, potentially benefiting fish-eating birds. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of increased turbidity/sedimentation as a result of piling installation on the avifauna VEC are *low to medium*, *<1 km^2*, and *1 to 12 months*, respectively (Table 8.2). The residual effects of wharf expansion during Construction on the avifauna VEC are *not significant* (Table 8.3).

Table 8.2 Environmental Effects Assessment of Construction on Avifauna VEC

Valued Ecosystem Component: Avifauna								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Construction Activities and Physical Works								
Earthworks	Increased turbidity (N)	Water spray dust suppression; Silt curtains	0-1	1	6	4	R	2
Wharf expansion	Loss of foraging habitat (N); Increased turbidity (N)	Installation of armour stone for scour protection; Sediment curtains	1-2	1	6	2	R	2
Dredging	Disturbance to birds (N); Increased turbidity (N)	Sediment curtains; Removal of existing manmade waste	0-1	1	1	2	R	2
Shore and scour protection (installation and presence)	Increased prey species abundance and diversity (P)		-	-	-	-	-	-
Effluent pipeline (installation and presence)	Displacement of birds (N); Alteration of bottom habitat (N); Increased turbidity (N)	Increased prey species abundance and diversity; Sediment curtain	0-1	1	6	2	R	N/A
Atmospheric emissions (incl. dust)	Increased turbidity (N)	Water spray dust suppression; Minimization of material stockpiling	0-1	1	6	4	R	2
Shipping	Displacement of birds (N)		0-1	3	2	2	R	N/A
Lighting	Attraction of Storm-Petrels (N); Possible disturbance to other species (N)		0-1	1	4	4	R	2
Noise	Displacement of birds (N); Injury to hearing	Muffling to minimize noise level	1-2	2	6	4	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 8.3 Significance of Potential Residual Environmental Effects of Construction on Avifauna VEC

Valued Ecosystem Component: Avifauna				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Construction Activities and Physical Works				
Earthworks	NS	3	-	-
Wharf expansion	NS	3	-	-
Dredging	NS	3	-	-
Shore and scour protection (installation and presence)	P	2	-	-
Effluent pipeline (installation and presence)	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Shipping	NS	2	-	-
Lighting	NS	2	-	-
Noise	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

8.6.3 Dredging

Dredging will remove bottom substrate from the wharf area and increase turbidity/sedimentation, which has the potential to negatively affect populations of prey fish species for Great Cormorant. As discussed above, increased turbidity could also reduce foraging efficiency of fish-eating birds. The presence and activity of the dredging machinery would likely prevent cormorants from feeding in the immediate area. Mitigation measures to reduce the effect of dredging will be detailed in the EPP and will include the use of sediment curtains. The use of armour stone to protect the bottom habitat in the ship berthing area may improve fish habitat, as discussed previously. Also, the impacts of dredging on marine fish and fish habitat were predicted to be not significant. Because the area to be dredged is relatively small and any effects temporary, and because large areas of similar marine habitat are found nearby in the Long Harbour area, the overall effect on feeding cormorants will be negligible. Bald Eagles are not expected to be affected by dredging activities. Dredging would be continuous for at least 45 to 60 days during the Construction Phase. With the appropriate mitigation measures, the occurrence of sediment resuspension and subsequent sedimentation as a result of these activities would be limited.

The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of decreased prey abundance, increased turbidity/sedimentation, and displacement from feeding in the area as a result of dredging on the avifauna are *negligible* to *low*, *<1 km*^{2}, and *1 to 12 months*, respectively (Table 8.2). The residual effects of dredging during the Construction Phase on the avifauna are *not significant* (Table 8.3).

8.6.4 Shore and Scour Protection

The installation of armour stone (i.e., riprap, a common fish habitat improvement technique) along the reclaimed shoreline and at the toe of the wharf berthing area may have a coincidental positive effect on populations of many marine fish species (including the focal ones) and increase fish species diversity. Therefore, the effects of shore and scour protection are predicted to be *positive* for the avifauna VEC.

8.6.5 Effluent Pipeline

The effects of pipeline installation on marine prey are not expected to be significant (see Chapter 7.0). Installation of the pipeline near Shag Rock would cause a temporary geographically-restricted increase in turbidity and temporarily displace cormorants that could potentially feed along the route. The time period for the laying of pipeline is brief, and the area of activity of the pipeline laying equipment is expected to be limited to a single barge; the activity of pipeline laying is therefore expected to have a minor and temporary effect on a limited area of potential feeding habitat for cormorants. Bald Eagles are not expected to be affected. Mitigation measures to reduce the effect of pipeline installation will be detailed in the EPP. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of pipeline installation on the avifauna VEC are predicted to be *negligible* to *low*, *<1 km*^{2}, and *1 to 12 months*, respectively (Table 8.2). The residual effects of pipeline installation and presence on the avifauna VEC during the Construction Phase are *not significant* (Table 8.3).

8.6.6 Ships and Boats

Ship traffic usually does not cause much disturbance to fish-eating birds. For example, some seabirds such as gulls are known to be attracted to fishing vessels. Potential effects from vessel traffic are therefore expected to be temporary and limited in geographic extent. Bald Eagle should be unaffected. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of ship and boat traffic during the Construction Phase on the avifauna VEC are predicted to be *negligible* to *low*, *<11 to 100 km*^{2}, and *1 to 12 months*, respectively (Table 8.2). The residual effects of ship and boat traffic on the avifauna VEC during the Construction Phase are *not significant* (Table 8.3).

8.6.7 Atmospheric Emissions (including dust)

Concentrations of NO_2 and total suspended particulates would be contained in a small area, and no exceedances of the Newfoundland Air Quality Standards were predicted off-site for the marine environment. Mitigation measures will be detailed in the EPP and will include dust control techniques and appropriate construction practices such as minimization and/or stabilization of stockpiled material.

Impacts on populations of marine fish prey of fish-eating birds were predicted to be not significant. Because of the small geographic extent and low concentrations of suspended particles and NO_2, these emissions are also predicted to have little direct impacts on marine-associated birds. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of atmospheric emissions on the avifauna VEC are *negligible to low*, *<1* km^2, and *37 to 72 months*, respectively (Table 8.2). The residual effects of the atmospheric emissions produced during the Construction Phase on the avifauna VEC are *not significant* (Table 8.3).

8.6.8 Noise

Noise sources in the Project Area during Construction include marine vessels, dredging, pipelaying vessel, piling installation equipment, and heavy equipment associated with the earthworks. It is likely that the noise with the greatest amplitude and greatest potential to cause effects on marine-associated birds will be emitted by the equipment used to install the wharf pilings.

It is likely that Great Cormorant will be displaced by the visual disturbance and noise. There is little potential for underwater noise to affect cormorants. The Bald Eagle is not expected to be affected by construction noises.

The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of noise on the marine-associated birds are *low to medium*, *1 to 10* km^2, and *37 to 72 months*, respectively (Table 8.2). The residual effects of noise during the Construction Phase on the avifauna VEC are *not significant* (Table 8.3).

8.6.9 Lighting

As discussed above, Leach's Storm-Petrel feed at night and are attracted to artificial light sources. Although this species occurs regularly offshore in Placentia Bay, it rarely ventures close to shore, so it is rare in Long Harbour. Effects of lighting on the night roosting of diurnal birds is expected to be minimal, given that Great Cormorant and Bald Eagle will have habituated to existing artificial light sources around Long Harbour. In addition, Long Harbour is not on any known major migration routes for birds. Therefore, lighting at the wharf is not expected to have adverse effect. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of lighting on marine-associated birds are *negligible to low*, *<1* km^2, and *37 to 72 months*, respectively, during the Construction Phase (Table 8.2). The residual effects of artificial lighting during the Construction Phase on the avifauna VEC are *not significant* (Table 8.3).

8.7 Effects of Operations

Potential interactions between operational routine activities and the avifauna VEC are shown in Table 8.4.

Table 8.4 Potential Interactions between Operations and Avifauna VEC

Valued Ecosystem Component: Avifauna		
Project Activity	**Great Cormorant**	**Bald Eagle**
Operational Activities and Physical Works		
Total footprint	✓	
Residue storage	✓	✓
Shipping	✓	
Offloading dust	✓	
Offloading washdowns/runoff	✓	
Water use		
Electricity use		
Diesel use		
Fuel oil#2 use		
Atmospheric emissions (incl. dust)	✓	✓
Marine effluent	✓	✓
Site runoff	✓	✓
Surge pond		
Sewage		
Solid waste		
Noise	✓	✓
Lighting	✓	✓
Maintenance	✓	

8.7.1 Total Footprint

The effects of the marine portion of the total footprint (e.g., wharf expansion) of the Project Area on marine-associated birds will be negligible as it represents such a negligible portion of their available habitat.

8.7.2 Residue Storage

Marine avifauna would be affected by residue storage only if it increased metal concentrations in the marine environment and if those metals accumulated in prey in high enough concentrations to cause effects. It has been predicted that groundwater flow from Sandy Pond will not result in a significant change in the concentrations of copper, nickel, iron, and sulphate in Long Harbour, and thus metals from groundwater sources will not accumulate in prey species or in marine avifauna, including cormorants or Bald Eagle. The predicted magnitude, geographic extent and duration of the potential *reversible* residual effects of groundwater from the residue storage area (Sandy Pond) on marine-associated birds are *negligible to low*, *<1 km^2*, and *>72 months*, respectively (Table 8.5). The residual effects of the groundwater from the residue storage area on the avifauna VEC are *not significant* (Table 8.6).

8.7.3 Marine Traffic

Up to 25 ships per year will arrive at Long Harbour carrying bulk feed materials including concentrate, limestone, and sulphuric acid. This will not greatly increase the total shipping traffic present or predicted in Placentia Bay. Cormorants on the water in the path of a ship traveling in Long Harbour will probably fly out of the way; they generally have a high tolerance to the presence of ships, as is demonstrated by their abundance in busy harbours in Nova Scotia such as North Sydney and Halifax (B. Mactavish, pers. obs.). Bald Eagles will not be affected by the presence of ships traveling in Long Harbour, as they appear to acclimate well to vessel traffic. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of groundwater project-related ship traffic on marine-associated birds are *negligible to low*, *11 to 100 km^2*, and *>72 months*, respectively (Table 8.5). The residual effects of marine traffic during the Operation Phase on the avifauna VEC are *not significant* (Table 8.6).

8.7.4 Dust

The equipment used to offload the limestone and nickel concentrate will have self-contained dust collection systems and will be enclosed to control fugitive dust. Any dust from the offloading that reaches the marine environment would likely have a negative effect on fish-eating marine birds because of potential effects on fish prey. Increased turbidity would also reduce foraging efficiency of marine-associated birds. However, it is anticipated that large quantities of dust would be necessary to have a significant effect on the marine environment. Since the effects on the marine fish and fish habitat were predicted to be not significant, the effect on marine-associated birds is likely to be minimal.

The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of offloading dust on marine-associated birds are *negligible to low*, *11 to 100 km^2*, and *<1 month*, respectively (Table 8.5). The residual effects of off-loading dust on the avifauna VEC are *not significant* (Table 8.6).

8.7.5 Washdowns/Runoff

Washdown water will be directed into the concentrate preparation process or the Tier 1 settling pond. During winter, the washdown water will contain glycol and will be barreled and disposed of onshore, and thus there will be no interaction with avifauna. Effects of washdown and runoff water on marine-associated birds would likely be negative because of the effects on foraging efficiency and on the health of their fish prey. However, such effects are highly unlikely, as discussed previously.

Table 8.5 Environmental Effects Assessment of Operations on Avifauna VEC

Valued Ecosystem Component: Avifauna								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Operational Activities and Physical Works								
Total footprint	(N)	-	0	1	6	5	R	2
Residue storage	Increased turbidity (N)	Minimize leakage from Sandy Pond	0-1	1	6	5	R	2
Shipping	Disturbance (N)	-	0-1	3	2	5	R	2
Offloading dust	Increased turbidity (N)	Dust collection systems;	0-1	3	2	1	R	2
Offloading washdowns/ runoff	Increased turbidity (N)	Collected in sumps and used in plant site process water	0-1	3	2	1	R	2
Atmospheric emissions (incl. dust)	Increased turbidity (N);	Scrubbers to reduce aerosol mists, chlorine gas and particulate carry over; Air pollution control equipment; Air quality monitoring; Dust collection systems; Water spray dust suppression;	0-1	2	6	5	R	2
Marine effluent	Contamination of prey (N);	Effluent monitoring and treatment; Diffuser end of effluent pipe positioned in area to maximize dispersion by mixing	0	2	6	5	R	2
Site runoff	Contamination (N)	Collected in Tier 1 settling pond before discharge to marine environment	0-1	1	1	1	R	2
Noise	Disturbance (N)	Muffling to minimize noise level;	0-1	2	6	5	R	2
Lighting	Attraction of Storm-Petrels (N)	Turn of non-essential lighting.	0-1	1	6	5	R	2
Maintenance	Disturbance (N)	Maximize efficiency;	0-1	2	1	1	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 8.6 Significance of Potential Residual Environmental Effects of Operations on Avifauna VEC

Valued Ecosystem Component: Avifauna				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Operational Activities and Physical Works				
Total footprint	NS	3	-	-
Residue storage	NS	3	-	-
Shipping	NS	3	-	-
Offloading dust	NS	3	-	-
Offloading washdowns/runoff	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Marine effluent	NS	2	-	-
Site runoff	NS	3	-	-
Noise	NS	2	-	-
Lighting	NS	2	-	-
Maintenance	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

The predicted magnitude, geographic extent, and duration of the potential reversible residual effects of offloading washdowns/runoff on marine-associated birds are *negligible to low*, *11 to 100 km^2*, and *<1 month*, respectively (Table 8.5). The residual effects of offloading washdowns/runoff on the avifauna VEC are *not significant* (Table 8.6).

8.7.6 Atmospheric Emissions

Modeling predicted a minimal negative effect of atmospheric emissions during Operations on the marine environment within and proximate to the Project Area (SENES 2007a; Intrinsik 2007, 2008). Effects on marine-associated birds are not likely to be significant because effects on marine fish are predicted to be not significant, especially after mitigation measures are applied. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of operations atmospheric emissions on marine-associated birds are *negligible to low*, *1 to 10 km^2*, and *>72 months*, respectively (Table 8.5). The residual effects of production atmospheric emissions during the Operation Phase on the avifauna VEC are *not significant* (Table 8.5).

8.7.7 Marine Effluent

Based on the data and assumptions made in the Intrinsik (2007, 2008) study, the likelihood of marine birds experiencing adverse effects is considered to be negligible. For only two substances (iron and selenium) did the modelling results indicate a potential concern. There could be a concern if cormorant feed within 250 m of the diffuser, which will be at a depth of 50 to 70 m, a very unlikely scenario as cormorants are shallow feeders. Selenium has low biomagnification potential in a high energy marine environment, and the potential for direct or prolonged interaction with most marine avifauna is very low.

The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of marine effluent on marine-associated birds are *negligible*, *1 to 10* km^2, and *>72 months*, respectively (Table 8.5). The residual effects of marine effluent during the Operation Phase on the avifauna VEC are *not significant* (Table 8.6).

8.7.8 Site Runoff

Site runoff will be diverted to containment ponds for treatment prior to release to Long Harbour. Site runoff has the potential to cause negative effects on marine-associated birds through negative effects on marine fish populations. However, marine-associated birds are not likely to be affected by site runoff, especially after application of mitigations, because effects on marine fish are not significant.

The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of site runoff on marine-associated birds are *negligible to low*, *<1* km^2, and *<1 month*, respectively (Table 8.5). The residual effects of site runoff during the Operation Phase on the avifauna VEC are *not significant* (Table 8.5).

8.7.9 Noise

Underwater noise during Operations will be less of a concern for marine-associated birds in comparison with Construction because overall noise levels will be relatively diminished (SENES 2007b). Underwater noise during the Operation Phase will originate exclusively from marine vessels traffic. The effects of underwater noise during this phase have the potential to be negative but will likely be minimal, and will not likely exceed present or past levels in Long Harbour.

The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of Operation Phase noise on marine-associated birds are *negligible to low*, *1 to 10* km^2, and >72 *month*, respectively (Table 8.5). The residual effects of Operation Phase noise on the avifauna VEC are *not significant* (Table 8.6).

8.7.10 Lighting

Lighting at the wharf during the Operation Phase is not expected to have adverse effects on birds. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of lighting on marine-associated birds are *negligible to low*, *<1 km^2*, and *>72 months*, respectively, during the Operation Phase (Table 8.5). The residual effects of artificial lighting during the Operation Phase on the avifauna VEC are *not significant* (Table 8.6).

8.7.11 Electrical Transmission Line

The new electrical transmission line and commissioning of the existing transmission line have the potential to cause bird mortality through collision and electrocution. The only bird concentration in the vicinity of the Project is the gathering of Bald Eagles in early spring at the mouth of Rattling Brook and the existing wharf. Bald Eagles may interact with the transmission lines when flying between the herring concentration and roosting, loafing, or nesting areas; however, there are no known corridors of high bird use in the vicinity of the Project. Effective measures to mitigate collisions and electrocutions are relatively simple and inexpensive to incorporate into the design and construction of the new line without increasing line load; and if frequent collisions with the existing lines become a problem, to retrofit the existing lines (e.g., Manville 2005).

8.7.12 Maintenance

Maintenance activities have the potential to negatively affect marine-associated birds. Interactions are likely with respect to the inspection and repair of equipment/infrastructure located in or proximate to the marine environment. Proper mitigation measures (e.g., proper containment of oily materials, etc.) will reduce these effects substantially. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of maintenance activities on marine-associated birds are *negligible to low*, *1 to 10 km^2*, and *<1 month*, respectively, during the Operation Phase (Table 8.5). The residual effects of maintenance activities during the Operation Phase on the avifauna VEC are *not significant* (Table 8.6).

8.7.13 Mitigation

Mitigation measures for routine activities during the Operation Phase will be described in the EPP after consultation with Canadian Wildlife Service. A number of mitigations could be used to reduce effects of the Project on avifauna:

- Dust collection systems;
- Atmospheric emission control systems;
- Treatment of marine effluent;
- Careful timing and limited duration of each activity;

- Installation of yellow or red "bird-flight diverters" (originally derived from spiral vibration dampers) to increase visibility of phase (conductor) and ground wires;
- Design to incorporate sufficient spacing between phase wires, and between phase and ground wires prevent large-winged birds such as Bald Eagles from completing a circuit;
- Insulating jumper wires connecting transformers, protective cutouts, and surge arresters; and
- Insulating metal cross-arm braces or substituting wooden cross-arm braces.

Because of these mitigation measures and the absence of high-use bird flight corridors, the predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of the construction and operation of electrical transmission lines on birds are *low*, *1 to 10 km*^{2}, and *>72 months*, respectively. The residual effects of the construction and operation of electrical transmission lines on the avifauna VEC are *not significant*.

8.7.14 Residual Effects

After implementation of appropriate mitigation measures, all predicted residual environmental effects of routine activities during the Operation Phase on the avifauna VEC are assessed *not significant*.

8.8 Effects of Decommissioning

Rehabilitation and Closure will involve a greatly diminished set of activities in comparison to other Project Phases and interactions with avifauna will be proportionately diminished.

8.8.1 Closure

While some of the activities associated with Closure might have temporary negative effects on marine-associated birds, the end result of these activities will be beneficial to the VEC. Some activities associated with Closure include:

- Drainage and cleaning of pipeline;
- Demolition and removal of infrastructure including wharf (except phosphorus encapsulated area) and marine effluent pipeline; and
- Assessment of areas subject to chronic exposure and implementation of appropriate measures to remediate identified contaminated areas.

Mitigation to reduce the effect of Closure activities on marine-associated birds will be detailed in the EPP. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of Closure activities on marine-associated birds are *low, 1 to 10 km*^{2}, and *13 to 36 months*, respectively. The residual effects of Closure activities on the avifauna VEC are *not significant*.

8.8.2 Post-closure

Post-closure activities such as the long-term monitoring, care and maintenance of the phosphorus encapsulated in the wharf, and the implementation of a monitoring program to determine the effectiveness of decommissioning will have positive effects on the avifauna VEC.

8.8.3 Mitigation

Mitigation measures for Decommissioning will be described in an EPP.

8.8.4 Residual Impacts

After implementation of appropriate mitigation measures, all predicted residual environmental effects of routine activities during the Decommissioning Phase on marine-associated birds are assessed as initially negative due to increased disturbance during Closure but eventually reverting to positive as the site returns to a more natural state, and in any event *not significant*.

8.9 Cumulative Environmental Effects

8.9.1 Within-Project

The within-Project cumulative effects are integrated into the effects assessment of the individual routine activities of the various phases of the Project. Since the residual effects of all routine activities with potential to interact with marine-associated birds were predicted to be *not significant*, within-Project cumulative effects are also *not significant*.

8.9.2 With Other Projects

Of the ten ongoing and proposed projects and activities that comprise the cumulative effects listing, only marine shipping and hunting have any overlap or interaction with the Project in terms of marine-associated birds. The additional approximately 25 (maximum) vessel round trips per year into Long Harbour are well within historical activity for the area and represent only a very small percentage of current or projected vessel traffic. Any effects from the Project's routine activities on marine-associated birds should be minimal. Any bird mortalities caused by the Project would most likely be caused by an accidental event as opposed to routine activities (see Chapter 11.0).

At present, the largest sources of marine-associated bird mortality in Placentia Bay are the winter murre hunt (primarily Thick-billed Murre) and oiling as a result of illegal discharge of oily bilge water by trans-Atlantic shipping. However, the hunt is regulated by the federal Canadian Wildlife Service so any effects from that source can be considered to be not significant. Bald eagles are unlikely to be oiled because they spend so little time in contact with the water, although they could come in contact with contaminated prey. The population effects of oiling on other marine-associated birds are unknown because of the difficulty in accurately estimating the mortality from that source.

Any added effects on the Placentia Bay ecosystem from routine activities associated with the proposed nickel processing plant at Long Harbour will likely not change the effects predictions on a cumulative basis, unless significant marine hydrocarbon or chemical spills occur. The cumulative effect of the Project in association with the effects of other projects and activities in Placentia Bay is predicted to be *not significant*.

8.10 Summary of Effects on Avifauna

The main potential effects of routine activities of the Construction, Operation, and Decommissioning phases on marine-associated birds include:

- Decline in abundance of prey species;
- Food chain contamination from effluent discharge;
- Suspended sediments affecting feeding behaviour; and
- Disburbance from noise.

Some of the predicted effects are *low* in magnitude; all are *reversible*. Resumption of foraging in the Project Area after completion of specific construction activities will return quickly to pre-activity conditions. As discussed in earlier sections, enhancements of affected areas will likely provide additional or improved marine fish habitat and consequently prey for avifauna. Installation and presence of the marine effluent pipeline will not have a significant effect on contaminant levels in avifauna.

Overall, the predicted residual effects of the Project routine activities on the avifauna VEC are *not significant*.

9.0 Otter Effects Assessment

Marine mammals are a typical VEC in Canadian marine environmental assessments because they are of prime concern from both a public and a scientific perspective – locally, nationally and internationally. For the purposes of this EIS, the river otter is a surrogate and focal species because it is a year-round resident top-level predator, has potential sensitivity to Project activities and accidental events, and has a marine lifestyle in Long Harbour.

9.1 Existing Conditions

Detailed background material on this species (and marine mammals in general), including results of VBNC studies, are presented in Chapter 2.0 of this volume and in the Marine Component Study (LGL 2007).

River otter is not technically a marine mammal, but in Placentia Bay many individuals have adopted a marine lifestyle and the bay is known to support a relatively large population. Its role as a top predator and its relatively large spatial requirements make the species sensitive to anthropogenic stress including contamination by water-borne pollutants, drainage of wetlands, and other forms of habitat degradation (Duffy et al. 1993; Bowyer et al. 1995). Because of this susceptibility, river otters are commonly used as indicators of the health of aquatic ecosystems (Duffy et al. 1993; Elliot et al. 1999). In various areas of its range, this species lives a largely marine existence or may alternate between coastal and interior habitats (Larsen 1984; Stenson et al. 1984).

The VBNC surveys discovered several otter haul-out areas in the vicinity of the Project Area.

9.2 Assessment Criteria

Assessment criteria including boundaries are as described in Chapter 3.0. Significant environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the otter VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EIS, a *significant* effect is defined as:

> *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2.*

9.3 Issues and Concerns

The main pathways for potential effects include disturbance (e.g., from noise) and exposure to contaminants with some potential for biomagnification due to their high rate of consumption of fish. During the various phases of the Project, the main types of activities or sources of effects that may interact with river otters include:

- Noise;
- Vessels and ships;
- Anthropogenic disturbance (including physical presence of structures); and
- Contaminants.

Of these Project activities, noise has perhaps the greatest potential to affect river otters, as noise is associated with almost every aspect of the Construction, Operation, and Decommissioning phases, and this VEC is sensitive to noise. There is little systematic information available for reactions of river otters to the primary sources of noise produced during the proposed Project including land-based blasting, pile driving, dredging and shipping.

9.4 Existing Knowledge

This section summarizes existing knowledge concerning the main pathways for effects on river otter, much of which is applicable as well to marine mammals in general.

9.4.1 Noise

The effects of noise are highly variable, and can be categorized as follows (based on marine mammals; Richardson et al. 1995):

- The noise may be too weak to be heard at the location of the animal, i.e., lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both.
- The noise may be audible but not strong enough to elicit any overt behavioural response, i.e., the mammals may tolerate it.
- The noise may elicit behavioural reactions of variable conspicuousness and variable relevance to the well being of the animal; these can range from subtle effects on respiration or other behaviours (detectable only by statistical analysis) to active avoidance reactions.
- Upon repeated exposure, animals may exhibit diminishing responsiveness (habituation), or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal perceives as a threat.
- Any anthropogenic noise that is strong enough to be heard has the potential to reduce (mask) the ability of mammals to hear natural sounds at similar frequencies.
- Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity, or other physical or physiological effects. Received sound levels must far exceed the animal's hearing threshold for any temporary threshold shift to occur. Received levels must be even higher for a risk of permanent hearing impairment.

Hearing Abilities

There is no published (primary literature) information on river otter hearing abilities (or sea otter hearing; Ketten 1998). Gunn (1988) prepared a thesis on the behavioural audiogram of the North American river otter (*Lutra canadensis*). River otters are known to emit a snarling growl or hissing bark when disturbed and a shrill whistle when in pain. When at play or traveling, they sometimes emit a low purring grunt. An alarm call in the form of an explosive snort is made by expelling air through the nostrils. Otters also may use a bird-like chirp for communication over long distances, but the most common sound heard is low-frequency chuckling (see Lariviere and Walton 1998). Unfortunately, the frequencies of these calls have not been documented.

Sea otters seem to produce some of the same airborne sounds as river otters (McShane et al. 1995). The in-air vocalizations of sea otters have most of their energy concentrated at three to five kHz (McShane et al. 1995; Thomson and Richardson 1995; Richardson et al. 1995). Sea otter vocalizations are considered to be most suitable for short-range communication among individuals (McShane et al. 1995).

Sound Thresholds for Hearing Impairment

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds (see Richardson et al. 1995). The minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable Temporary Threshold Shift (TTS). The level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage. Current U.S. National Marine Fisheries Service (NMFS) policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds exceeding 180 and 190 dB re 1 µPa (rms), respectively (NMFS 2000). [Note that NMFS is considering alternative criteria—see Federal Register/Vol. 70(7): 1871-1875.] [NMFS is developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS, the expected offset between the TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For preliminary information about this process, and about the structure of the new criteria in marine and terrestrial mammals see Wieting (2004), Miller et al. (2005), and Southall et al. (2007).]

No hearing impairment sound criterion exists to date to mitigate potential effects of noise on river otters, or other Mustelidae, specifically. The 180 and 190 dB criteria have been used in establishing the safety (power-down) zones for cetaceans and pinnipeds for seismic surveys in some parts of Canada (and the U.S.). Most sound levels produced by Construction and Operations activities for the Project are much lower than those produced during seismic surveys. In the absence of sound criterion for river otters, a 180 dB criterion is used when attempting to mitigate potential effects of noise on river otters.

Land-based Blasting

There are no systematic data available for effects of blasting on river otters. However, Hussain and Choudhury (1997) did not find any signs of smooth-coated otters (*Lutra perspicillata*) within five kilometres of construction sites and areas where stone quarrying and sand mining were occurring. They also noted that otters that left disturbed areas returned to these sites later. Sea otters exposed to a shock wave (from an underground nuclear test) with a peak pressure of 237 to 246 dB were killed (see p. 308 in Richardson et al. 1995).

Pile-driving Noise (Wharf Construction)

Impact pile driving produces higher sound levels that are impulsive, whereas vibratory pile driving produces continuous sound at lower sound levels. Figure 9.1 summarizes the results of seven acoustic studies of impact pile (or pipe) driving (HDR Alaska et al. 2006). The highest received sound level recorded during these studies was 202 dB re 1 uPa (rms) at 14 m (HDR Alaska et al. 2006). Sound levels from most impact pile driving sources diminished below 180 dB at distances <300 m. The dominant frequency range of pile driving is most likely related to differences in the size, shape and thickness of the piles. Most of the pulse energy typically falls between 50 to 2,000 Hz (HDR Alaska et al. 2006).

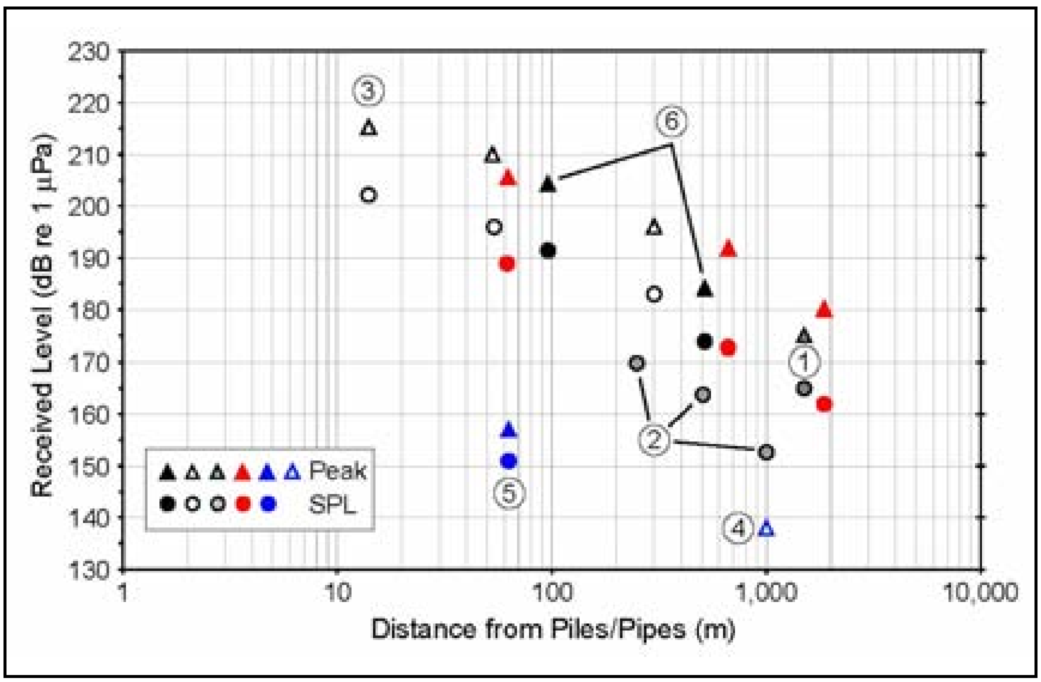

Figure 9.1 Summary of Peak and Sound Pressure Levels (SPL) of Impact Pile/Pipe Driving

Key: Based on HDR Alaska et al. (2006; red symbols)
(1) Greene (1999) (3) Reyff et al. (2002) (5) Blackwell et al. (2004)
(2) Wursig et al. (2000) (4) Johnson et al. (1986) (6) Blackwell and Burgess (2004)
Source: From HDR Alaska et al. (2006).

Dredging

Dredging can produce significant noise in nearshore regions, especially in the low frequencies, but rapid attenuation occurs in the shallow water and dredging may not be detectable beyond about 25 km (Richardson et al. 1995). Source levels in the 1/3 octave of strongest noise (centered at 250 Hz) ranged from 150 to 162 dB re 1 μPa-1 m of a clamshell dredge; noise from the tug and barge used to transfer dredged material produced stronger sound levels (Richardson et al. 1995). Sound is not expected to exceed levels that may cause hearing impairment, at least for pinnipeds and cetaceans. There have been no results found of the reactions of river otters to dredging.

9.4.2 Vessels and Ships (Physical Presence)

There are no systematic data on river otter reactions to ships and boats. Sea otters, which may react similarly to river otters, often allow close approaches (within several hundred metres) by boats, but may avoid heavily disturbed areas (Richardson et al. 1995).

9.4.3 Anthropogenic Disturbance

There is some limited information (with no details about sound levels) about responses of otter species to other anthropogenic disturbance sources. The Eurasian otter (*Lutra lutra*) did not show changes in distribution or frequency of use of shelters in response to human disturbance, either at a riverine locality (Green et al. 1984) or in a coastal area (MacDonald and Mason 1980). Similarly, in southeastern Brazil, human disturbance around shelters did not influence use by Neotropical river otters, *Lutra longicaudis* (Pardini and Trajano 1999). In contrast, an inverse relationship between human disturbance and the abundance of otter shelters were noted by O'Sullivan (1993) for *L. lutra* at a riverine site, and by Verwoerd (1987) for the African river otter, *Aonyx capensis*, in a coastal area. In a South Indian river system, smooth-coated otters (*L. perspicillata*) avoided areas with high levels of disturbance by fishing activities and people; the frequency of visits to disturbed sites was lower than that to undisturbed sites, but the number of sites did not differ between disturbed and undisturbed areas (Shenoy et al. 2006). River otters have been observed to haul-out on (active) wharves in North Harbour and may be readily adaptable to areas of disturbance (D. Slade, retired Wildlife Officer, pers. comm.). Sea otters often allow close approaches (within several hundred metres) by boats but may avoid heavily disturbed areas (Richardson et al. 1995).

9.4.4 Contaminants

There has been little research on contamination by metals of relevance to the proposed nickel processing plant. River otters are known to be susceptible to environmental contaminants such as dioxin, mercury, and polychlorinated biphenyls (PCBs) present in rivers and lakes (Foley et al. 1988; Sloan and Brown 1988; Organ 1989; Sample and Suter 1999). Otter habitat use has been positively correlated with neutral pH levels, which means that they may be vulnerable to acid rain in some situations (Shackleford 1995). Mercury residue in river otters was correlated to those in whole-body fish from a same watershed; mercury levels were higher in adults than juveniles, suggesting a risk of bioaccumulation (Organ 1989). Mercury concentrations found in Georgia river otters indicated sublethal contamination, with concentrations in some individuals approaching levels observed in experimentally dosed individuals that developed clinical signs of mercurialism (Halbrook et al. 1994). Harding et al. (1998) examined heavy and trace metal concentrations in mustelids from the Fraser and Columbia river systems receiving metals discharges and concluded that the metals concentrations in tissues of mink and river otter were generally low and within the range of values reported for ranch and wild populations.

9.5 Effects of Construction

Potential interactions between construction routine activities and the river otter VEC are shown in Table 9.1.

Table 9.1 Potential Interactions between Construction and Otter VEC

Valued Ecosystem Component: River Otter	
Construction Activities and Physical Works	
Earthworks[1]	✓
Wharf expansion	✓
Dredging	✓
Shore and scour protection	✓
Blasting	✓
Effluent pipeline	✓
Atmospheric emissions (incl. dust)	✓
Roads	✓
Storm system	✓
Sewage system	✓
Pipelines	✓
Water supply dam	✓
Residue storage dams	✓
Power lines	-
Shipping	✓
Vehicle traffic	✓
Sewage	✓
Solid waste	✓
Temporary power	✓
Lighting	✓
Noise	✓
Note: [1] Includes all activities involving earthworks, including grubbing, excavation, grading, and levelling.	

9.5.1 Earthworks

Although the proposed site (Tier 1) does not appear to offer suitable otter habitat, site grading and leveling could result in a loss of potential habitat for the otter, potentially causing negative effects. In addition, site grading and leveling on Tier 1 could potentially result in the introduction of silt to the marine environment, especially when these activities are conducted in areas proximate to the shoreline. Sediment entering the sea water will result in increased turbidity and sedimentation, potentially having negative effects on the otter and its prey. Mitigation to reduce the effect of earthworks on the otter will be detailed in the EPP and will include the use of silt curtains. Earthworks activities might be continuous throughout the Construction Phase; however, with the appropriate mitigation measures, the occurrence of sediment entering the marine system as a result of these activities would be minimal.

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of earthworks activities on the otter are *negligible to low, <1 km^2,* and *37 to 72 months (42 months)*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of earthworks activities on the otter VEC are *not significant* (Table 9.3).

9.5.2 Dredging and Wharf Expansion

All dredging activities (including on-land disposal) will be conducted in accordance with regulatory requirements. Dredging activities using a clamshell dredge are expected to last about 45 to 60 days. Wharf construction activities, in general, are expected to last 1.5 to two years. Dredging and wharf expansion (not including noise effects) will result in the loss of potential habitat for prey (at least temporarily), potentially causing negative effects to the otter VEC. In addition to loss of habitat, the noise from dredging may disturb river otters and they may avoid at least an immediate area around the wharf. However, no otter haul-out sites are located in the immediate area of the wharf.

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of dredging and wharf expansion activities on the otter are *low, <1 km^2* and may last *13 to 36 months*, respectively (Table 9.2). Based on the value of these evaluation criteria, the potential residual effects of dredging and wharf expansion activities on the otter VEC are *not significant* (Table 9.3).

9.5.3 Blasting

Blasting will not occur in marine areas during any phase of the Project. However, blasting in and near the Plant footprint during the Construction Phase has the potential to generate a shock wave that could propagate into the marine water column. It is expected that blasting operations at the plant site could occur periodically over 15 months. The short rise time to a high peak pressure of shock pulses from explosives appears to be responsible for much of the damage to marine mammals during detonations (Ketten 1995) and there is potential for behavioural disturbance (Richardson et al. 1995).

Details about explosive types and locations are not available at the time of writing of this EIS; however, blasting parameters will be such that they adhere to the DFO guidance outlined in *Guidelines for the Use of Explosives in or near Canadian Fisheries Waters* (Wright and Hopky 1998). Most notably, these guidelines suggest that the maximum pressure should not exceed 100 kPa and that a setback distance from the land-water interface should be determined to restrict peak ground velocities to less than 13 mm/s. Common practice is to undertake a blast impact assessment prior to execution of the project and design the blasting to conform with these guidelines. During construction the pressures from blasting will be monitored at the shoreline and in the water. If there is exceedence of the DFO Guidelines, adjustments will be made to the blasting procedures.

Table 9.2 Effects Assessment of Construction on Otter VEC

Valued Ecosystem Component: River Otter								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Construction Activities and Physical Works								
Earthworks	Increased turbidity; sedimentation (N); Loss of habitat (N)	Standard operating procedures	0-1	1	6	4	R	2
Wharf expansion	Loss of habitat (N)	-	1	1	6	3	R	2
Dredging	Loss of habitat for prey (N)	Standard operating procedures	1	1	1	2	R	2
Shore and scour protection	Increased prey species abundance and diversity (P)	-	-	-	-	-	-	-
Blasting	Loss of habitat (N); Physical (N)	Setback distance; delay start; monitoring	0-1	1	3	3	R	2
Effluent pipeline	May attract prey (P?); Disturbance to prey (N)	-	0-1	2	6	4	R	2
Atmospheric emissions (incl. dust)	Contamination (N)	Equipment design, dust control measures	1	2	6	4	R	2
Roads	Loss of habitat (N)	-	0	2	6	4	R	2
Storm system	Loss of habitat (N)	Standard operating procedures	0	1	6	4	R	2
Sewage system	Loss of habitat (N)	Standard operating procedures	0	1	6	4	R	2
Pipelines	Loss of habitat (N)	-	0	2	6	4	R	2
Water supply dam	Loss of habitat (N)	-	0-1	2	6	4	R	2
Residue storage dams	Loss of habitat (N)	-	0-1	2	6	4	R	2
Shipping	Disturbance (N)	-	0-1	3	2	4	R	2
Vehicle traffic	Physical (N)	-	0-1	2	5	4	R	2
Sewage	Contamination (N)	-	1	2	6	4	R	2
Solid waste	Contamination (N)	-	1	2	6	4	R	2
Temporary power	-	-	0-1	1	6	4	R	2
Lighting	May attract prey (P?), Temporary loss of habitat (N)	-	-	-	-	4	-	-
Noise	Disturbance (N)	Monitoring; delay start if in safety zone	1	2-3	6	4	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 9.3 Significance of Potential Residual Environmental Effects of Construction on Otter VEC

Valued Ecosystem Component: River Otter				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Construction Activities and Physical Works				
Earthworks	NS	3	-	-
Wharf expansion	NS	2	-	-
Dredging	NS	2	-	-
Blasting	NS	2	-	-
Effluent pipeline	MS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Roads	NS	3	-	-
Storm system	NS	3	-	-
Sewage system	NS	3	-	-
Pipelines	NS	3	-	-
Water supply dam	NS	3	-	-
Residue storage dams	NS	3	-	-
Shipping	NS	2	-	-
Vehicle Traffic	NS	2	-	-
Sewage	NS	3	-	-
Solid waste	NS	3	-	-
Temporary power	NS	3	-	-
Lighting	NS	3	-	-
Noise	NS	2	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

Prior to blasting, a blast impact assessment will be undertaken to determine appropriate setback distances and ensure that 100 kPa is not exceeded. In addition, the sound levels in the water column will be evaluated to determine a safety zone for river otters. Received sound levels of 180 dB re 1 µPa rms for river otters will be used as a guide for these zones (see NMFS 2000), which will be monitored for 30 minutes prior to blasting operations near the marine environment, and blasting operations will be temporarily suspended if a river otter is sighted within or about to enter the zone. In addition, blasting operations will not commence if a river otter (or terrestrial wildlife) is sighted in a designated safety zone.

Blasting has the potential to cause a negative effect on otters (Table 9.2). Based on field studies, river otters do not use coastal haul-out sites in the immediate area of the Project site. Based upon available information, river otters will likely avoid the area near blasting (and other construction activities) operations. Mitigation measures to reduce the effect of blasting on the otter will be detailed in the EPP. Blasting operations would be delayed if sensitive animals on land, including the river otter are observed close to a blast site (Table 9.2).

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of blasting activities on the otter are *negligible to low, <1 km*^{2}*, and 13 to 36 months (15 months)*, respectively (Table 9.2) Based on the value of these evaluation criteria, the residual effects of blasting activities on the otter VEC are *not significant* (Table 9.3).

9.5.4 Effluent Pipeline

The effluent outflow line into Long Harbour is planned to consist of an estimated six km of HDPE pipe extending from the shore line to a point near Shag Rock. The effluent outflow line, once in place, will provide additional fish habitat, and thus could attract otter prey, causing potentially positive effects for the otter VEC at the shallow end of the pipeline (Table 9.2). Care will be taken to reduce physical disturbance and sedimentation to protect fish and fish habitat during construction, limiting the potential disturbance, and negative effects, to the otter's prey (Table 9.2).

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of effluent pipeline activities on the otter are *negligible to low, 1 to 10 km*^{2}*, and 37 to 72 months*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of effluent pipeline activities on the otter VEC are *not significant* (Table 9.3).

9.5.5 Dust and Atmospheric Emissions

Dust and atmospheric emissions could lead to contamination of otter habitat, causing potentially negative effects to the otter VEC (Table 9.2). Dust from construction activities will be controlled by using frequent applications of water or use of dust controlling agents (wood chips, matting). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of dust and atmospheric emissions activities on the otter are *low, 1 to 10 km*^{2}*, and 37 to 72 months (42 months)*, respectively (Table 9.2). The residual effects of dust and atmospheric emissions on the otter VEC are *not significant* (Table 9.3).

9.5.6 Roads

Site access road construction will result in a loss of potential habitat for the otter, causing potentially negative effects to the otter VEC (Table 9.2). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of roads activities on the otter are *negligible, 1 to 10 km*^{2}*, and 37 to 72 months*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of roads activities on the otter VEC are *not significant* (Table 9.3).

9.5.7 Storm and Sewage Systems

Storm and sewage system construction will result in a loss of potential habitat for the otter, causing potentially negative effects to the VEC (Table 9.2). Storm-water within the property boundaries at Tiers 1 and 2 will be collected and treated as necessary to meet government regulations. All sewage disposal systems will comply with relevant health and safety regulations, and all septic waste will be transported off-site and disposed in an approved disposal site by a licensed waste disposal operator.

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of storm and sewage systems activities on the otter are *negligible, <1 km^2, and 37 to 72 months*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of storm and sewage systems activities on the otter VEC are *not significant* (Table 9.3).

9.5.8 Pipelines

Pipeline construction could result in a loss of potential habitat for the otter, causing potentially negative effects (Table 9.2). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of the physical presence of pipelines activities on the otter are *negligible, 1 to 10 km^2, and 37 to 72 months*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of pipelines activities on the otter VEC are *not significant* (Table 9.3).

9.5.9 Water Supply and Residue Storage Dams

A water supply berm will be constructed to retain sufficient water quantity in Rattling Brook Big Pond to supply the Plant with water and to meet instream flow needs for fish habitat. Three dams will be constructed at Sandy Pond to contain the residue. While surveys have not shown any evidence of current usage by otter, the sites for the water supply and residue storage dams will result in a loss of potential habitat, causing potentially negative effects to the otter VEC (Table 9.2).

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of water supply and residue storage dams on the otter are *negligible* to *low, 1 to 10 km^2, and 37 to 72 months*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of water supply and residue storage dam activities on the otter VEC are *not significant* (Table 9.3).

9.5.10 Vehicle Traffic

Vehicle traffic could result in physical harm via collision with individual otters, causing potentially negative effects (Table 9.2). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of vehicle traffic activities on the otter are *negligible to low, 1 to 10 km^2, and 37 to 72 months (42 months)*, respectively (Table 9.2). Note that effects are considered reversible at the population level but may not be reversible at the individual level. Based on the value of these evaluation criteria, the residual effects of vehicle traffic activities on the otter VEC are *not significant* (Table 9.3).

9.5.11 Temporary Power and Lighting

Any effects from temporary power would be that caused by generator noise (see following section).

Lighting near the shoreline may result in the potential attraction of otter prey, causing potentially positive effects to the otter VEC (Table 9.2). However, it is uncertain how river otters will respond to lighting. There is increased potential of an impact from lighting because this species is most active at night and during twilight hours. Assuming that river otters avoid areas with artificial lighting, it is predicted that lighting will have a potentially negative effect on the otter VEC (Table 9.2). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of lighting on the otter are *negligible to low, <1 km*^{2}*, and 37 to 72 months (42 months)*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of temporary power and lighting activities on the otter VEC are *not significant* (Table 9.3).

9.5.12 Noise

Noise will be present throughout the Construction Phase of the Project and during every project activity. Noise originating from generators, wharf construction (e.g., pile driving, dredging), and the presence of ships and boats are likely to cause the highest potential effect on river otters, as many of their life activities are linked to the marine environment. On-land blasting, especially in proximity to the coastline, may also affect them.

Based upon field studies, the closest river otter haul-out sites are in the order of two kilometres from the proposed wharf expansion (LGL 2007). Little is known about the sound levels from pile driving that would cause a river otter to avoid an area or exhibit another behavioural response. Based on available information, river otters will likely avoid the area of pile driving operations.

Pile driving activities are expected to last 60 to 90 days. If pile driving sounds are expected to exceed 180 dB (likely the case for impact pile driving), the area around the wharf will be watched (for 30 minutes prior to start of pile driving) and impact pile driving will be temporarily delayed or halted if a river otter is sighted within a designated safety zone (180 dB re 1 μPa rms).

Pile driving noise will result in disturbance to the otter, causing potentially negative effects to the otter VEC (Table 9.2). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects are *low,* range from *1 to 100 km*^{2}*,* and *1 to 12 months* (*60 to 90 days*), respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of pile driving noise activities on the otter VEC are *not significant* (Table 9.3).

Dredging with a clamshell dredge is anticipated to occur for 45 to 60 days during construction of the marine wharf. As with other noise sources, it is uncertain how river otters will respond but it is assumed that they will avoid at least the immediate area around dredging activities. The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects are *low, 1 to 100 km^2,* and *1 to 12 months (1 to 2 months)*, respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of dredging noise on the otter VEC are *not significant* (Table 9.3).

Little is known about what sound levels from vessels would cause a river otter to avoid an area or exhibit another behavioural response. Based upon available information, river otters will likely avoid the area of vessel operations. During Construction, they may exhibit avoidance of the area where vessels are involved in construction activities. Vessel noise will result in disturbance, causing potentially negative effects to the otter VEC (Table 9.2). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects are *low, 1 to 100 km^2, and 37 to 72 months* (42 months), respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of vessel noise activities on the otter VEC are *not significant* (Table 9.3).

Based on available information, river otters will likely avoid the area near blasting (and other construction activities) operations. On-land blasting noise will result in disturbance to the otter, causing potentially negative effects to the VEC (Table 9.2). Mitigation to reduce the effect of blasting on the otter will be detailed in the EPP. Blasting operations would be delayed if sensitive animals on land, including the river otter, are observed close to a blast site, which would be monitored prior to a blast (Table 9.2). If blasting is to occur in close proximity to waterbodies, it shall be undertaken in compliance with the required permits and guidelines. The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects are *low, 1 to 100 km^2, and 13 to 36 months* (15 months), respectively (Table 9.2). Based on the value of these evaluation criteria, the residual effects of on-land blasting noise activities on the otter VEC are *not significant* (Table 9.3).

9.6 Effects of Operations

Potential interactions between operational routine activities and the river otter VEC are shown in Table 9.4.

9.6.1 Total Footprint and Residue Storage

The total footprint of the Operation Phase will result in a loss of potential habitat (albeit very poor habitat at present) for the otter, potentially causing negative effects (Table 9.5). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of total footprint activities on the otter are *low, 1 to 10 km^2,* and *>72 months*, respectively (Table 9.5). Based on the value of these evaluation criteria, the residual effects of total footprint (including residue storage) activities on the otter VEC are *not significant* (Table 9.6).

Table 9.4 Potential Interactions between Operations and Otter VEC

Valued Ecosystem Component: River Otter	
Operational Activities and Physical Works	
Total footprint	✓
Residue storage	✓
Shipping	✓
Offloading	
Dust	✓
Washdowns/runoff	✓
Water use	
Electricity use	
Diesel use	
Fuel oil#2 use	
Atmospheric emissions (incl. dust)	✓
Marine effluent	✓
Site runoff	✓
Surge pond	✓
Sewage	✓
Solid waste	✓
Vehicle traffic	✓
Noise	✓
Lighting	✓
Maintenance	✓

Table 9.5 Effects Assessment of Operations on Otter VEC

Valued Ecosystem Component: River Otter								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Operational Activities and Physical Works								
Total footprint	Loss of habitat (N)	-	1	2	6	5	R	2
Residue storage	Loss of habitat (N), Contamination (N)	Treatment & monitoring	0	2	6	5	R	2
Shipping	Disturbance (N)	-	0-1	3	2	5	R	2
Offloading								
Dust	Contamination (N)	Treatment	1	1	5	5	R	2
Washdowns/runoff	Contamination (N)	Treatment	0	1	5	5	R	2
Atmospheric emissions (incl. dust)	Contamination (N)	-	1	2	6	5	R	2
Marine effluent	Contamination (N)	Treatment & monitoring	1-2	2	6	5	R	2
Site runoff	Contamination (N)	-	0-1	1	6	5	R	2
Surge pond	Loss of habitat (N)	-	0-1	1	6	5	R	2
Sewage	Loss of habitat (N), Contamination (N)	Treatment	0	1	5	5	R	2
Solid waste	-	-	1	2	6	5	R	2
Vehicle traffic	Physical (N)	-	0-1	2	5	5	R	2
Noise	Disturbance (N)	-	1	2-3	6	5	R	2
Lighting	May attract prey (P?), Loss of habitat (N)	-	0	1	5	5	R	2
Maintenance	Disturbance (N)	-	0-1	2	4	5	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 9.6 Significance of Potential Residual Environmental Effects of Operations on Otter VEC

Valued Ecosystem Component: River Otter				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Operational Activities and Physical Works				
Total footprint	NS	2	-	-
Residue storage	NS	3	-	-
Shipping	NS	2	-	-
Offloading				
Dust	NS	3	-	-
Washdowns/runoff	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Marine effluent	NS	2	-	-
Site runoff	NS	2	-	-
Surge Pond	NS	3	-	-
Sewage	NS	2	-	-
Solid waste	NS	3	-	-
Vehicle traffic	NS	2	-	-
Noise	NS	2	-	-
Lighting	NS	3	-	-
Maintenance	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

9.6.2 Dust and Atmospheric Emissions

Dust and atmospheric emissions can lead to contamination of the habitat, causing potentially negative effects to the otter VEC (Table 9.5). The Plant will be releasing a variety of airborne emissions. Dust during production activities will be controlled. Intrinsik estimated "reasonable worst-case" exposure ratio (ER) values for small mammals for metals in all scenarios (Intrinsik 2007, 2008). Modelling results indicated a negligible potential for acute or chronic adverse human health effects (by extrapolation ,little or no adverse effects on otters) resulting from exposure to predicted ground level air concentrations of these chemicals, during the 15-year Operations period (Intrinsik 2007, 2008).

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of dust and atmospheric emissions activities on the otter are *low, 1 to 10 km^2*, and *>72 months*, respectively

(Table 9.5). Based on the value of these evaluation criteria, the potential residual effects of dust and atmospheric emissions activities on the otter VEC are *not significant* (Table 9.6).

9.6.3 Marine Effluent

The underwater diffuser outfall into open water in Long Harbour will discharge various contaminants; if this leads to habitat degradation or contaminant uptake in otters, it could potentially cause negative effects to the animal (Table 9.5).

Intrinsik (2007, 2008) modelled the uptake of effluent contaminants into higher trophic level species (including otter). The results indicated that most chemicals of potential concern (COPC) did not produce critical ER values. However, iron and selenium required special attention. Further examination indicated that these apparently elevated values are overly conservative and exposure rates were likely exaggerated, e.g., otter diet based on foraging for fish exclusively within 10 m of the diffuser head. When considered with respect to a 250-m distance from the diffuser head, the potential for adverse effects, while still elevated, are greatly diminished.

In any event, it is unlikely that otter will feed close to the effluent outfall, which will lie in over 50 m of water, probably beyond their normal feeding depths. Feeding studies of otter indicate that their diet consists of shallow-water fish and invertebrates. Data are not extensive for Placentia Bay but otters there appear to consume primarily inshore marine fish species, as the main prey items identified from scats collected at otter haul-out sites in Placentia Bay included cunner, gunnels/pouts, sculpins, flounder and sticklebacks (Cote et al. 2007 in prep.)

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of marine effluent activities on the otter are *low to medium, 1 to 10 km^2*, and *>72 months*, respectively (Table 9.5). Based on the value of these evaluation criteria, the potential residual effects of marine effluent activities on the otter VEC are *not significant* (Table 9.6).

9.6.4 Site Runoff and Surge Pond

Site runoff will lead to contamination of the otter habitat, causing potentially negative effects to the otter VEC (Table 9.5). Runoff will be conveyed to the main outlet through a combination of subsurface drainage, roadside ditches, and storm sewers. It will be collected in the storm-water capture pond. Surge pond (Matte scenario) will lead to contamination of potential otter habitat, causing potentially negative effects to this VEC (Table 9.5). The surge pond will have a staff gauge for direct reading of water level, and a water level sensor with high and low level alarms. The surge pond will have an emergency overflow spillway to prevent overtopping of the perimeter containment dike. There will be no surge pond in the Hydromet facilities.

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of site runoff and surge pond activities on the otter are *negligible* to *low, <1 km^2, and >72 months*, respectively (Table 9.5). Based on the value of these evaluation criteria, the residual effects of site runoff and surge pond activities on the otter VEC are *not significant* (Table 9.6).

9.6.5 Sewage

If untreated, sewage will lead to contamination of the otter habitat, causing potentially negative effects to the otter VEC (Table 9.5). Mitigations include sewage treatment. The sewage treatment plant on Tier 2 will include a collection station pit, pumps, and a biological waste treatment plant. The treatment system will include an equalization chamber, primary solids removal, secondary aerobic treatment, and aerobic sludge stabilization. Stabilized sewage sludge from the treatment plant will be periodically removed by an approved waste disposal contractor to an off-site landfill. The treated sewage liquid will be discharged through the outfall pipe and diffuser into Long Harbour. Domestic sewage generated at the facilities on Tier 1 will be collected and fed to a septic tank where solids are settled and removed. The sewage will then be discharged to a tile field system located at the port. The tile field and septic tank will be designed to meet government requirements. Sludge from the septic tank will be removed by an approved waste disposal contractor, along with stabilized sludge from the Tier 2 sewage treatment plant, and stored off-site in a government-approved landfill.

With appropriate mitigation measures in place, the predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of sewage activities on the otter are *negligible, <1 km^2,* and *>72 months*, respectively (Table 9.5). Based on the value of these evaluation criteria, the residual effects of sewage activities on the otter VEC are *not significant* (Table 9.6).

9.6.6 Vehicle Traffic

Vehicle traffic could result in physical harm via collision to the otter, causing potentially negative effects to the otter VEC (Table 9.5). The predicted magnitude, geographic extent, and duration of these potential *reversible* (at the population level) residual effects of vehicle traffic activities on the otter are *negligible to low, 1 to 10 km^2,* and *72 months*, respectively (Table 9.5). Based on the value of these evaluation criteria, the residual effects of vehicle traffic activities on the otter VEC are *not significant* (Table 9.6).

9.6.7 Washdowns

Washdowns, if not controlled, could lead to contamination of otter habitat, causing potentially negative effects to the otter VEC (Table 9.5). Mitigations will include collection and treatment. Washdown at the wharf will be collected in sumps and pumped in a vacuum-type truck for disposal into the plant site process water.

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of washdowns activities on the otter are *negligible, <1 km^2,* and *>72 months*, respectively (Table 9.5). Based on the value of these evaluation criteria, the residual effects of washdowns activities on the otter VEC are *not significant* (Table 10.6).

9.6.8 Noise

Noise will be present throughout the Operation Phase of the Project and during every project activity. Noise originating from ship activities is likely to pose the highest potential for impact on river otters, as many of their life activities are linked to the marine environment. Up to 25 ships per year are expected to tie up at the wharf during Operations. Based upon available information, river otters will likely avoid the area of vessel operations.

Noise will result in disturbance to the otter, causing potentially negative effects to the otter VEC (Table 9.5). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of noise activities on the otter are *low, 1 to 100 km^2*, and *>72 months*, respectively (Table 9.5) Based on the value of these evaluation criteria, the residual effects of noise activities on the otter VEC are *not significant* (Table 9.6).

9.6.9 Lighting

Lighting near the shoreline will result in the potential attraction of otter prey, causing potentially *positive* effects to the otter VEC (Table 9.5). Lighting on land may result in avoidance behaviour and thus a loss of potential habitat for the otter, causing negative effects on the otter VEC (Table 9.5). The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of lighting activities on the otter are *negligible, <1 km^2,* and *>72 months*, respectively (Table 9.5) Based on the value of these evaluation criteria, the residual effects of lighting activities on the otter VEC are *not significant* (Table 9.6).

9.6.10 Maintenance

Proper maintenance is essential to keeping a facility productive. Preventive maintenance procedures and inspections procedures will include overall plant, utilities, and port facilities equipment inspections to maximize reliability and environmental protection. This will include equipment repairs, upgrades and internal/external inspections of components such as vessels, exchangers, pipes and pipelines. Maintenance operations may result in temporary disturbance to the otter, causing potentially negative effects to the otter VEC (Table 9.5).

The predicted magnitude, geographic extent, and duration of these potential *reversible* residual effects of maintenance activities on the otter are *negligible to low, 1 to 10 km^2,* and *>72 months*, respectively (Table 9.5) Based on the value of these evaluation criteria, the residual effects of maintenance activities on the otter VEC are *not significant* (Table 9.6).

9.7 Effects of Decommissioning

An overview of rehabilitation activities is provided in Volume 1. At no point are any of the Decommissioning activities expected to have greater environmental effects on the river otter than equivalent activities occurring during the Construction or Operation Phase. The potential residual effects of Decommissioning activities on the otter VEC are predicted to be *not significant*.

9.8 Cumulative Environmental Effects

9.8.1 Within-Project

The within-project cumulative effects were considered in the impact assessment of each project phase. The cumulative environmental effects are expected to be *not significant*.

9.8.2 With Other Projects

A description of other existing and proposed projects or activities is provided in Chapter 3.0 of this Volume. A cumulative effect of noise, mainly from vessel traffic, is expected to have the main effect on the otter VEC. Up to 25 ships per year are expected during the Operation Phase, representing a minor proportion of total current or planned marine traffic. The added effect of an additional 25 ships per year to the cumulative effects of noise on the otter VEC will be additive (<3%) and well within the range of historical ship traffic associated with Long Harbour), and is predicted to be *not significant*.

9.9 Summary of Effects

Although technically semi-aquatic, river otters spend a large proportion of their time in marine waters and coastal habitat relative to other members of the Mustelidae. River otter is an appropriate VEC because it is common in Placentia Bay; it breeds and feeds there, and is a top-level predator that is potentially sensitive to bioaccumulation. It can be considered as a conservative surrogate for seals in the assessment, as any effects from project activities are likely to be greater on otters than on seals. (Seals are discussed in detail in Section 2.4.7. None are known to breed in Placentia Bay, although three species may occur there at least seasonally, and very few were observed during boat-based, periodic year-round marine mammal surveys of Placentia Bay conducted by LGL as part of the proposed refinery baseline studies.) During the various phases of the Project, there are four main types of activities that may affect river otters: noise, vessels and ships, anthropogenic disturbance (loss of habitat), and contaminants.

Noise is the Project activity predicted to have the greatest potential to affect otter. Marine activities such as pile driving, dredging, and vessel traffic are the most likely activities to result in disturbance and in avoidance behaviour. On-land blasting, if performed close to the coast, could also affect the otter in its marine environment; in-air noise from blasting would also affect the otter in its freshwater or terrestrial setting. No river otter haul-out sites were found in the Project Area and with the appropriate mitigation measures in place, it is predicted that the potential residual effects of Construction, Operation, and Decommissioning activities on the otter VEC are *not significant*. Cumulative effects, within the Project and with other projects, are predicted to be additive, but *not significant*.

10.0 Species at Risk Effects Assessment

Species listed as Species at Risk (SAR) are described in detail in previous sections on terrestrial, freshwater, and marine environments, as well as specifically in a SAR background section (Section 2.5).

10.1 Existing Conditions

Species at Risk are defined broadly here to consider a variety of species that are listed under both federal and provincial lists. Individual SAR have been described under the previous sections dealing with the terrestrial, freshwater, and marine environments, but they must be assessed as a separate VEC because of their potential legal standing. Consideration is also given to the COSEWIC listings because some of these species may become listed under the federal legislation in the near future.

10.1.1 Provincial Listings

The provincial legislation that concerns SAR is the *Endangered Species Act*. Their listing as of October 6, 2006, is provided below.

Newfoundland and Labrador Endangered Species

Common Name	**Scientific Name**
American marten (Island of Newfoundland population)	*Martes americana atrata*
Barrens willow	*Salix jejuna*
Eskimo Curlew	*Numenius borealis*
Long's Braya	*Braya longii*
Low northern rockcress	*Neotorularia humilis*
Piping Plover	*Charadrius melodus*
Red Crossbill (Island of Newfoundland population)	*Loxia curvirostra percna*
Wolverine	*Gulo gulo*

Newfoundland and Labrador Threatened Species

Common Name	**Scientific Name**
Fernald's Braya	*Braya fernaldii*
Peregrine Falcon (*anatum*)	*Falco peregrinus anatum*
Peregrine Falcon (*tundra*)	*Falco peregrinus tundrius*
Porsild's Bryum	*Mielichhoferia macrocarpa*
Woodland caribou (Lac Joseph herd)	*Rangifer tarandus caribou*
Woodland caribou (Mealy Mountain herd)	*Rangifer tarandus caribou*
Woodland caribou (Red Wine herd)	*Rangifer tarandus caribou*

Newfoundland and Labrador Vulnerable Species

Common Name	Scientific Name
Banded killifish	*Fundulus diaphanus*
Barrow's Goldeneye	*Bucephala islandica*
Boreal felt lichen	*Erioderma pedicellatum*
Fernald's milk-vetch	*Astragalus robbinsii* var. *fernaldii*
Gray-cheeked Thrush	*Catharus minimus*
Harlequin Duck	*Histrionicus histrionicus*
Ivory Gull	*Pagophila eburnea*
Polar bear	*Ursus maritimus*
Short-eared Owl	*Asio flammeus*

Of the above species, only five potentially might be encountered (albeit very rarely) in the Long Harbour area:

1. Boreal felt lichen;
2. Harlequin Duck;
3. Banded killifish;
4. Red Crossbill; and
5. Peregrine Falcon.

However, of the provincially-listed, only the boreal felt lichen and the Red Crossbill have been reported in or near the Project Area (I. Goudie and B. Mactavish, LGL, pers. comm.). The boreal felt lichen is specific in its habitat requirements (I. Goudie, LGL, pers. comm.) whereas the Red Crossbill, while rare, is very widely distributed and may be seen throughout the Island of Newfoundland (B. Mactavish, LGL, pers. comm.).

10.1.2 Federal Listings

The relevant federal *Species at Risk Act* (*SARA*) Schedule 1 listing is provided below (November 3, 2006).

SARA Schedule 1 Endangered Species

Common Name	Scientific Name
Newfoundland marten	*Martes americana atrata*
Blue whale, Atlantic population	*Balaenoptera musculus*
North Atlantic right whale	*Eubalaena glacialis*
Red Crossbill, *percna* subspecies	*Loxia curvirostra percna*
Leatherback sea turtle	*Dermochelys coriacea*

SARA Schedule 1 Threatened Species

Common Name	Scientific Name
Northern wolffish	*Anarhichas denticulatus*
Spotted wolffish	*Anarhichas minor*

SARA Schedule 1 Special Concern

Common Name	Scientific Name
Fin whale, Atlantic population	*Balaenoptera physalus*
Peregrine Falcon	*Falco pereginus anatum*
Harlequin Duck, Eastern population	*Histrionicus histrionicus*
Barrow's Goldeneye	*Bucephala islandica*
Ivory Gull	*Pagophila eburnea*
Banded killifish, Newfoundland population	*Fundulus diaphanus*
Atlantic wolffish	*Anarhichas lupus*
Boreal felt lichen, Boreal population	*Erioderma pedicellatum*

Barrow's Goldeneye and Peregrine Falcon are unlikely to occur in or adjacent the Project Area. Even Common Goldeneye, a widespread nester and wintering bird is likely rare in the Project Area. Barrow's Goldeneye occurs in much lower numbers than Common Goldeneye so is extremely unlikely to ever occur in the Project Area. Peregrine Falcon migrates through Newfoundland, typically found at exposed coastal sites. The forested, relatively sheltered location of the Study Area does not offer much attraction to the Peregrine Falcon. The odds of a Peregrine Falcon using the Study Area are remote. Red Crossbill on the other hand may use the Study Area for food and potentially for breeding so is included on the list of species that could be encountered in the Study Area.

Of the above federally-listed species, only three might be encountered, in or immediately adjacent to the Project Area, albeit very rarely:

1. Boreal felt lichen,
2. Red Crossbill, and
3. Wolffishes.

Routine activities associated with the three phases of the Project have more than negligible potential to interact with only some of the Species at Risk. These species include the Red Crossbill, the boreal felt lichen, and the three wolffishes. Assessment of the potential effects of routine activities on the Species at Risk VEC in this section includes only these five species.

The other species listed above could occur in Placentia Bay, but they are considered so rare there that they were not analysed further in this assessment. Leatherbacks have been recorded in outer Placentia Bay but none were observed in the Study Area during the 2006 and 2007 baseline surveys, nor are they considered particularly sensitive to Project activities. Similarly, no blue, fin, or right whales were observed in the Study Area by LGL observers. The North Atlantic right whale (a baleen whale) is the species most susceptible to collisions with ships, but this species is very unlikely to occur in the Study Area. Ship collisions with sea turtles or whales are not anticipated to occur in the Study Area because of the few ship transits involved, the extreme rarity of the most vulnerable species to collisions, and the moderate speed of Project vessels as they enter Placentia Bay controlled lanes.

10.2 Assessment Criteria

Significant environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the Species at Risk VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EIS, a *significant* effect is defined as:

> *Having a high magnitude or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2.*

10.3 Potential Interactions

Considering that there are both terrestrial and marine representative species, the Species at Risk VEC could potentially interact with most of the routine activities associated with the Construction, Operation, and Decommissioning phases.

10.4 Issues and Concerns

The primary concerns associated with the potential interactions between routine activities of the three phases of the Project and Species at Risk include those associated with disturbance, loss of habitat, effects of atmospheric emissions and marine effluent.

10.5 Existing Knowledge

Published information on the effects of Project routine activities on marine fish is presented in Chapter 7.0. Much of this information is applicable to wolffishes. Additional relevant information pertaining to the Red Crossbill, the wolffishes, and the boreal felt lichen is presented in this section.

It is notable that no critical habitat has been identified within the Project Footprint for any of the subject Species at Risk.

10.5.1 Red Crossbill

As indicated in Chapter 2.0, the Red Crossbill is known to occur in the vicinity of Long Harbour, although this songbird species was not observed within the Project Area during baseline surveys. It may be relatively common in certain parts of the Avalon Peninsula at certain times (B. Mactavish, LGL, pers. comm.). Red Crossbills are believed to require a mosaic of cone-producing conifers for foraging, roosting and nesting (COSEWIC 2004 *in* Environment Canada 2006). Balsam fir habitat comprises over 80 per cent of the identified vegetation habitat within the Project Area but it is not unique to it; in fact, it is very common throughout the terrestrial Study Area and beyond. However, Red Crossbill habitat associations are difficult to identify and are presently unknown for *percna*. The roles that habitat loss or degradation may have played in *percna* declines and continue to play in recovery prevention are unknown. Knowledge of important habitat and seasonal use of habitat is required for proper assessment.

10.5.2 Wolffishes

Three species of wolffish (i.e., Atlantic, northern, and spotted wolffish), have potential to occur periodically in Long Harbour. Although the Atlantic wolffish is typically found in shallower areas than the other two species, a young spotted wolffish was caught near the mouth of Long Harbour during gillnet fishing for winter flounder as part of the VBNC marine baseline study. It was released unharmed.

According to the Recovery Strategy/Management Plan for these wolffishes (Kulka et al. 2007), the three species are at the center of their distributions on the northeast Newfoundland and Labrador Shelf. They distribute over a wide range of depths (20 m to >1,500 m) and are generally associated with a narrow range of bottom temperatures (1.5 to 5.0ºC). The Atlantic wolffish distributes in more shallow, southern waters (densest concentrations between 150 and 350 m) often associated with hard bottoms. The northern wolffish spends more time off bottom, but when on bottom, it tends to be at deeper locations (densest concentrations between 500 and 1,000 m) and on more diverse bottom types than the other two species. The spotted wolffish inhabits an intermediate habitat in terms of depth (densest concentrations between 200 and 750 m) and water temperature. It too inhabits a wide range of bottom types including mud, sand, small rock, and hard bottom (Kulka et al. 2007).

Three factors impede the definition of critical habitat for wolffishes: deficient knowledge of wolffish life history, limited information on the influence of multi-scale processes on wolffish population dynamics, and lack of information on acceptable targets for wolffish population abundance and range.

10.5.3 Boreal Felt Lichen (Boreal Population)

The boreal felt lichen population appears to be in serious decline throughout its range. This foliose lichen is most often found on balsam fir in cool, humid, oceanic climates. Balsam fir habitat comprises over 80 per cent of the identified vegetation habitat within the Project Area but is far from unique to it; in fact, it is common throughout the terrestrial Study Area and beyond. Acid precipitation/air pollution remains one of the most serious threats to this lichen, followed by lost and degraded critical habitat due to habitat disruption and wood harvesting. Acid precipitation is destructive to boreal felt lichen in two ways: damage to the thallus through uptake of air pollutants, particularly sulphur dioxide, and further acidification of naturally acidic substrates on which the lichen lives, thereby reducing the buffering capacity of the lichen. There is a lack of understanding of its life cycle, growth rate, life history, genetic diversity, population dynamics, and minimum viable population size (Maass and Yetman 2002 *in*

Environment Canada 2007). VBNC, in addition to conducting detailed surveys within the Project Area, has funded broader research efforts to define the status of the lichen and to identify appropriate protection and restoration measures.

10.6 Effects of Construction

Potential interactions between construction routine activities and the Species at Risk VEC are shown in Table 10.1.

10.6.1 Wolffishes

Assessment of the indicated potential interactions between the wolffishes and some of the routine activities associated with the Construction Phase is the same as the assessments of the potential interactions between marine fish and fish habitat and the same routine activities completed in Chapter 7.0. Therefore, the residual effects of Construction Phase routine activities on wolffishes are predicted to be *not significant*.

10.6.2 Red Crossbill

Earthworks

While there is no reported critical habitat for this species in the Project or Study Areas, site grubbing, excavation, grading, and leveling may nevertheless cause loss of potential habitat for the Red Crossbill, a negative effect on this songbird. Once the appropriate mitigations that will be detailed in the EPP (e.g., establishing a buffer around active nests, minimization of vegetation removal) are implemented, the predicted magnitude, geographic extent, and duration of the *reversible* residual effect of interaction between earthworks and the Red Crossbill will be *low to medium*, *11 to 100* km^2, and *37 to 72 months*, respectively (Table 10.2). The residual effects of earthworks on the Red Crossbill are *not significant* (Table 10.3).

Blasting

Blasting during the Construction Phase could result in a negative disturbance effect on the Red Crossbill in the Project Area. Once the appropriate mitigations that will be detailed in the EPP (e.g., survey of the immediate area of the blast site one hour prior to a blast) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of interaction between blasting and the Red Crossbill will be *low*, <1 km^2, and *13 to 36 months*, respectively (Table 10.2). The residual effects of blasting on the Red Crossbill are *not significant* (Table 10.3)

Table 10.1 Potential Interactions between Construction and Species at Risk VEC

Valued Ecosystem Component: Species at Risk			
Project Activity	Species/Species Group		
	Red Crossbill	Wolffishes	Boreal Felt Lichen
Construction Activities and Physical Works			
Earthworks[1]	✓	✓	✓
Wharf expansion		✓	
Dredging		✓	
Shore and scour protection		✓	
Blasting	✓		
Effluent pipeline		✓	✓
Atmospheric emissions (incl. dust)	✓	✓	✓
Roads	✓		✓
Storm system	✓		✓
Sewage system	✓		✓
Pipelines	✓		✓
Water supply dam			
Residue storage dams			
Power lines	✓		✓
Shipping			
Vehicle traffic	✓		
Sewage			✓
Solid waste			✓
Temporary power	✓		✓
Lighting	✓		
Noise	✓	✓	

Note: [1] Includes all activities involving earthworks, including grubbing, excavation, grading, and levelling.

Table 10.2 Effects Assessment of Construction on the Species at Risk VEC (Red Crossbill)

Valued Ecosystem Component: Species at Risk (Red Crossbill)								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Construction Activities and Physical Works								
Earthworks	Loss of habitat (N)	Minimize removal of vegetation	1-2	3	6	4	R	2
Blasting	Disturbance (N)	Check of immediate area	1	1	2	3	R	2
Atmospheric emissions (incl. dust)	Contamination (N) Loss of habitat (N)	Air emission controls Monitoring	1	2	6	4	R	2
Roads	Loss of habitat (N)	Minimize removal of vegetation	1	2	1	4	R	2
Storm system	Loss of habitat (N)	Minimize removal of vegetation	0-1	1	1	4	R	2
Sewage system	Loss of habitat (N)	Minimize removal of vegetation	0-1	1	1	4	R	2
Pipelines	Loss of habitat (N)	Minimize removal of vegetation	0-1	2	1	4	R	2
Power lines	Loss of habitat (N)	Minimize removal of vegetation	0-1	2	1	4	R	2
Vehicle traffic	Disturbance (N)	-	0-1	2	6	4	R	2
Temporary power	Loss of habitat (N)	Minimize removal of vegetation	0-1	1	6	4	R	2
Lighting	Disturbance (N) Attraction (?)	Minimize lighting	0-1	2	5	4	R	2
Noise	Disturbance (N)	Minimize noise	0-1	2	6	4	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 10.3 Significance of Potential Residual Environmental Effects of Construction on the Species at Risk VEC (Red Crossbill)

Valued Ecosystem Component: Species at Risk (Red Crossbill)				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Construction Activities and Physical Works				
Earthworks	NS	3	-	-
Blasting	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Roads	NS	3	-	-
Storm system	NS	3	-	-
Sewage system	NS	3	-	-
Pipelines	NS	3	-	-
Power lines	NS	3	-	-
Vehicle traffic	NS	3	-	-
Temporary power	NS	3	-	-
Lighting	NS	3	-	-
Noise	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

Atmospheric Emissions

Atmospheric emissions (including dust) produced during the Construction Phase could reduce habitat quality and result in a negative effect on the Red Crossbill in the Project Area. Once the appropriate mitigations that will be detailed in the EPP (e.g., dust suppression measures, proper equipment maintenance to reduce emissions) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of interaction between atmospheric emissions and the Red Crossbill will be *low*, *1 to 10 km^2*, and *37 to 72 months*, respectively (Table 10.2). The residual effects of atmospheric emissions during Construction Phase on the Red Crossbill are *not significant* (Table 10.3).

Roads

Site access road construction could result in a loss of potential habitat for the Red Crossbill, thereby potentially causing negative effects to the Species at Risk VEC (Table 10.2). Once the appropriate mitigations that will be detailed in the EPP (e.g., establishing a buffer around active nests, minimization of vegetation removal) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of interaction between the construction/presence of roads and the Red Crossbill will be *low*, *1 to 10* km^2, and *37 to 72 months*, respectively (Table 10.2). The residual effects of construction/presence of roads on the Red Crossbill are *not significant* (Table 10.3).

Storm and Sewage Systems

Storm and sewage system installation and operation could result in a loss of potential habitat for the Red Crossbill, thereby potentially causing negative effects on the Species at Risk VEC (Table 10.2). Storm-water within the property boundaries at Tiers 1 and 2 will be collected and treated as necessary to meet government regulations. All sewage disposal systems used during construction will comply with all health and safety regulations. All septic waste will be transported off-site and disposed in an approved disposal site by a licensed waste disposal operator.

Considering the appropriate mitigations that will be detailed in the EPP, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of interaction between the storm and sewage systems and the Red Crossbill will be *negligible to low*, *<1* km^2*, and 37 to 72 months*, respectively (Table 10.2). The residual effects of the storm and sewage systems on the Red Crossbill are *not significant* (Table 10.3).

Pipelines

Pipeline installation/presence could result in a loss of habitat for the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.2). Once the appropriate mitigations that will be detailed in the EPP (e.g., minimization of vegetation removal) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of installation and presence of pipelines on the Red Crossbill will be *negligible to low*, *1 to 10* km^2*, and 37 to 72 months*, respectively (Table 10.2). The residual effects of pipelines on the Red Crossbill are *not significant* (Table 10.3).

Power Lines

Power line installation/presence could result in a loss of habitat for the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.2). Once the appropriate mitigations that will be detailed in the EPP (e.g., minimization of vegetation removal) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of installation and presence of power lines on the Red Crossbill will be *negligible to low*, *1 to 10* km^2, and *37 to 72 months*, respectively (Table 10.2). The residual effects of power lines on the Red Crossbill are *not significant* (Table 10.3).

Vehicular Traffic

On-site vehicular traffic could result in disturbance to the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.2). However, any of these songbirds that remain within the Project Area would likely habituate to continuous traffic. The predicted magnitude, geographic extent and duration of the *reversible* residual effects of vehicular traffic on the Red Crossbill will be *negligible to low*, *1 to 10 km^2,* and *37 to 72 months*, respectively (Table 10.2). The residual effects of vehicular traffic on the Red Crossbill are *not significant* (Table 10.3).

Temporary Power

Temporary power (i.e., installation and presence of generating units) could result in loss of potential habitat for the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.2). Once the appropriate mitigations that will be detailed in the EPP (e.g., mufflers, preventive maintenance) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of temporary power on the Red Crossbill will be *negligible to low*, *<1 km^2, and 37 to 72 months*, respectively (Table 10.2). The residual effects of temporary power on the Red Crossbill are *not significant* (Table 10.3).

Lighting

Lighting in the Project Area could result in some nighttime disturbance for the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.2). Once the appropriate mitigations that will be detailed in the EPP (e.g., minimization of lighting) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of lighting on the Red Crossbill will be *negligible to low*, *1 to 10 km^2,* and *37 to 72 months*, respectively (Table 10.2). The residual effects of lighting on the Red Crossbill are *not significant* (Table 10.3).

Noise

Noise will be produced by numerous activities during Construction, potentially disturbing the Red Crossbill and causing a negative effect on the Species at Risk VEC. Considering habituation of this songbird to noise and appropriate mitigations that will be detailed in the EPP (e.g., mufflers and other noise suppression equipment), the predicted magnitude, geographic extent and duration of the *reversible* residual effects of noise on the Red Crossbill will be *negligible to low*, *1 to 10 km^2,* and *37 to 72 months*, respectively (Table 10.2). The residual effects of noise on the Red Crossbill are *not significant* (Table 10.3).

10.6.3 Boreal Felt Lichen

Site development activities have the potential to disrupt habitat for boreal felt lichen and to remove host trees. These two actions will produce a negative effect on this organism. Earthworks activities at Tier 2, linear facilities construction (roads, pipelines, and power lines), dam construction, storm drainage preparation, and ancillary activities will all act potentially to disrupt habitat and/or remove host trees within the Project footprint. In total 97 thalli were documented within the Project Area, all associated with balsam fir habitat. Most (90%) will not be directly disturbed by Construction activity.

Erioderma pedicellatum has been successfully transplanted (2 thalli) in the Lockyer's Waters study on the upper watershed of the Avondale River in 1997, and has been monitored by Dr. Christoph Sheidegger of the Swiss Federal Institute for Forest, Snow and Landscape Research, WSL, Switzerland. The findings are promising although still considered experimental. Vale Inco NL is consulting with Dr. Sheidegger regarding the feasibility of deploying transplantation in the Project Area if a potential conflict cannot be prevented through avoidance. Any decisions to consider transplanting will be undertaken in consultation with and direction from the Department of Environment and Conservation, Wildlife Division.

The predicted magnitude, geographic extent and duration of the *reversible* residual effect of interaction between Construction activities and the boreal felt lichen will be *negligible to medium*, *1 to 10* km^2 and *37 to 72 months* respectively (Table 10.4). The residual effects of Construction on the boreal felt lichen are *not significant* (Table 10.5).

10.7 Effects of Operations

Potential interactions between operational routine activities and the Species at Risk VEC are shown in Table 10.6.

10.7.1 Wolffishes

Assessment of the indicated potential interactions between the wolffishes and some of the routine activities associated with the Operation Phase is the same as the assessments of the potential interactions between marine fish and fish habitat and the same routine activities completed in Chapter 7.0. Therefore, the residual effects of Operation Phase routine activities on wolffishes are predicted to be *not significant*.

Table 10.4 Environmental Effects Assessment of Construction on the Species at Risk VEC (Boreal Felt Lichen)

Valued Ecosystem Component: Species at Risk (Boreal felt Lichen)								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Construction Activities and Physical Works								
Earthworks	Loss of habitat (N)	Minimize vegetation removal	1-2	3	6	4	R	2
Effluent pipeline	Loss of habitat (N)	Minimize vegetation removal	0-1	1	6	4	R	2
Atmospheric emissions (incl. dust)	Contamination (N) Loss of habitat (N)	Air emission control/treatment Monitoring	1	2	6	4	R	2
Roads	Loss of habitat (N)	Minimize vegetation removal	1	2	6	4	R	2
Storm system	Loss of habitat (N)	Minimize vegetation removal	0-1	1	6	4	R	2
Sewage system	Loss of habitat (N)	Minimize vegetation removal	0-1	1	6	4	R	2
Pipelines	Loss of habitat (N)	Minimize vegetation removal	0-1	2	6	4	R	2
Power lines	Loss of habitat (N)	Minimize vegetation removal	0-1	2	6	4	R	2
Sewage	Contamination (N)	Treatment	0-1	2	6	4	R	2
Solid waste	Contamination (N)	Treatment	0-1	2	6	4	R	2
Temporary power	Loss of habitat (N)	Minimize vegetation removal	0-1	1	6	4	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = $>10,000$ km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 10.5 Significance of Potential Residual Environmental Effects of Construction on the Species at Risk VEC (Boreal Felt Lichen)

Valued Ecosystem Component: Species at Risk (Boreal Felt Lichen)				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Construction Activities and Physical Works				
Earthworks	NS	3	-	-
Effluent pipeline	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Roads	NS	3	-	-
Storm system	NS	3	-	-
Sewage system	NS	3	-	-
Pipelines	NS	3	-	-
Power lines	NS	3	-	-
Sewage	NS	3	-	-
Solid waste	NS	3	-	-
Temporary power	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

Table 10.6 Potential Interactions between Operations and Species at Risk VEC

Valued Ecosystem Component: Species at Risk			
Project Activity	**Species/Species Group**		
	Red Crossbill	**Wolffishes**	**Boreal Felt Lichen**
Operational Activities and Physical Works			
Total footprint	✓		✓
Residue storage		✓	
Shipping			
Offloading			
Dust		✓	
Washdowns/runoff		✓	
Water use			
Electricity use			
Diesel use			
Fuel oil#2 use			
Atmospheric emissions (incl. dust)	✓	✓	✓
Marine effluent		✓	
Site runoff		✓	
Surge pond			
Sewage			
Solid waste			
Vehicle traffic	✓		
Noise	✓	✓	
Lighting	✓		
Maintenance	✓	✓	

10.7.2 Red Crossbill

Total Footprint

The total footprint associated with the Operation Phase will cause loss of potential habitat for the Red Crossbill, a negative effect on this songbird. Once the appropriate mitigations that will be detailed in the EPP (e.g., establishing a buffer around active nests, minimization of vegetation removal) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effect of interaction between the total footprint and the Red Crossbill will be *low to medium*, *11 to 100* km^2, and *>72 months*, respectively (Table 10.7). The residual effects of the total footprint on the Red Crossbill are *not significant* (Table 10.8).

Table 10.7 Effects Assessment of Operations on Species at Risk VEC (Red Crossbill)

Valued Ecosystem Component: Species at Risk (Red Crossbill)									
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**						
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Operational Activities and Physical Works									
Total footprint	Loss of habitat (N)	Minimization of vegetation removal	1-2	3	6	5	R	2
Atmospheric emissions (incl. dust)	Contamination (N) Loss of habitat (N)	Atmospheric emissions control system	1	3	6	5	R	2
Vehicle traffic	Disturbance (N)	-	0-1	2	6	5	R	2
Noise	Disturbance (N)	Minimization noise	1	2	6	5	R	2
Lighting	Disturbance (N) Attraction (?)	Minimization of lighting	0-1	2	5	5	R	2
Maintenance	Disturbance (N)	-	0-1	1	1	1	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 10.8 Significance of Potential Residual Environmental Effects of Operations on Species at Risk VEC (Red Crossbill)

Valued Ecosystem Component: Species at Risk (Red Crossbill)				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood[a]	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Operational Activities and Physical Works				
Total footprint	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-
Vehicle traffic	NS	3	-	-
Noise	NS	3	-	-
Lighting	NS	3	-	-
Maintenance	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

Atmospheric Emissions

Atmospheric emissions (including dust) produced during the Operation Phase could result in a negative effect on the Red Crossbill in the Project Area, primarily by affecting its preferred balsam fir habitat. Once the appropriate mitigations that will be detailed in the EPP (e.g., atmospheric emission control systems) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of interaction between atmospheric emissions and the Red Crossbill will be *low*, *11 to 100 km^2*, and *>72 months*, respectively (Table 10.7). The residual effects of atmospheric emissions during Operation Phase on the Red Crossbill are *not significant* (Table 10.8).

Vehicular Traffic

On-site vehicular traffic could result in disturbance to the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.7); however, any of these songbirds that remain within the Project Area would likely habituate to it. The predicted magnitude, geographic extent and duration of the *reversible* residual effects on the Red Crossbill will be *negligible to low*, *1 to 10 km^2*, and *>72 months*, respectively (Table 10.7). The residual effects of vehicular traffic on the Red Crossbill are *not significant* (Table 10.8).

Noise

Noise will be produced during numerous routine activities of the Operation Phase, potentially disturbing the Red Crossbill and causing a negative effect on the Species at Risk VEC. Considering habituation of this songbird to noise and appropriate mitigations that will be detailed in the EPP (e.g., noise suppression), the predicted magnitude, geographic extent and duration of the *reversible* residual effects of noise on the Red Crossbill will be *low*, *1 to 10* km^2, and *>72 months*, respectively (Table 10.7). The residual effects of noise on the Red Crossbill are *not significant* (Table 10.8).

Lighting

Lighting in the Project Area could result in some nighttime disturbance for the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.7). Once the appropriate mitigations that will be detailed in the EPP (e.g., minimization of lighting) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of lighting on the Red Crossbill will be *negligible to low*, *1 to 10* km^2, and *>72 months*, respectively (Table 10.7). The residual effects of lighting on the Red Crossbill are *not significant* (Table 10.8).

Maintenance

Periodic maintenance activities in the Project Area could result in some disturbance for the Red Crossbill, causing potentially negative effects on the Species at Risk VEC (Table 10.7). If considered from a different perspective, maintenance might also have a positive effect in that it helps to make equipment run more efficiently and to prevent accidental events. Once the appropriate mitigations that will be detailed in the EPP are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of maintenance on the Red Crossbill will be *negligible to low*, *<1* km^2, *and <1 month*, respectively (Table 10.7). The residual effects of maintenance on the Red Crossbill are *not significant* (Table 10.8).

10.7.3 Boreal Felt Lichen

Total Footprint

The total footprint associated with the Operation Phase will cause loss of potential habitat for the boreal felt lichen, a negative effect on this organism. However, the Terrestrial Environment Component Study (JWL 2007a) indicated that most of the confirmed locations of boreal felt lichen within the Project Area should not be physically disturbed by the Project footprint. Once the appropriate mitigations that will be detailed in the EPP (e.g., minimization of vegetation removal) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effect of interaction between the total footprint and the boreal felt lichen will be *low to medium*, *11 to 100* km^2, and *>72 months*, respectively (Table 10.9). The residual effects of the total footprint on the boreal felt lichen are *not significant* (Table 10.10).

Atmospheric Emissions

Atmospheric emissions arising from the Operation Phase could result in a negative effect on the boreal felt lichen in the Project Area. Effluents and emissions of substances such as sulphur dioxide arising from nickel ore processing can affect terrestrial environments, and the sensitivity of lichens in particular to atmospheric pollutants is well documented. Different lichen species exhibit differential sensitivity to specific air pollutants. As a consequence, lichens are well suited as biological indicators for monitoring environmental quality. This sensitivity to air quality stems from their reliance on airborne nutrients and water, as well as from the lack of protective layers, such as cuticles and structures such as stomates found in vascular plants. Gases are absorbed over the entire thallus surface and may readily diffuse down to the photobiont layer. Furthermore, uptake primarily involves physiochemical processes with limited biological control by lichens. Cyanolichens (those that host a blue-green bacteria as a symbiont) are particularly sensitive to acid rain, sulphur dioxide, and nitrogen oxides. This is in part because nitrogen fixation, not commonly used by other lichens but essential to cyanolichen survival, is more sensitive to acid rain than is photosynthesis (Cameron et al. 2007).

Once the appropriate mitigations that will be detailed in the EPP (e.g., atmospheric emission control systems) are implemented, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of interaction between atmospheric emissions and the boreal felt lichen will be *low to medium*, *11 to 100* km^2*, and >72 months*, respectively (Table 10.9). The residual effects of atmospheric emissions during Operation Phase on the boreal felt lichen are *not significant* (Table 10.10).

10.8 Effects of Decommissioning

Rehabilitation and Closure is anticipated to take up to two years with the exception of the residue storage pond and associated infrastructure of dams and pipeline from the pond to Long Harbour, which will be subject to ongoing environmental monitoring, inspection and maintenance for a number of years Post-closure. The following sections outline the basic elements of the proposed Rehabilitation and Closure Plan.

10.8.1 Closure

The activities associated with Closure will have a positive or negligible effect on the Species at Risk (i.e., Red Crossbill, wolffishes, and boreal felt lichen). The end result of these activities will be beneficial to the VEC as the site returns to a more natural state. Activities will include:

- Drainage and cleaning of pipeline;
- Demolition and removal of infrastructure including wharf (except phosphorus encapsulated area) and marine effluent pipeline; and
- Assessment of sediment in the area of certain facilities and implementation of appropriate measures to remediate identified contaminated areas.

Table 10.9 Effects Assessment of Operations on Species at Risk VEC (Boreal Felt Lichen)

Valued Ecosystem Component: Species at Risk (Boreal Felt Lichen)								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Operational Activities and Physical Works								
Total footprint	Loss of habitat (N)	Minimization of vegetation removal	1-2	3	6	5	R	2
Atmospheric emissions (incl. dust)	Contamination (N) Loss of habitat (N)	Atmospheric emission control system	1-2	3	6	5	R	2

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

Frequency:
1 = <11 events/yr
2 = 11-50 events/yr
3 = 51-100 events/yr
4 = 101-200 events/yr
5 = >200 events/yr
6 = continuous

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

Duration:
1 = <1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity
2 = Evidence of existing adverse effects

Table 10.10 Significance of Potential Residual Environmental Effects of Operations on Species at Risk VEC (Boreal Felt Lichen)

Valued Ecosystem Component: Species at Risk (Boreal Felt Lichen)				
Project Activity	**Significance of Predicted Residual Environmental Effects**		**Likelihood[a]**	
	Significance Rating	**Level of Confidence**	**Probability of Occurrence**	**Scientific Certainty**
Operational Activities and Physical Works				
Total footprint	NS	3	-	-
Atmospheric emissions (incl. dust)	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Only applicable to significant effect.

Mitigation measures to reduce the effect of Closure activities on Species at Risk will be detailed in the EPP but will include standard operating procedures designed to minimize impact. The predicted magnitude, geographic extent, and duration of the potential *reversible* residual effects of Closure activities on Species at Risk are *low*, *1 to 10* km^2, and *13 to 36 months*, respectively. The residual effects of Closure activities during the Decommissioning Phase on the Species at Risk VEC are *not significant*.

10.8.2 Post-closure

Post-closure activities such as the long-term monitoring, care and maintenance of the phorphorus encapsulated in the wharf, and the implementation of a monitoring program to determine the effectiveness of decommissioning will have positive (relative to previous project phases) effects on the Species at Risk VEC.

10.8.3 Mitigation

Mitigation measures for activities during the Decommissioning Phase will be described in the EPP.

10.8.4 Residual Impacts

After implementation of appropriate mitigation measures, all predicted residual environmental effects of routine activities during the Decommissioning Phase on Species at Risk are assessed *not significant*.

10.9 Cumulative Environmental Effects

10.9.1 Within-Project

The within-project cumulative effects are integrated into the effects assessment of the individual routine activities of the various phases of the Project. Since the residual effects of all routine activities with potential to interact with Species at Risk were predicted to be *not significant*, the within-project cumulative effect is also predicted to be *not significant*.

10.9.2 With Other Projects

Any added effects on the Placentia Bay ecosystem from routine activities associated with the proposed nickel processing plant at Long Harbour will likely not change the effects predictions when viewed on a cumulative basis, unless significant marine hydrocarbon or chemical spills occur. Therefore, the cumulative effect of the Project in association with the effects of other projects and activities in Placentia Bay on Species at Risk is predicted to be *not significant*.

10.10 Summary of Effects

Three wolffishes, the Red Crossbill, and the boreal felt lichen were the species considered with respect to the potential effects of Construction, Operation, and Decommissioning phases of the Project. The other Species at Risk species identified as potential occurrences in the Study Area are unlikely to be affected by the Project.

The primary issue related to the potential effects of Construction, Operation, and Decommissioning on Species at Risk is loss and/or alteration of potential habitat. The effects considered are *negligible to medium* in magnitude; most are *low*, especially with respect to habitat disruption. None of the identified habitat is critical to any of the Species at Risk, nor is there evidence of current habitat use (except for boreal felt lichen). No direct (mortality or morbidity) effects have been identified. A key concern is with respect to boreal felt lichen and the cumulative effect of a series of habitat disturbance activities in its known range. Work conducted by or on behalf of VBNC has contributed to defining the distribution of this species and its status on the Avalon Peninsula. Plans to reduce habitat disturbance and avoid the loss of host trees may be supplemented by programs to relocate boreal felt lichen thalli if operational transplants are feasible and supported by the Department of Environment and Conservation.

Overall, the residual effects of routine activities on Species at Risk are predicted to be *not significant*.

11.0 Accidental Events Effects Assessment

Accidental events can be generally categorized as spills or unplanned releases to the environment of materials such as fuel and hazardous materials, concentrate or wastewater, or the failure of engineered designs that may result in material spills or releases to the environment. Accidental events can lead to damage to the biophysical environment. The severity of effects from accidental events depends on the magnitude of the event, the location, and the time of year.

Vale Inco NL's goal will be zero accidental events. Accident prevention (as described in Volume 1, Section 9.0) is a primary goal of the Vale Inco NL Environmental Health and Safety Management System. Relevant and up-to-date EPPs and emergency response plans will be developed for each phase of the Project.

Five scenarios were selected based on the potential to cause significant environmental effects on at least one VEC, and possibly more. The five scenarios are analyzed on a VEC-by-VEC basis and effects predictions developed. Additional information is provided on accidental introductions of non-indigenous biota and accidental collisions with marine mammals.

11.1 Accidents Assessed by VEC

Accident scenarios were analysed by AMEC (2007d) for accidental spills of acid, nickel concentrate, lime and limestone, and fuel, as well as dam failures at the residue storage location. Two accidental releases of chlorine were modeled by SENES (2007c). Accidents scenarios to be assessed for individual VECs are shown in Table 11.1. These were selected to represent the "reasonable worst-case" scenarios that have the potential to affect VECs.

Table 11.1 Accident Scenarios Assessed on a VEC by VEC Basis

Accident Type	Size	Timing	Location	Rationale	Source
Marine shipping accident – loss of sulphuric acid	7,500 tonnes at 0.1 m^3/s	Spring	Placentia Bay, entrance to Long Harbour	Marine transport of sulphuric acid is the largest movement of a hazardous substance associated with the Project.	AMEC (2007d)
Shipping accident – loss of loose concentrate	30,000 tonnes at 0.1 m^3/s	Spring	Placentia Bay, entrance to Long Harbour	Loose concentrate is a worse case than packaged concentrate.	AMEC (2007d)
Shipping accident – loss of bunker C	2,180 m^3	Spring	Long Harbour	Shortest time to landfall; most potential to affect Bald Eagle concentrations	AMEC (2007d)
Large dam failure on Sandy Pond	n/a	Fall of Year 15	Residue storage pond	Worst-case residue storage scenario	AMEC (2007d)
Pipe rupture - chlorine release	59.2 kg	Spring	Tier 2, plant site	Plausible worst-case air emissions	SENES (2007c)

11.2 Effects on Air Quality

Of the five accident scenarios assessed, a large release of chlorine gas is probably the most severe and plausible worst case (Table 11.1). This is qualitatively assessed in the following section.

Air-emission concentrations resulting from the Matte Plant are slightly higher than those from the Hydromet Plant and the foregoing predictions of effects on air quality were based on the Matte scenario. However, an exception to this is an accidental chlorine release.

In the event of an emergency chlorine release, alarms in the chlorine room(s) will sound when the chlorine Threshold Limit Value (TLV) is met or exceeded. When this occurs, the ventilation rate will double and the room will be evacuated. The maximum release values for this scenario were provided by SGE Hatch.

The following elevated releases of chlorine were modeled for the Chlorine area in the Pre-leaching and Pressure Oxidative Leaching Building (0.0221 g/s), and Nickel Electrowinning Chlorine Room (0.0976 g/s).

In the event of a process upset condition, the 24-hour Ontario Ambient Air Quality Criterion for chlorine is exceeded only within the immediate vicinity of the Plant complex. Concentrations at the property boundary are four times lower. There is no Newfoundland Air Quality Standard for Cl_2.

11.3 Effects on Water Resources

The accident scenario that concerns effects on freshwater quality is dam failure (Table 11.1). The effects of a chlorine release on water quality are considered in the following section.

Predicted contaminant loadings to Sandy Brook and Long Harbour are as shown in Table 11.2 based on AMEC (2007d) groundwater modeling of a fair-weather failure of Dam #2, which would inundate a 0.76 km^2 area. Predicted peak groundwater discharge concentrations into Long Harbour and maximum concentrations during low-flow conditions in Sandy Brook are given in Table 11.3. Note that copper effects on Sandy Brook are predicted to exceed the freshwater aquatic life criteria regardless of the cleanup time frame (i.e., one, six, or 12 months). Nickel concentrations may be elevated above these criteria, depending on $CaCO_3$ concentrations in the groundwater.

The modeling showed that groundwater nickel concentrations will decrease to concentrations within the freshwater aquatic life criteria in less than four years. Copper concentrations in Sandy Brook, however, will stay above these criteria for more than five years (AMEC 2007d).

Based on peak groundwater discharge concentrations of copper into Long Harbour, the levels are within the aesthetic objective of the Guidelines for Canadian Drinking Water Quality (GCDWQ) (CCME 2006). No GCDWQ criteria are established for nickel as a contaminant.

Given the limited area of groundwater effects (<1 km), the fact that contaminant loadings on groundwater quality meet the GCDWQ, and affected freshwater habitat will be within the authorized HADD area, the residual effect of elevated nickel and copper concentrations on groundwater is predicted to be *not significant*.

Table 11.2 Model-Predicted Mass Contaminant Loadings

Parameter of Concern	Mass Loading into Sandy Brook (kg)	Mass Loading into Long Harbour (kg)	Total (kg)
Copper			
1 month cleanup	39.5	3.9	43.4
6 month cleanup	41.2	5.0	46.2
12 month cleanup	46.0	7.6	53.6
Nickel			
1 month cleanup	97.6	14.8	112.4
6 month cleanup	130.4	21.0	151.4
12 month cleanup	289.2	51.4	340.6
pH	na	na	na

Notes: na – not applicable
Source: AMEC (2007d).

Table 11.3 Model-Predicted Peak Contaminant Concentrations

Parameters of Concern	Predicted Levels in Sandy Brook (during low flow conditions)	Predicted Levels in Groundwater Discharging into Long Harbour	Background Levels in Groundwater	Guidelines for Canadian Drinking Water Quality	CEQG Marine Aquatic Life Criteria	CEQG Freshwater Aquatic Life Criteria
Copper (µg/L)						
1 month cleanup	~14	~48	4	<1,000	ne	2-4
6 month cleanup	~15.5	~48	4	<1,000	ne	2-4
12 month cleanup	~16	~54	4	<1,000	ne	2-4
Nickel (µg/L)						
1 month cleanup	~38	~145	1.7	ne	ne	25-150
6 month cleanup	~48	~180	1.7	ne	ne	25-150
12 month cleanup	~98	~600	1.7	ne	ne	25-150
pH	ne	ne	7.72-10.0 @ 4ºC	6.5-8.5	7.0-8.7	6.5-9

Notes: ne – value not established
freshwater aquatic life criteria for copper depend on water hardness
drinking water criteria are considered aesthetic objectives
Source: AMEC (2007d).

11.4 Effects on Freshwater Fish and Fish Habitat

Chlorine release and dam failure have potential to affect the freshwater fish and fish habitat VEC.

11.4.1 Chlorine Release

A potential chlorine gas release at the plant site has the potential to interact with the freshwater ecosystem. Chlorine, a gas at room temperature (Cl_2), will react with water to become hydrated (hypochlorous acid). The gas is denser than air and will therefore fill in low-lying areas and can reach streams and ponds. Although chlorine is only slightly soluble in water, even low concentrations in water can be detrimental to aquatic life (Airgas 2001). A release of chlorine near a stream or other body of water has the potential to kill fish and other aquatic life. Typical toxicity values (LC_{50}) are outlined in Table 11.4.

Table 11.4 LC_{50} Values for Various Species for Chlorine Concentrations in Water

Species	**Concentration and time to LC_{50} exceedance**
Daphnia magna – water flea	0.097 mg/L : 30 minutes
Daphnia magna – water flea	0.063 mg/L : 60 minutes
Oncorhyncus kisutsh – coho salmon	208 g/L : 60 minutes
Oncorhyncus mykiss – rainbow trout	0.08 mg/L : 168 hours
Micropterus salmoides – largemouth bass	0.74 mg/L : 24 hours

Invertebrates appear to be more sensitive to chlorine concentrations than fish species. Chlorine dissolves in water at a rate of 6.5 g of chlorine to one litre of water at ambient temperature. Water below 9.4°C can form a solid chlorine hydrate ($CL_2 \cdot 8H_2O$) called chlorine ice (Snoeyink and Jenkins 1980).

The overall effect on fish and fish habitat would depend on the release volume, the water flow at the time of the spill, the direction of the wind, and the time it takes the chlorine to dissipate in the atmosphere. If a spill occurs during the spring, the majority of the chlorine would most likely form solid chlorine hydrate that may be transported downstream to the marine environment. In addition, mean flows in Rattling Brook during April are estimated at 3.0 m^3/s (i.e., 3,000 L/s), which would be the largest seasonal flows.

If chlorine is dissolved into the stream, the dominant form below a pH of 7.5 would be hypochlorous acid (Snoeyink and Jenkins 1980). This acid is relatively weak with a pK_a of 7.5 (e.g., sulphuric acid has a pk_a of -3, acetic acid has a pk_a of 4.5 and boric acid has a pk_a of 9.3). The ranges of LC_{50} values indicate that fish species can be resilient against chlorine concentrations in water. However, the values also indicate that fish would be unable to withstand a worst-case concentration of 6.5 g/L of chlorine for more than a day. Values in Table 11.4 indicate that macroinvertebrates may be more affected than fish.

Based on the low likelihood of release of chlorine gas as a result of a pipe rupture (i.e., preventative mitigative measures), and the rapid initial dissipation of chlorine, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a chlorine gas release on freshwater fish and fish habitat are *low*, *1 to 10 km*^{2}, and *<1 month*, respectively. The residual effects of a chlorine gas release on freshwater fish and fish habitat are *not significant*.

11.4.2 Dam Failure

Dam failure at Sandy Pond would affect freshwater fish and fish habitat. However, any fish habitat losses would already be accounted in the DFO HADD determination and resulting compensation agreement, and has no further significant effect on freshwater fish and fish habitat.

11.5 Effects on Marine Fish and Fish Habitat

Five accidental events are associated with effects on the marine fish and fish habitat VEC:

1. Marine shipping accidents resulting in release of sulphuric acid to the marine environment;
2. Marine shipping accidents resulting in release of loose nickel concentrate to the marine environment;
3. Marine shipping accidents resulting in release of Bunker C oil to the marine environment;
4. A large berm failure on Sandy Pond resulting in release of residue to terrestrial and freshwater environments; and
5. A pipe rupture resulting in release of chlorine gas to the environment.

There are four primary effect pathways:

1. pH change;
2. Nickel, cobalt and copper contamination;
3. Hydrocarbon contamination; and
4. Chlorine contamination.

11.5.1 Effects of Sulphuric Acid Spill

The scenario involved in this assessment is characterized by a springtime release of 7,500 tonnes of concentrated sulphuric acid as a result of a marine shipping accident in Placentia Bay at the mouth of Long Harbour (Table 11.1).

Investigation of the effects of lowered pH on aquatic biota has focused on freshwater more so than marine (Wolff et al. 1988 *in* OSPAR 2006). Effects caused by pH changes in seawater include changes in productivity in algae (Hinga 2002) and heterotrophic microorganisms (e.g., bacteria, fungi, protozoans), altered rates of biological calcification and decalcification, and altered rates of metabolism of zooplankton, benthic invertebrates and fishes (OSPAR 2006). Lowered pH values in seawater may impair reproduction of particular marine biota (e.g., smaller eggs and delayed hatching) (Vinogradov and Komov 1985). Egg fertilization in mussels is most successful at slightly alkaline pH (Alvarado-Alvarez et al. 1996 *in* OSPAR 2006). Sperm mobility in some marine fish appears to be negatively affected by lowered pH (Ingermann et al. 2002; Alavi and Cosson 2005). Parra and Yúfera (2002) found that small fluctuations in seawater pH can cause development problems and mortality in the larvae of particular seabream and sole species.

The pH of seawater has a substantial effect on the toxicity of many compounds. Changes in pH can affect solubility, polarity, volatility, stability and speciation of a compound, thereby affecting its bioavailability as well as its toxicity (Rand 1995).

Preventative measures are the primary mitigation measures associated with the accidental release of sulphuric acid. These include:

- Compartmentalized tanker vessels;
- Designated shipping lanes;
- The Environmental Protection Plan (EPP); and
- Emergency Response and Contingency Plans (ERCP).

While an attempt was made to model the effects of an acid spill on the marine environment (AMEC 2007d) there were a number of factors which confounded this effort, including the chemical reaction of the acid with the ship hull, the effect of TSS in sea water and the interactions with sea bottom sediments. Each of these would have an important influence of the fate and effects of spilled acid; however, it was not possible to incorporate these into the model. Consequently reliance was placed on a review of empirical experience from sulphuric acid spills worldwide (Ifremer 2001; Bemvenuti et. al. 2003; EPA 2007, all as cited in AMEC 2007d). Modeling nevertheless served to provide an estimate of the spatial extent of a release. It showed that the relatively dense acid plume will descend rapidly (in minutes) as a "slug" and then more gradually disperse and dilute along the seabed.

The experience of actual spill events provides some insight into potential effects on the marine environment. Estimates of the plume size based on modeling can be compared with actual observations. The *Bahamas* spill as reported by Bemvenuti et al. (2003) was monitored for pH changes and these results showed that the actual changes in pH were far less than that predicted by the modeling. Therefore, it can be concluded that the modeled area of impact is conservative (i.e., greater than would actually be the case in a real situation).

Given the sinking behaviour of the acid plume, the major interactions would be with benthos, especially with immobile species. Least affected will be mobile animals, especially pelagic species. The spill in Brazil (Bemvenuti et. al. 2003) resulted in acute and chronic impact on benthos occurring within 500 m of the spill source. Sessile species such as blue mussels would likely suffer high mortalities within the impact zone, as would a high proportion of resident bottom fish species such as flounder. The spilled acid can be expected to become quickly neutralized and dissolved in seawater, thereby losing its acute toxicity. In the actual spills reported, the affected areas all appear to have recovered within six months.

Based on results of the study of the spill in Brazil, the *reversible* residual effects of a 7,500 tonne sulphuric acid release at the mouth of Long Harbour on the marine fish and fish habitat VEC are *low to medium*, *11 to 100 km*^{2}, and *1 to 12 months*. The residual effects of the accidental release of sulphuric acid on the marine fish and fish habitat are *not significant*.

11.5.2 Effects of Bulk Concentrate Spill

The scenario involved in this assessment is characterized by a springtime release of 30,000 tonnes of loose nickel concentrate as a result of a marine shipping accident in Placentia Bay at the mouth of Long Harbour (Table 11.1).

The level of toxicity of nickel, cobalt and copper in the marine environment is dependent on many biological, chemical and physical factors (e.g., species of marine animal, life stage of marine animal, chemical speciation of metal, water temperature, pH, etc.). The potential toxicity of these three metals with respect to marine fish and fish habitat is discussed in Chapter 7.0.

According to AMEC (2007d), the chance of a loss of loose nickel concentrate associated with this 15-year Project is low. The scenario being assessed involves the loss of 30,000 tonnes of loose nickel concentrate, a very unlikely scenario. Due to the density of the concentrate, particles would quickly fall to the ocean bottom and remain relatively stable in deep water locations such as the mouth of Long Harbour. From a long term perspective, the concentrate particles would likely remain part of the bottom sediment.

Preventative measures are the primary mitigations associated with the accidental release of bulk concentrate. These include:

- Compartmentalized tankers;
- Designated shipping lanes in Placentia Bay;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plans.

Considering these measures and the associated low likelihood of such a large release of bulk nickel concentrate, the localized nature of any accumulation of concentrate on the sea bottom, and the likely low bioavailability of the primary chemicals associated with the concentrate, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of the loss of 30,000 tonnes of loose nickel concentrate at the mouth of Long Harbour on the marine fish and fish habitat VEC are *low*, *<1 km*^{2}, and *>72 months*, respectively. The residual effects of the accidental loss of loose nickel concentrate on marine fish and fish habitat are *not significant*.

11.5.3 Effects of Oil Spill

There is a massive amount of literature devoted to the effects of various types of oil in the marine environment. A review of this material was beyond the scope of assessing a nickel processing project that will not be transporting oil in ships. During the 1970s and '80s there was a large effort on detailing the effects of oil on marine biota in the lab and in the field and some of the important works were referenced. Some more recent general references include GESAMP (1993) and NAS (2003) (oil in the marine environment); Armstrong et al. (1995), Rice et al. (1986) and Payne et al. (2003) (effects of oil on fish); and Frink and White (1990) and Khan and Ryan (1991) (effects of oil on birds). The last very large oil spill in North America was the *ExxonValdez* reported in Wells et al. (1995) and a host of follow-on papers. The reader is also referred to Buchanan et al. (2006) for a recent assessment of oil spills in the Newfoundland and Labrador offshore and NLRC (2007) for a recent assessment of oil spills in Placentia Bay.

The scenario involved in this assessment is characterized by a springtime release of 2,180 m^3 of Bunker C oil due to a shipping accident at a location between Crawley Island and southern shore of Long Harbour (Table 11.1). The primary concern related to such an accidental event is the potential impact on the proximate shallow subtidal and intertidal zones.

When discussing the potential effects of an oil spill on marine fish and fish habitat, the primary concern is with the hydrocarbons below the water surface. Crude oils are generally less toxic to marine biota than refined products, although there are exceptions. It is generally accepted that most cases of acute toxicity of a petroleum product is directly correlated to its content of soluble aromatic derivatives including benzene, naphthalene, phenanthrene, and their alkyl homologs (Moore and Dwyer 1974 *in* Neff and Anderson 1981).

Based on a considerable amount of literature, lethal effects from water soluble fractions (WSF) of petroleum and petrochemicals on the adult stages of a wide variety of marine invertebrates and fish occur in the one to 100 ppm (mg/L) range. Larval and juvenile life stages are typically more sensitive to oil pollutants with lethal concentrations in the 0.1 to 1.0 ppm (mg/L) range (Schneider 1976 *in* Neff and Anderson 1981).

Although there are data to support the idea that larval and juvenile life stages of marine invertebrates and fish are more sensitive to exposure to oil than adults, studies to date have not indicated any relationship between the phylogenetic position or habitat of any species and its relative sensitivity to oil in terms of acute effects (Neff and Anderson 1981).

The highest levels of petroleum hydrocarbons in oil-impacted marine environments are found in bottom sediments (Neff and Anderson 1981). It is therefore important to consider the biological availability of sediment-adsorbed hydrocarbons to marine biota. Hydrocarbons dissolved or dispersed in seawater are also important sources, but more so in terms of acute toxicity.

Invertebrate populations and communities form the foundation for marine ecosystems, and they are continually being subjected to stresses from both chronic and acute oil toxicity. There is wide range of invertebrate responses to exposure to oil. Impacts typically felt at the population level involve changes in abundance, age structure, population genetic structure, reproduction and reduced recruitment potential. Typical community level impacts include modified interactions between competitors, predator/prey and symbionts (Suchanek 1993).

There is a potential for transfer of hydrocarbons up the food chain in an environment subject to chronic inputs of hydrocarbons, but there is no potential for biomagnification. Individual zooplankton could be affected by a spill through mortality, sublethal effects or hydrocarbon accumulation if oil concentrations are high enough.

Eggs and larvae exposed to high concentrations of oil generally exhibit morphological malformations, genetic damage, and reduced growth. Damage to embryos may not be apparent until the larvae hatch. For example, although Atlantic cod eggs were observed to survive oiling, the hatched larvae were deformed and unable to swim (Kühnhold 1974). The natural mortality rate in fish eggs and larvae is so high that large numbers could be destroyed by anthropogenic sources before effects would be detected in an adult population (Rice 1985). Oil-related mortalities would probably not affect year-class strength unless >50 per cent of the larvae in a large proportion of the spawning area died (Rice 1985).

If exposed to oil in high enough concentrations, macroinvertebrates and fish may suffer effects ranging from direct physical effects (e.g., coating of gills and suffocation) to more subtle physiological and behavioural effects. Actual effects depend on a variety of factors such as the amount and type of oil, environmental conditions, species and life stage, lifestyle, fish condition, degree of confinement of experimental subjects, and others.

Reported behavioural effects include avoidance of contamination (Weber et al. 1981; Bohle 1986 *in* Crucil 1989) and altered natural behaviours related to predator avoidance (Pearson et al. 1984) or feeding (Christiansen and George 1995).

According to accidental release modeling (Figure 4.9 *in* AMEC 2007d), the predicted largest area of >1 per cent probability slick extent would occur in August when southwesterly winds predominate. The predicted area of >1 per cent probability slick extent is approximately 5.0 km^2. Within this area, the predicted area of five to 15 per cent probability slick extent is approximately 0.07 km^2. Results indicate a one to two per cent probability that oil would reach a two to three km stretch of shore on the south side of Long Harbour. This stretch of coastline is relatively high relief and moderately exposed. Other shorelines with a one to two per cent probability of being reached include a 0.5 km stretch of the southern shore of Crawley Island, and a similar length of shoreline on the north side of Long Harbour between Mount Arlington Heights and Long Harbour. Most of Long Harbour has at least a zero to one per cent chance of being reached by the slick. According to the modeling, St. Croix Bay appears to be less at risk in February than in August.

Preventative measures are the primary mitigations associated with the accidental release of Bunker C oil inside Long Harbour. These include:

- Training and education to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

Given the low probability of occurrence of an accidental release of Bunker C oil during the Project and the implementation of an appropriate Emergency Response Plan in the unlikely event of such a release, the residual effects of an accidental release of Bunker C oil on marine fish and fish habitat are predicted to have *low to medium* magnitude, *11 to 100* km^2 geographic extent, and a *1 to 12 month* duration. The residual effects of an accidental release of Bunker C oil on the marine fish and fish habitat VEC are *not significant*.

11.5.4 Dam Failure on Sandy Pond

The scenario involved in this assessment is characterized by a release of approximately 3.5 million m^3 of water/residue mixture from Sandy Pond as a result of a dam failure in the fall of Year 15 of the Operation Phase (Table 11.1). Released water/residue mixture would eventually reach the marine environment of the inner portion of Long Harbour and alter the marine habitat. The large volume of water/residue mixture would be expected to reach the inner Long Harbour basin within hours of a berm breach, essentially displacing the water in the basin. The liquid component of the water/residue mixture would likely be flushed from the basin to the more outer portion of Long Harbour within two to 10 days, depending on the time of year and associated freshwater flows. Much of the solid particles in the water/residue mixture would likely settle and remain in the receiving basin. Some of the solids would remain in suspension and move into the portion of Long Harbour outside of the inner basin. There is potential for the TSS from the spill to smother and/or contaminate the benthic environment. The potential for recolonization will depend on the constituency and consistency of the settled material. If it clads, it may not be suitable for infauna and the chemicals in it may discourage settlement of sessile species. Much of the chemical constituent of the water/residue mixture would likely become incorporated in the sediment and therefore be less bioavailable than chemicals soluble in sea water.

Preventative measures are the primary mitigations associated with the accidental release of water/residue mixture from Sandy Pond as a result of the large berm failure. These include:

- Selection of appropriate materials for construction of the process equipment and storage facilities;
- Strict adherence to inspection/maintenance schedule;
- Training and education for operators to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

A large dam failure from Sandy Pond would release a portion of the stored residue down gradient into the receiving environment, most likely to the former outflow of Sandy Pond. Sandy Brook downstream of Sandy Pond is assumed to fall within the DFO HADD determination. Compensation for this habitat will be required. Therefore, the nearest downstream aquatic receptor would be the marine environment of Long Harbour. The effect of the dam failure was considered *not significant* on freshwater fish and fish habitat.

Based on the unlikelihood of release of water/residue mixture to Long Harbour as a result of a large dam failure on Sandy Pond (preventative mitigative measures), the large buffering capacity of seawater, and the low bioavailability of chemical constituents of the water/residue mixture, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a large berm failure on marine fish and fish habitat are *low to medium*, *1 to 10* km^2, and *<1 month*, respectively. The residual effects of a large berm failure on marine fish and fish habitat are *not significant*.

11.5.5 Release of Chlorine Gas

The scenario involved in this assessment is characterized by a springtime release of 59.2 kg of chlorine gas due to a pipe rupture at the Tier 2 plant site (Table 11.1).

Chlorine is a highly reactive gas. It dissolves when mixed with water and subsequently reacts with other chemicals. It combines with inorganic material in water to form chloride salts, and with organic material in water to form chlorinated organic chemicals. Chlorine is especially harmful to organisms living in water. Lewis et al. (1994, 1997) reviewed the data on the toxicity of chlorine to marine organisms and found that invertebrates, especially crustaceans, exhibit the greatest sensitivity.

Chlorination studies conducted on natural and artificial seawater, have shown two phases of chlorine losses in seawater: a rapid initial loss followed by a continuous loss at a sharply reduced rate. The initial loss reaches a saturation level that varies widely between natural seawater samples and appears to be related to a true organic demand. Losses continue over 10-day periods and are pronounced in seawater containing bromine. Other studies have indicated that the loss of chlorine is associated with the bromide chemical system in seawater. The fate of the lost chlorine was not determined (http://www.speclab.com/elements/chlorine.htm).

A modeling dispersion study (SENES 2007c) indicated that chlorine air concentrations as far as 3.4 km from the release site could still exceed the level immediately dangerous to life and health (IDLH). Based on this prediction, dangerous concentrations of chlorine could potentially reach a large area of the marine system in Long Harbour, from Crawley Island to the head of the harbour. Chlorine is highly toxic to all forms of aquatic life, although there is no potential for bioaccumulation or bioconcentration. It is likely that marine biota in the upper water column would be most at risk to the deposition of chlorine gas on the seawater surface.

Considering the predicted period of time (i.e., 18 minutes) between release of the chlorine and when elevated concentrations will reach the maximum IDLH distance from the pipe rupture, preventative measures are the primary mitigations associated with such an accidental event. These include:

- Total fail safe design with isolation valves to limit any accidental release;
- Selection of appropriate materials for construction of the process equipment and storage facilities;
- Strict adherence to inspection/maintenance schedule; and
- Training and education for operators to ensure proper reaction to all possible scenarios.

Based on the low likelihood of release of chlorine gas as a result of a pipe rupture (i.e., preventative mitigative measures), and the rapid initial loss of chlorine in seawater, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a chlorine gas release on marine fish and fish habitat are *low*, *1 to 10* km^2, and *<1 month*, respectively. The residual effects of a chlorine gas release on marine fish and fish habitat are *not significant*.

11.6 Effects on Avifauna

This section will discuss the known effects of exposure to various accidental event types on avifauna, and then assess the potential effects of five accidental event scenarios on the avifauna VEC (with Great Cormorant and Bald Eagle focal species).

The effects of oil spills on marine-associated birds are well known, however, the effects of other types of accidental events have received little study. Five accidental events are associated with the assessment of effects on the avifauna VEC:

1. Marine shipping accident resulting in release of sulphuric acid to the marine environment;
2. Marine shipping accident resulting in release of loose nickel concentrate to the marine environment;
3. Marine shipping accident resulting in release of Bunker C oil to the marine environment;
4. Large berm failure on Sandy Pond resulting in release of residue to terrestrial and freshwater environments; and
5. Pipe rupture resulting in release of chlorine gas to the environment.

See Table 11.1 for size, timing, location and rationale for each of the five accidental event scenarios.

Great Cormorants, Bald Eagles and other marine-associated birds may affected directly by exposure to contaminants or indirectly via effects on their prey (primarily fish).

11.6.1 Effects of Sulphuric Acid Spill

The scenario involved in this assessment is characterized by a springtime release of 7,500 tonnes of concentrated sulphuric acid as a result of a marine shipping accident in Placentia Bay at the mouth of Long Harbour (Table 11.1).

This scenario is highly unlikely due to a number of factors, including the compartmentalization in tankers. Even if the tanker were to sink, release of sulphuric acid at the sea bottom would not be sustained at high rates for very long. A sulphuric acid spill in Brazil (Bemvenuti et al. 2003) resulted in acute and chronic effects on the benthos occurring within 500 m of the spill but the benthos appeared to recover within six months.

Preventative measures are the primary mitigations associated with the accidental release of sulphuric acid as a result of a marine incident in Placentia Bay at the mouth of Long Harbour. These include:

- Compartmentalized tanker vessels;
- Designated shipping lanes in Placentia Bay;
- Environmental Protection Plan (EPP); and
- Emergency Response and Contingency Plan (ERCP).

The sulphuric acid spill (>7,500 tonnes) in Brazil (Bemvenuti et al. 2003) appeared to recover within six months. No effects were observed at locations four km from the spill site. Typically, the acid would dissolve in seawater which has a strong neutralizing capacity, thereby reducing the impact of rapid acidification of the habitat. Such a spill may have effects on the prey of fish-eating predators over a similar total area in and near Long Harbour. The results of the literature reviews of accidents suggest that release of typical size (0.3 to 6% of the entire shipment) at the harbour entrance would have a substantial effect on pH in the inner part of Long Harbour (AMEC 2007d). A spill at the entrance in March and April may therefore directly affect the herring spawn in inner Long Harbour and indirectly have negative effects on fish-eating birds. As described in Chapter 2.0, Bald Eagles concentrate annually in the inner part of the harbour to feed on the spawning herring.

Based on the study of the spill in Brazil, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a 7,500 tonne sulphuric acid release at the mouth of Long Harbour on the avifauna VEC are *low*, *11 to 100 km*^{2}, and *1 to 12 months*, respectively. Based on the value of these evaluation criteria, the potential residual effects of accidental chemical spills in the marine environment on the avifauna VEC are *not significant*.

11.6.2 Effects of Bulk Concentrate Spill

The scenario involved in this assessment is characterized by a springtime release of 30,000 tonnes of nickel concentrate as a result of a marine shipping accident in Placentia Bay at the mouth of Long Harbour (Table 11.1).

The level of toxicity of nickel, cobalt, and copper in the marine environment is dependent on many biological, chemical, and physical factors (e.g., species of marine animal, life stage of marine animal, chemical speciation of metal, water temperature, pH, etc.). The effects of nickel, cobalt and copper are unknown in marine-associated birds in general and in cormorants and the Bald Eagle in particular (Hatch and Weseloh 1999; Buehler 2000; Hatch et al. 2000).

The scenario being assessed involves the loss of 30,000 tonnes of loose nickel concentrate, a very unlikely scenario. Due to the density of the concentrate, particles would quickly fall to the ocean bottom and remain relatively stable in deep water locations such as the mouth of Long Harbour. From a long term perspective, the concentrate particles would likely remain part of the bottom sediment.

Preventative measures are the primary mitigations associated with the accidental release of loose concentrate as a result of a marine incident in Placentia Bay at the mouth of Long Harbour. These include:

- Designated shipping lanes in Placentia Bay;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

Considering the preventative mitigations and associated low likelihood of such a large release of loose nickel concentrate, the localized nature of any accumulation of concentrate on the sea bottom, and the likely low bioavailability of the primary chemicals associated with the concentrate, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of the loss of 30,000 tonnes of loose nickel concentrate at the mouth of Long Harbour on the avifauna VEC are *low*, *<1 km*^{2}, and *>72 months*, respectively. The residual effects of the accidental loss of loose nickel concentrate on the avifauna VEC are predicted to be *not significant*.

11.6.3 Effects of Oil Spill

The scenario involved in this assessment is characterized by a springtime release of 2,180 m^3 of Bunker C oil due to a shipping accident at a location between Crawley Island and southern shore of Long Harbour (Table 11.1). The primary concern related to such an accidental event is the potential effect on the proximate shallow subtidal and intertidal zones.

It is recognized by Vale Inco NL that an oil spill at Cape St. Mary's during the breeding season (April to September) is the absolute worst-case scenario for an oil spill in Placentia Bay and could result in significant effects on seabird populations. This scenario has been analysed in several oil transportation project EAs for Placentia Bay. As a result, Vale Inco NL decided to select a scenario specific to the Long Harbour project: a spill of ship's fuel at the entrance to the harbour.

Exposure to oil causes thermal deficiencies, and in the case of diving birds buoyancy deficiencies that typically lead to death. Although some may survive these immediate effects, long-term physiological changes may eventually result in death (Ainley et al. 1981; Williams 1985; Frink and White 1990; Fry 1990). Reported effects vary with bird species, type of oil (Gorsline et al. 1981), weather conditions, time of year, and duration of the spill or blowout.

It appears that direct, long-term sublethal toxic effects on seabirds are unlikely (Hartung 1995). The extent of bioaccumulation of the chemical components of oil in birds is limited because vertebrate species are capable of metabolizing them at rates that minimize bioaccumulation (Neff 1985 *in* Hartung 1995). Birds generally excrete much of the hydrocarbons within a short time period (McEwan and Whitehead 1980). However, nesting seabirds that are contaminated with oil but still survive, generally exhibit decreased reproductive success.

Nesting seabirds transfer oil from their plumage and feet to their eggs (Albers and Szaro 1978). Very small quantities of oil (1 to 20 µl) on eggs have produced developmental defects and mortality in avian embryos of many species (Albers 1977; Albers and Szaro 1978; Hoffman 1978, 1979a; Macko and King 1980; Parnell et al. 1984; Harfenist et al. 1990). The resultant hatching and fledging success of young appears to be related to the type of oil (Hoffman 1979b; Albers and Gay 1982; Stubblefield et al. 1995) and the timing of exposure during incubation. Embryos are most sensitive to oil during the first half of incubation (Albers 1978; Leighton 1995).

Marine-associated bird species that forage by diving from a resting position on the water's surface (cormorants, Black Guillemot, murres, Atlantic Puffin, Dovekie, eiders, Long-tailed Duck, scoters, Red-breasted Merganser, and loons) are considered to be the most susceptible to the immediate effects of surface slicks (Leighton et al. 1985; Chardine 1995; Wiese and Ryan 1999). Alcids often have the highest oiling rate of seabirds recovered from beaches along the south and east coasts of the Avalon Peninsula (Wiese and Ryan 1999). Within the diving species group, murres appear to be the most affected by exposure to oil. There also appears to be a strong seasonal effect, as significantly higher proportions of alcids (along with other seabird groups) are oiled in winter versus summer (Wiese and Ryan 1999).

Other species such as Northern Fulmar, shearwaters, storm-petrels, gulls and terns are vulnerable to contact with oil because they feed over wide areas and make frequent contact with the water surface. They are also vulnerable to the disturbance and habitat damage associated with oil spill cleanup (Lock et al. 1994). The greatest decrease in use of contaminated habitats immediately following a spill occurs in species that feed on or close to shore, and that either breed along the coast or are full-year residents (Wiens et al. 1996). Oil residues in bedrock habitat like that used by most seabirds in Newfoundland do not persist as long as residues in sedimentary habitat (e.g., sand beaches) (Gilfillan et al. 1995).

Cormorants are susceptible to oiling, but in general only a small proportion of oiled birds reported are from this group (Hatch et al. 2000). Although the Bald Eagle does not pursuit-dive underwater or plunge-dive, large numbers died directly from oiling as a result of the *Exxon Valdez* oil spill in Prince

William Sound, Alaska (Bowman et al. 1993 *in* Buehler 2000). Bald Eagle productivity in Prince William Sound declined, with only 31 per cent of active nests successfully raising young and an average of 0.4 young per active nest after the spill. The population also declined. Reproduction and population size increased a few years after the spill (White et al. 1995 *in* Buehler 2000; Bernatowicz et al. 1996 *in* Buehler 2000; Murphy et al. 1997 *in* Buehler 2000).

Birds are particularly vulnerable to oil spills during nesting, and moulting, and prior to young seabirds gaining the ability to fly. Newly fledged murres and Northern Gannets are unable to fly for the first two to three weeks at sea, and are therefore less likely to avoid contact with oil during this time (Lock et al. 1994). Before and during moult, the risks of hypothermia and drowning (Erasmus and Wessels 1985) are increased because feather wear and loss reduce the ability to repel water by about 50 per cent (Stephenson 1997).

Rescue, cleaning and rehabilitation of oiled birds have been practised in several parts of the world for a number of years (Clark 1984). Considerable effort has been made to improve rehabilitation techniques (Berkner et al. 1977; Williams 1985; Frink and White 1990), and release rates of birds have generally increased (Randall et al. 1980; Williams 1985; Frink 1987).

According to accidental release modeling (Figure 4.9 *in* AMEC 2007d), the predicted largest area of >1 per cent probability slick extent would occur in August, when southwesterly winds predominate. The predicted area of >1 per cent probability slick extent is approximately five km^2. Within this area, the predicted area of five to 15 per cent probability slick extent is approximately 0.07 km^2. There is a one to two per cent probability that oil would reach a two to three kilometre stretch of shore on the south side of Long Harbour. This stretch of coastline is relatively high relief and moderately exposed. Other shorelines with a one to two per cent probability of being reached by oil include a 0.5 km stretch of the southern shore of Crawley Island, and a similar length of shoreline on the north side of Long Harbour between Mount Arlington Heights and the town of Long Harbour. Most of Long Harbour has at least a zero to one per cent chance of being reached by the slick. According to the modeling, St. Croix Bay appears to be less at risk in February than August.

As discussed above, Bald Eagles concentrate in the inner part of Long Harbour during spring to feed on spawning herring. Bald Eagles and their nests are more densely distributed in the inner part of the Bay (Chapter 2.0) and the adults presumably do most of their feeding in the same area. However, the results of the modeling suggest that probability of a slick in this scenario reaching herring spawning areas or high density eagle nesting areas is low.

Preventative measures are the primary mitigations associated with the accidental release of Bunker C oil inside Long Harbour. These include:

- Training and education to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

Given the low probability of occurrence of an accidental release of Bunker C oil during the Project, the low probability of such a slick reaching inner harbour eagle concentration areas or inner Placentia Bay nest concentration areas, and the implementation of an appropriate Emergency Response Plan in the unlikely event of such a release, the residual effects of an accidental release of Bunker C oil on marine-associated birds are predicted to have *low* magnitude, *11 to 100 km*^{2} geographic extent, and a *1 to 12 month* duration. The residual effects of an accidental release of Bunker C oil on the avifauna VEC are *not significant*.

11.6.4 Effects of Dam Failure on Sandy Pond

The scenario involved in this assessment is characterized by a release of approximately 3.5 million m^3 of water/residue mixture from Sandy Pond as a result of a dam failure in the fall of Year 15 of the Operation Phase (Table 11.1). Released water/residue mixture would eventually reach the marine environment of the inner portion of Long Harbour and alter marine habitat. The large volume of water/residue mixture would be expected to reach the inner basin within hours of a berm breach, essentially displacing the water in the basin. The liquid component of the water/residue mixture would likely be flushed from the basin to the more outer portion of Long Harbour within two to 10 days, depending on the time of year and associated freshwater flows. Much of the solid particles in the water/residue mixture would likely settle and remain in the receiving basin. Some of the solids would remain in suspension and move into the portion of Long Harbour outside of the inner basin. Much of the chemical constituent of the water/residue mixture would likely become incorporated in the sediment and therefore be less bioavailable than chemicals soluble in sea water.

Potential effects on a Sandy Pond dam failure on avifauna may include loss of a small number of individuals of potential fish prey in Sandy Brook and the inner Long Harbour basin, ingestion of toxic chemicals, and the loss of foraging habitat. In Sandy Brook, elevated concentrations of copper and suspended solid particles are predicted, which would likely kill the small fish population quickly. The effects of copper in fish consumed by cormorants, the Bald Eagle, and other marine-associated birds are unknown (Hatch and Weseloh 1999; Buehler 2000; Hatch et al. 2000). However, as discussed in the effects assessment for marine fish and fish habitat, the liquid component of the water/residue mixture would likely be flushed from the inner basin to the outer portion of Long Harbour within a few days. In addition, much of the chemical constituent, including selenium, would likely be diluted and become incorporated into the sediment and therefore be less bioavailable than chemicals soluble in sea water. Dam failure would also likely result in the loss of small areas of freshwater and marine fish habitat and may affect fish-eating birds, but would be compensated through the DFO HADD determination and would have no further significant effect on freshwater fish and fish habitat. Also, there are no known concentrations of birds in the inner Long Harbour Basin. Consequently, dam failure would be unlikely to cause acute toxicity in fish-eating birds and would not have significant effects on the foraging habitat of fish-eating birds.

Preventative measures are the primary mitigations associated with the accidental release of water/residue mixture from Sandy Pond as a result of the dam failure. These include:

- Selection of appropriate materials for construction of the process equipment and storage facilities;
- Strict adherence to inspection/maintenance schedule;
- Training and education for operators to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

Based on the low likelihood of release of water/residue mixture to Long Harbour (preventative mitigative measures), the large buffering capacity of seawater, and the low bioavailability of chemical constituents of the water/residue mixture, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a large berm failure on marine-associated bird are *low*, *1 to 10 km^2*, and *<1 month*, respectively. The residual effects of a dam failure on the avifauna VEC are *not significant*.

11.6.5 Effects of Chlorine Gas Release

The scenario involved in this assessment is characterized by a springtime release of 59.2 kg of chlorine gas due to a pipe rupture at the Tier 2 plant site (Table 11.1).

Chlorine is a highly reactive gas that dissolves when mixed with water and subsequently reacts with other chemicals. It combines with inorganic material in water to form chloride salts, and with organic material in water to form chlorinated organic chemicals. Chlorine is especially harmful to organisms living in water. Lewis et al. (1994, 1997) reviewed the data on the toxicity of chlorine to marine organisms and found that invertebrates, especially crustaceans, exhibit the greatest sensitivity. The effects of direct exposure on marine-associated birds are not known. There are few data on the effects of air emission upsets on birds, although chlorine in gaseous form is probably lethal in high enough concentrations. The modeling dispersion study (SENES 2007c) indicated that chlorine air concentrations as far as 3.4 km from the release site could still exceed the level immediately dangerous to life and health (IDLH). Based on this prediction, dangerous concentrations of chlorine could potentially reach a large portion of the marine system from Crawley Island to the head of Long Harbour. Chlorine is highly toxic to all forms of aquatic life, although there is no potential for bioaccumulation or bioconcentration. It is likely that marine biota at the surface would be most at risk to the deposition of chlorine gas on the seawater surface. Negative effects on marine fish populations of chlorine entering the marine system would have a negative effect on fish-eating birds by reducing prey availability.

Given the predicted period of time (18 minutes) between release of the chlorine and when elevated concentrations will reach the maximum IDLH distance from the pipe rupture, preventative measures are the primary mitigation measures associated with such an accidental event. These include:

- Total fail-safe design with isolation valves;
- Selection of appropriate materials, process equipment, and storage facilities;
- Strict adherence to inspection/maintenance schedule; and
- Training and education for operators to ensure proper reaction to all possible scenarios.

Based on the low likelihood of release of chlorine gas as a result of a pipe rupture (i.e., preventative mitigative measures), rapid dispersion in air, and rapid initial loss of chlorine in seawater, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a chlorine gas release on marine-associated birds are *low*, *1 to 10* km^2, and *<1 month*, respectively. The residual effects of a chlorine gas release on the avifauna VEC are *not significant*.

11.7 Effects on Otter

This EIS considers five scenarios of accident types:

1. Marine shipping accident resulting in release of sulphuric acid to the marine environment;
2. Marine shipping accident resulting in release of loose nickel concentrate to the marine environment;
3. Marine shipping accident resulting in release of Bunker C oil to the marine environment;
4. Large dam failure on Sandy Pond resulting in release of residue to terrestrial and freshwater environments; and
5. Pipe rupture resulting in release of chlorine gas to the environment.

See Table 11.1 for the details regarding size, timing, location and rationale for each of the five accidental event scenarios.

There is little information on the effects of these accidental events on river otters other than studies related to the *Exxon Valdez* oil spill (EVOS) and the effects of oiling on river otters

11.7.1 Effects of Concentrate Spill

The level of toxicity of nickel, cobalt and copper in the marine environment is dependent on many biological, chemical and physical factors (e.g., species of marine animal, life stage of marine animal, chemical speciation of metal, water temperature, pH, etc.). Chapter 9.0 discusses the potential toxicity of metals with respect to river otters. These effects would also apply to a concentrate spill; however the magnitude, area and duration would vary in accordance with the location and extent of loss.

11.7.2 Effects of Sulphuric Acid Spill

The scenario involved in this assessment is characterized by a springtime release of 7,500 tonnes of concentrated sulphuric acid as a result of a marine shipping accident in Placentia Bay at the mouth of Long Harbour (Table 11.1).

Chemical spills in the marine environment may adversely affect the otter by making habitat unsuitable and decreasing prey availability. Otter habitat use has been positively correlated with neutral pH levels, low levels of turbidity, and low nitrate concentrations (Shackleford 1995).

Preventative measures are the primary measures to take in mitigating the potential effects of a spill of sulphuric acid as a result of a marine incident in Placentia Bay at the mouth of Long Harbour. These include:

- Compartmentalized tanker vessels;
- Designated shipping lanes in Placentia Bay;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

The sulphuric acid spill in Brazil (Bemvenuti et al. 2003) resulted in acute and chronic impact on the benthos occurring within 500 m of the spill, but the area appeared to recover within six months. No effect was observed at locations four km from the spill site. Typically, the acid dissolves in seawater which has a strong neutralizing capacity. Effects on otter prey in Long Harbour are predicted to be limited to an area no greater than that affected in Brazil.

Otters are widely distributed in Placentia Bay, but little is known about the distribution of suitable and preferred otter habitat within the bay or their ability to relocate in the event of habitat contamination.

Based on reported effects of the spill in Brazil, the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a 7,500-tonne sulphuric acid release at the mouth of Long Harbour on the river otter VEC are *low to medium*, *11 to 100 km^2*, and *1 to 12 months*, respectively. The potential residual effects of accidental chemical spills in the marine environment on the otter VEC are *not significant*.

11.7.3 Effects of Oil Spill

The scenario in this assessment is characterized by a springtime release of 2,180 m^3 of Bunker C oil due to a shipping accident at a location between Crawley Island and southern shore of Long Harbour (Table 11.1).

Most research on effects of oiling on river otters has occurred as a result of the EVOS. In March 1989, 39,000 metric tons of crude oil were spilled in Prince William Sound and eventually spread along 3,500 km of coastline, including river otter habitat. Bowyer et al. (2003) provide a review and synthesis of the EVOS research on river otters and this publication is summarized below. The authors repeatedly note the difficulties in interpreting study results because of the absence of pre-spill or baseline data on many aspects of the river otter biology in the area.

Following the EVOS, beach surveys revealed 12 river otter carcasses. These animals died from acute effects of oiling. However, it does not appear that recruitment and survival were depressed after 1997 (Bowyer et al. 2003).

Ingestion of oil can happen as a result of an animal grooming its coat after swimming through an oil slick or ingesting prey that has oil in its tissues. Ormseth and Ben-David (2000) showed that river otters that ingested oil via grooming had an increased passage rate of digesta and reduced assimilation of hydrocarbons. These and other chronic physiological effects could result in a decrease in body condition of free-ranging river otters. This is supported by an observed reduction of body mass of otters at oiled vs. non-oiled sites.

River otter diet differed between oiled and non-oiled sites after the EVOS. At oiled sites, the crustacean component increased and the (preferred) fish component of the diet decreased. This change in diet may have been attributable to the lower availability of fishes or, alternatively, a reduction in the ability of otters to dive and forage as a result of exposure to oil (see Bowyer et al. 2003).

Differences in habitat selection have been demonstrated for river otters during EVOS studies. Bowyer et al. (1995) showed that otters avoided oiled beaches and that those in oiled areas selected steep tidal slopes and large rocks where oil did not accumulate for at least a year after the spill. These differences decreased seven years after the spill (potentially earlier), suggesting that river otters were recovering from deleterious effects (Bowyer et al. 2003).

According to accidental release modeling (AMEC 2007d), the predicted largest area of >1 per cent probability slick extent would occur in August, when southwesterly winds predominate. The predicted area of >1 per cent probability slick extent is approximately five km^2. Within this area, the predicted area of five to 15 per cent probability slick extent is approximately 0.07 km^2. There is a one to two per cent probability that oil would reach a two to three km stretch of shore on the southside of Long Harbour. This stretch of coastline is relatively high relief and moderately exposed. Other shorelines with a one to two per cent probability of being reached by oil include a 0.5 km stretch of the southern shore of Crawley Island, and a similar length of shoreline on the north side of Long Harbour between Mount Arlington Heights and the town of Long Harbour. Most of Long Harbour has at least a zero to one per cent chance of being reached by the slick.

Preventative measures are the primary mitigations associated with the accidental release of Bunker C oil inside Long Harbour. These measures include:

- Training and education to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plans.

Given the low probability of occurrence of an accidental release of Bunker C oil during the Project and the implementation of an appropriate Emergency Response Plan in the unlikely event of such a release, the residual effects of an accidental release of Bunker C oil on river otter are predicted to have *low to medium* magnitude, *11 to 100* km^2 geographic extent, and a *1 to 12 month* duration. The residual effects on the river otter VEC are *not significant*. In the unlikely event that a large oil spill occurs and river otters are exposed to oil, follow-up monitoring will be undertaken to compare results with the effects prediction.

11.7.4 Effects of Dam Failure on Sandy Pond

The scenario involved in this assessment is characterized by a release of approximately 3.5 million m^3 of water/residue mixture from Sandy Pond as a result of a dam failure in the fall of Year 15 of the Operation Phase (Table 11.1). Released water/residue mixture would eventually reach the marine environment of the inner portion of Long Harbour and alter marine habitat. The large volume of water/residue mixture displaces the water in the basin. The liquid component of the water/residue mixture would likely be flushed to the outer portion of Long Harbour within two to 10 days, depending on the time of year and associated freshwater flows. Much of the solid particles in the water/residue mixture would likely settle and remain in the receiving basin. Some of the solids would remain in suspension and move into the portion of Long Harbour outside of the inner basin. Much of the chemical constituent of the water/residue mixture would likely become incorporated in the sediment and thereby less bio-available than chemicals soluble in sea water.

Preventative measures are the primary mitigation associated with the accidental release of water/residue mixture from Sandy Pond as a result of the dam failure. These include:

- Selection of appropriate materials for construction of the process equipment and storage facilities;
- Strict adherence to inspection/maintenance schedule;
- Training and education for operators to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plans.

Based on the unlikely release of water/residue mixture to Long Harbour as a result of a dam failure on Sandy Pond (preventative mitigative measures), the large buffering capacity of seawater, and the low bioavailability of chemical constituents of the water/residue mixture, the predicted magnitude, geographic extent, and duration of the *reversible* effects on river otters are *low to medium*, *1 to 10 km*^{2}, and *<1 month*, respectively. The residual effects of a dam failure on river otters are *not significant*.

11.7.5 Effects of Chlorine Gas Release

The scenario involved in this assessment is characterized by a springtime release of 59.2 kg of chlorine gas due to a pipe rupture at the Tier 2 plant site (Table 11.1). There is little systematic information available for reactions of river otters to air emission upsets, including chlorine. No studies have looked at the physiological limits of river otters in relation to increased atmospheric contaminant levels. While unlikely to affect river otters at the physiological level, air emissions entering the aquatic environment may negatively affect otter prey and otter foraging habitat. A modeling dispersion study (SENES 2007c) indicated that chlorine air concentrations as far as 3.4 km from the release site could still exceed the level immediately dangerous to life and health (10 ppm; IDLH). It is uncertain how this level relates to river otter.

Chlorine is a highly reactive gas. It dissolves when mixed with water and subsequently reacts with other chemicals. It combines with inorganic material in water to form chloride salts, and with organic material in water to form chlorinated organic chemicals. Chlorine is especially harmful to organisms living in water. Lewis et al. (1994, 1997) reviewed the data on the toxicity of chlorine to marine organisms and found that invertebrates, especially crustaceans, exhibit the greatest sensitivity. It is uncertain what direct impact exposure to chlorine would have on river otter.

The predicted magnitude and geographic extent of these potential *reversible* residual effects of accidental release of chlorine gas on the otter are *low, and 1 to 100* km^2, respectively. Duration will depend upon the degree of exposure of individual animals. It is likely that very few animals, if any, would be affected by a chlorine release, because otters are not concentrated in distribution and are able to avoid noxious areas to some degree. Furthermore, high levels are not expected much outside the property boundaries. Effects on individuals could be fleeting or in an extreme case could be permanent; however, any population effect probably would be limited to less than one year. Based on the value of these evaluation criteria, the potential residual effects of accidental air emission upsets on the otter VEC are *not significant*.

11.8 Effects on Species at Risk

This section assesses the potential post-mitigation residual effects of the five accidental event scenarios on the Species at Risk VEC.

11.8.1 Effects of Sulphuric Acid Spill

The scenario involved in this assessment is characterized by a springtime release of 7,500 tonnes of concentrated sulphuric acid as a result of a marine shipping accident at the mouth of Long Harbour (Table 11.1). Species at Risk that have realistic potential to interact with an accidental release of sulphuric acid include northern, spotted and Atlantic wolffish.

Locations of occurrence of the other marine Species at Risk in the Study Area are well outside the predicted affected area.

Based on the low likelihood of a release of sulphuric acid and the results of the study of the spill in Brazil, the predicted magnitude, geographic extent, and duration of the *reversible* residual effects of a 7,500 tonne sulphuric acid release at the mouth of Long Harbour on the Species at Risk VEC are *low*, *11 to 100* km^2, and *1 to 12 months*, respectively. Based on these evaluation criteria, the residual effects of the accidental release of sulphuric acid on Species at Risk (i.e., three wolffish species) are *not significant*.

11.8.2 Effects of Concentrate Spill

The scenario involved in this assessment is characterized by a springtime release of 30,000 tonnes of loose nickel concentrate as a result of a marine shipping accident at the mouth of Long Harbour (Table 11.1). Species at Risk that have realistic potential to interact with an accidental release of loose concentrate are wolffishes. Locations of occurrence of the other marine Species at Risk in the Study Area are well outside the predicted affected area.

There is low likelihood that a release of loose nickel concentrate could negatively affect the wolffish species.

Considering the preventative mitigations and associated low likelihood of such a large release of loose nickel concentrate, the localized nature of any accumulation of concentrate on the sea bottom, and the likely low bioavailability of the primary chemicals associated with the concentrate, the predicted magnitude, geographic extent, and duration of the *reversible* residual effects of the loss of 30,000 tonnes of loose nickel concentrate at the mouth of Long Harbour on the Species at Risk (i.e., three wolffish species) are *low*, *<1 km²*, and *>72 months*, respectively. Based on the values of these evaluation criteria, the residual effects of the accidental loss of loose nickel concentrate on Species at Risk VEC (i.e., three wolffish species) are *not significant*.

11.8.3 Effects of Oil Spill

The Species at Risk that have a realistic potential to interact with an accidental release of Bunker C oil consist of the wolffishes. Locations of occurrence of the other marine Species at Risk in the Study Area are well outside the predicted affected area.

According to accidental release modeling (Figure 4.9 *in* AMEC 2007d), the predicted largest area of >1 per cent probability slick extent would occur in August, when southwesterly winds predominate. The predicted area of >1 per cent probability slick extent is approximately 5.0 km^2. Within this area, the predicted area of 5 to 15 per cent probability slick extent is approximately 0.07 km^2. There is a one to two per cent probability that oil would reach a two-to-three km stretch of shore on the south side of Long Harbour. This stretch of coastline is relatively high relief and moderately exposed. Other shorelines with a one to two per cent probability of being reached by oil include a 0.5-km stretch of the southern shore of Crawley Island, and a similar length of shoreline on the north side of Long Harbour between Mount Arlington Heights and the town of Long Harbour. Most of Long Harbour has at least a zero to one per cent chance of being reached by the slick.

Preventative actions are the primary mitigation measures associated with the accidental release of Bunker C oil inside Long Harbour. Measures include:

- Training and education to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

Given the low probability of occurrence of an accidental release of Bunker C oil during the Project and taking into account the implementation of an appropriate Emergency Response Plan, the residual effects of an accidental release of Bunker C oil on the Species at Risk (three wolffish species) are predicted to have *low to medium* magnitude, *11 to 100* km^2 geographic extent, and a *1 to 12 month* duration. Therefore, the residual effects of an accidental release of Bunker C oil on the Species at Risk VEC are *not significant*.

11.8.4 Effects of Dam Failure on Sandy Pond

Species at Risk that have some potential to interact with an accidental release of a water/residue mixture due to berm failure include the Red Crossbill and the boreal felt lichen (boreal population). Locations of occurrence of the marine Species at Risk in the Study Area are outside the predicted affected area. Wolffishes are unlikely to occur in the shallow inner portion of Long Harbour. No Red Crossbills have been observed in the Project Area although they could occur there. It is not known at this time if there are any boreal felt lichen in the potential path of a breached dam.

The primary potential effect on the Red Crossbill and boreal felt lichen would be damage to their habitat. Both the force of the released water/residue mixture and its acidic properties might cause injury to balsam fir habitat that occurs in the path of the released mixture. It is possible that thalli, if present, could be destroyed. It is not likely that individual Red Crossbill would be directly affected by the event.

Preventative measures are the primary mitigations associated with the accidental release of water/residue mixture from Sandy Pond as a result of the large berm failure. Measures include:

- Selection of appropriate materials for construction of the process equipment and storage facilities;
- Strict adherence to inspection/maintenance schedule;
- Training and education for operators to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

Based on the low likelihood of release of water/residue mixture as a result of a large berm failure on Sandy Pond (preventative mitigative measures), the predicted magnitude, geographic extent and duration of the *reversible* residual effects of a large berm failure on Species at Risk (Red Crossbill and boreal felt lichen) are *low*, *1 to 10* km^2, and *<1 month*, respectively. Considering the values of these evaluation criteria, the residual effects of a large berm failure on the Species at Risk VEC are *not significant*.

11.8.5 Effects of Chlorine Gas Release

The scenario involved in this assessment is characterized by a springtime release of 59.2 kg of chlorine gas due to a pipe rupture at the Tier 2 plant site (Table 11.1). Species at Risk that have realistic potential to interact with an accidental release of chlorine gas due to pipe rupture are:

- Red Crossbill;
- Boreal felt lichen (boreal population);
- Northern wolfish;
- Spotted wolfish; and
- Atlantic wolffish.

Chlorine is highly toxic to all forms of terrestrial and aquatic life, although there is no potential for bioaccumulation or bioconcentration. Red Crossbill and boreal felt lichen in the immediate area of a pipe rupture could be susceptible to direct (injury) and/or indirect (affected habitat) negative effects of chlorine gas release. Red Crossbill occurrence in an area is quite episodi,c so the chance of direct interaction between occasionally present birds and an unlikely accidental release of chlorine gas is low. The boreal felt lichen, on the other hand, is a permanent resident of the Project Area and would be exposed if a chlorine release occurred. No information on the effects of chlorine gas on lichen is available; however, any acidification could potentially affect the lichen to some degree. It is likely that marine biota in the upper water column would be most at risk to the deposition of chlorine gas on the seawater surface. Although unlikely to occur in Long Harbour, early wolffish life stages could be negatively affected by chlorine gas reaching the marine environment.

Considering the predicted period of time (i.e., 18 minutes) between release of the chlorine and when elevated concentrations will reach the maximum IDLH distance from the pipe rupture, preventative measures are the primary mitigations associated with such an accidental event. Measures include:

- Total fail-safe design with isolation valves to limit any accidental release;
- Selection of appropriate materials for construction of the process equipment and storage facilities;
- Strict adherence to inspection/maintenance schedule;
- Training and education for operators to ensure proper reaction to all possible scenarios;
- Environmental Protection Plan; and
- Emergency Response and Contingency Plan.

Based on the low likelihood of release of chlorine gas as a result of a pipe rupture (i.e., preventative mitigative measures), the likely relatively narrow chlorine gas plume, and the rapid initial loss of chlorine in seawater, the predicted magnitude, geographic extent, and duration of the *reversible* residual effects of a chlorine gas release on Species at Risk (Red Crossbill, boreal felt lichen, and wolffishes) are *low*, *1 to 10* km^2, and *<1 month*, respectively. Considering the values of these evaluation criteria, the residual effects of a chlorine gas release on the Species at Risk VEC are *not significant*.

12.0 Summary and Conclusions

The following sections summarize the effects of the Project on the environment as discussed in this volume. The effects of the environment on the Project are detailed in Volume 1.

12.1 Environment without the Project

The atmospheric, terrestrial, freshwater, and marine environments of the Project Area will remain as described in Volume 1 and Chapter 2.0 of this Volume 2 if the Project does not proceed.

12.2 Effects of the Project

The effects on the biophysical VECs have each been assessed with respect to all Project phases including accidents and malfunctions. As well, the cumulative effects of the Project have been considered in combination with other ongoing and planned activities in the region.

12.2.1 Mitigations

Mitigations for the Project have been detailed in Volume 1 (Project Description) and in the various VEC sections. Some of the major design features and mitigations include procedures such as careful selection and maintenance of equipment, use of dust control measures, control and containment of site runoff, use of silt and bubble curtains (where and when appropriate), adherence to DFO guidelines for environmental protection, environmental protection plans (EPP for each project phase), fish habitat compensation, and monitoring for compliance, environmental effects, and the effectiveness of habitat compensation.

Accident prevention will be a major goal. Emergency response and contingency plans will be developed to provide effective and rapid mitigation to all accidents.

12.2.2 Air Quality

Air quality will be protected during all Project phases. Modelling indicates compliance with regulatory standards and guidelines. Environmental effects associated with routine activities of the Project are not significant. An accidental release of chlorine could have a negative, albeit short duration effect on air quality and consequently on the receiving environment. Preventative measures and emergency response procedures can moderate these effects.

12.2.3 Water Resources

All phases of the Project have the potential to affect water quality. Water quantity in Rattling Brook Big Pond, a historical water supply for the phosphorus plant, would only be affected during the Operation Phase as water is withdrawn for plant processes. Adherence to a water release regime will protect fish habitat. Any plausible accidental events in the Project Area that could affect water resources can be quickly controlled, given the site layout. Thus there will be no significant effects on water resources.

12.2.4 Freshwater Fish and Fish Habitat

The Project will affect some of the local streams and ponds in the Project Area, mostly through direct habitat loss. Any loss of habitat will be addressed by a Habitat Compensation Plan, presently being developed in consultation with DFO. Any plausible accidental events in the Project Area that could affect freshwater fish or habitat can be quickly controlled, given the site layout and adherence to the EPP. Thus there will be no significant effects on freshwater fish or their habitat.

12.2.5 Marine Fish and Fish Habitat

Marine fish and fish habitat within a limited area will be affected and disturbed by the Project during the Construction Phase when the wharf is being upgraded, when dredging occurs, and when armour stones are put in place. The main effect during operations will be from marine effluent. Modeling exercises predict that any effect on water quality or sediments from the treated effluent will be localized and will not accumulate to significant levels. This prediction will be verified by effects monitoring. Decommissioning should have no effect on the marine environment unless the pipeline is removed, an activity that would result in some short term disturbance. In summary, there will be no significant effects from routine activities.

Large-scale accidental events such as a dam failure, oil spill or sulphuric acid spill have the potential to create a large negative effect on marine fish habitat in Long Harbour and potentially within neighbouring Placentia Bay. Prevention and emergency response can mitigate effects, all of which would be reversible over time to not significant levels.

12.2.6 Avifauna

Bald Eagle, a resident top-level predator, congregates in Long Harbour to feed in spring, and cormorants are resident fish-eaters common in the area. These species were used as focal species to assess effects on marine avifauna. Construction activities will disturb these species in the Project Area, but effects are small scale and reversible. There is uncertainty regarding effects on Bald Eagle feeding in spring, but they are known to habituate to human presence (e.g., common at fish plants in British Columbia), and Vale Inco NL will monitor their occurrence in Long Harbour. Modelling of the marine effluent addressed the potential for food chain effects (bioaccumulation) on cormorants. Results indicate that there will be no significant effects on cormorants (or their food supplies) and, by inference, on marine avifauna in general.

Accidental events, particularly a large oil spill, could have large negative effects on marine avifauna. However, it was predicted that a large oil spill related to this Project is very unlikely, and a prompt emergency response should keep effects below the significant level on avifauna populations.

12.2.7 Otter

River otters were used as a focal species for marine mammals as it is resident in the area, potentially sensitive to Project activities, and mostly marine in lifestyle. The main effects on river otter are those associated with noise disturbance. Some individuals will be negatively affected and may be displaced, but any effects will be reversible. Effects of routine activities were assessed as not significant, although potential exists for negative effects on the Placentia Bay population from a large oil or acid spill.

12.2.8 Species at Risk

Relevant legislation includes the federal *Species at Risk Act* and the provincial *Endangered Species Act*. Species at Risk that may interact with the Project are the boreal felt lichen, the Red Crossbill, and wolffish. All are expected to be rare in and near the Project Area, where no critical habitat has been identified for any of these species. As wolffish and the Red Crossbill are highly mobile and there is no critical or limiting habitat in the area, any effect on these species should be very limited in magnitude and geographic extent and thus not significant. All predicted effects on these species are reversible.

None of the accident scenarios are likely to create a significant effect on these populations.

Boreal felt lichen is not mobile and is present in and adjacent to the Project Area (Tier 2). Special measures will be taken to protect this species and ensure that there is minimal disturbance to its habitat. The cumulative effect of the Project in combination with other human activities that affect air quality or reduce suitable habitat is a negligible increase of effect; however, these other activities may represent a greater threat than the Project to the survival of boreal felt lichen populations in general. Vale Inco NL will institute mitigations including additional analyses to determine specific numbers in the area, avoidance of clusters, and experimental transplantation where avoidance is not possible. Effects are predicted to be not significant.

12.3 Knowledge Gaps

Vale Inco NL has conducted a wide range of studies in Placentia Bay of atmospheric, terrestrial, freshwater, marine, and human environments over the past several years. These studies have significantly increased the body of knowledge for the northeastern part of Placentia Bay. Previous environmental assessments in the area include those for Long Harbour decommissioning, the Argentia offshore supply base, and an oil transshipment terminal at Whiffen Head. The current state of knowledge is sufficient to allow thorough effects assessment.

The knowledge gaps that remain do not impair the ability to make effects predictions or to complete a thorough EIS.

12.4 Cumulative Effects Summary

The cumulative effects were all predicted to be *not significant*. Other than ship traffic, there is little overlap with other existing and proposed projects in Placentia Bay. The proposed Vale Inco NL ship traffic is within historical levels and will add only a small percentage to existing and predicted levels.

12.5 Residual Effects of the Project and Sustainability

The routine activities and physical works associated with the Construction, Operation, and Decommissioning phases of the proposed Vale Inco NL nickel processing facility at Long Harbour will have no significant residual effects on the environment.

A large-scale accidental event could affect selected marine VECs depending upon amounts, timing, and location. Terrestrial or freshwater VECs would likely be less affected because prevention and clean-up are more controllable in these environments. Effects of large spills would likely be reversible at the population level. A large spill of concentrate could generate effects over the long term, but the concentrate would be expected to be relatively immobile physically, chemically, and biologically.

Approval of the Project will not prevent future generations from using the biophysical resources of the Study Areas.

12.6 Environmental Monitoring and Follow-up

Three types of monitoring are applicable to the Project:

1. Compliance monitoring that is required by legislation (e.g., monitoring of the marine effluent to comply with provincial *Water and Sewer Regulations)*;
2. Environmental effects monitoring (EEM) that may conducted to verify predictions made in the EIS where there are particular concerns, uncertainties, and/or potential for significant effects; and
3. Fish habitat compensation monitoring.

12.6.1 Compliance Monitoring

Vale Inco NL will conduct compliance monitoring of the marine effluent and air emissions according to applicable legislation.

12.6.2 Effects Monitoring

Vale Inco NL will design an effects monitoring program (including study design, numbers of replicates, sample locations, sampling frequency, and laboratory analysis standards) in consultation with DFO, Environment Canada, and the Department of Environment and Conservation. This program, as a minimum, will include the following:

- Water and sediment quality (freshwater);
- Water and sediment quality (marine);
- Fish and fish habitat;
- Cultured blue mussels (metals);
- Winter flounder;
- Boreal felt lichen; and
- Top-level predator (metal body burden).

12.6.3 Fish Habitat Compensation Monitoring

Vale Inco NL will monitor the effectiveness of the fish habitat compensation works in both freshwater and marine environments.