5019 – 52nd Street
Yellowknife, NT – X1A 1T5

VIA EMAIL

Chuck Hubert
Senior Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
PO Box 2130
Yellowknife, NT X1A 2P6

RE: Federal Response to Technical Session Undertakings for Canadian Zinc All Seasons Road Environmental Assessment

Dear Mr. Hubert,

The Canadian Northern Economic Development Agency's Northern Projects Management Office is pleased to provide the attached responses to technical session undertakings from the Canadian Zinc Corporation's All Season Road environmental assessment ("EA") on behalf of federal departments that are party to this EA.

The Government of Canada looks forward to continued participation in this environmental assessment.

Sincerely,

Adrian Paradis
Senior Project Manager
Northern Projects Management Office

Attachments: (1) Fisheries and Oceans Canada Undertaking Response
(2) Environment and Climate Change Canada Undertaking Response
(3) Parks Canada Agency Undertaking Response

Parks Canada Response to EA1415-01 Technical Session Undertakings

June 30, 2015

Undertaking Number	Submission to the Mackenzie Valley Environmental Impact Review Board
2	Parks Canada met with Canadian Zinc on June 28, 2016. Canadian Zinc provided a meeting summary to Parks Canada for Review prior to submission to the Board. The Parks Canada Vegetation Specialist is currently in the field and will not be able to review the document until her return. The response to Undertaking 2 will be provided to the Review Board no later than July 11, 2016.
7	Parks Canada met with Fisheries and Oceans and Canadian Zinc on June 28, 2016. Canadian Zinc to provide meeting information to the Board.
8	Undertaking changed to a commitment
10	Nahanni ELC for Prairie Creek EA-Output and Nahanni_Prairie Creek_Access_Road_Buffers_Shapefiles. Attached.
15	The Parks Canada Wildlife Specialist is currently in the field and unable to review the Parks Canada submission for this Undertaking until his return. The response to Undertaking 15 will be submitted to the Review Board no later than July 11, 2016.
16	Parks Canada Response to Undertaking 16. Attached.
18	PCA Response to Undertaking 18. Attached.
34	Postscript to the McMaster University Report 1974 on the Nahanni North Karst. Attached.

Parks Canada Response to Undertaking 18

Parks Canada will provide information on what is important with respect to restoring natural drainage patterns at closure and why.

Preamble

Under the *Canada National Parks Act*, Parks Canada is responsible on behalf of the people of Canada for the protection and presentation of nationally significant examples of Canada's natural and cultural heritage and to foster public understanding, appreciation and enjoyment in ways that ensure their ecological and commemorative integrity for present and future generations.

The first priority in Parks Canada's mandate is to protect ecological integrity. According to the *Canada National Parks Act*, "ecological integrity" means, with respect to a park, a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes. In other words, Parks Canada is tasked with maintaining all of the naturally occurring species and communities, and the processes that sustain them.

Importance of restoring natural drainage patterns at closure

The restoration of natural drainage, following disturbance of soils and shallow ground materials resulting from construction of the road and associated infrastructure, is required to restore ecological integrity. When reclaimed effectively, reclaimed areas approximate those of natural areas or are on a restoration trajectory that through time will result in areas approximating natural areas. Ensuring that reclaimed areas include natural patterns of drainage is crucial to effective restoration. Changes to drainage patterns can alter water quality, temperature and flow affecting habitat for species. Fine scale water features are integral to moving water across the landscape. The maintenance natural drainage patterns reduces the potential for changes to species at risk habitat for species such as yellow rail, and rusty blackbird. The Management Plan for Yellow Rail in Canada identifies changes to hydrology as a threat to yellow rail populations (Environment Canada, 2013).

Alterations to hydrology, including activities such as damming, draining wetlands, dredging, channelizing, and creation of impoundments, can threaten habitat at all stages of the life cycle, even when they occur away from Yellow Rail site

Rusty blackbird nest in riparian vegetation associated with wetland shores, slow moving streams, marshes and beaver ponds. Fish, aquatic insects, snails and crustacean provide food for rusty blackbird (Species at Risk Registry). Changes in hydrology can reduce available nesting habitat and decrease food sources for rusty blackbird.

The *Principles Guidelines for Ecosystem Restoration in Canada's Protected Areas* (Parks Canada and the Canadian Parks Council, 2008) provide direction for ecological restoration in National Parks. The Guidelines describe effective ecosystem restoration as follows[1]:

- *Restores the natural ecosystem's structure, function, composition and dynamics (e.g. perturbations, retrogressive or progressive succession) within the constraints imposed by medium to long-term changes.*

- *Strives to ensure ecosystem resilience over time.*
- *Endeavors to increase natural capital.*

Importance of restoring drainage patterns for permafrost and vegetation
Ineffective drainage can lead to ponding and subsequent degradation of permafrost which alters vegetation communities (Cameron, 2015) and can change wildlife use of habitat. Cameron (2015) reported that spruce muskeg vegetation adjacent to the original Prairie Creek Winter Road established in the early 1980s shifted to sedge wetlands as a result of permafrost thaw and increased soil moisture. Maintenance of natural drainage reduces the likelihood of water ponding, thaw of permafrost and shifts in the structure and function of vegetation communities.

Importance of restoring drainage patterns to manage sediment and erosion
Natural drainages have often developed over long periods of time. Changes in natural drainage patterns can increase the transport of sediment into watercourses, as runoff moves from development areas (e.g. roads, borrow sources, camps). In the absence of access to established small, fine scale features, water will either pond or develop new drainage channels. The gradient and composition of subgrade materials (e.g., composition of different size fractions of rock materials) of the local area will influence the development of these channels, influence the infiltration rate of these channels, and the transport of sediment to watercourses or water bodies. Increased sediment loading in watercourses or water bodies can alter riparian and instream habitats, and result in negative impacts on fish populations and communities through both direct and indirect effect pathways. Habitat may be altered through changes in structure and composition of vegetation, water flows may increase or decrease through a particular area changing habitat for invertebrates, birds, wildlife and fish.

Significance of Impacts
These effects described above are of significant import to Parks Canada Agency because they can lead to permanent changes in the ecosystem altering the structure (e.g., species present and impacting local population dynamics) and function of the ecosystem (i.e. the ability to support diverse, robust populations over the long term). The maintenance of natural drainage through all project phases will reduce the potential impacts associated with ponding, and changes in hydrology in the project area.

Restoration of natural drainage requires small scale features to maintain natural flow rates, water quality, temperature and infiltration, consistent with existing gradients, sub-bed and retention of existing aquatic habitat in the project area.

References

Cameron, E. A. (2015). Ecological impacts of roads in Canada's north. Ecological impacts of roads in Canada's north. Master of Science thesis, School of Environmental Studies, University of Victoria, Victoria, British Columbia.

Parks Canada and the Canadian Parks Council. (2008). *Principles, guidelines for ecosystem restoration in Canada's protected areas.* Report compiled by National Parks Directorate and Parks Canada Agency, Gatineau, Quebec.

Environment Canada. 2013. Management Plan for the Yellow Rail (*Coturnicops noveboracensis*) in Canada. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa. P10.

http://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=907#ot18

Undertaking #16

CanZinc will provide information on areas of sensitive wildlife and vegetation by road segment (including alternative segments and distinct borrow locations) in order to allow a risk assessment to account for these in terms of consequences from a spill. Parks Canada will provide any additional existing and known information to support this undertaking.

Without the appropriate level of baseline information on wildlife and vegetation it is impossible for Parks Canada to identify all areas adjacent to the all season road that would be most sensitive to a spill. In the absence of detailed and up to date baseline information, we have used existing knowledge to identify four reaches along the all season road that we know are of high biological value and likely highly sensitive to spills:

- The areas of Karst Terrain (approximately km 53-64). Spills in this area could be extremely difficult to contain and clean up with the extensive underground drainage.
- The Tetcela (~ km 84) and Fishtrap (~km 95) drainages. These areas are sensitive due to easy transport of any spill and are also part of a 'Key Migratory Bird Terrestrial Habitat Site' (NWT #17 – Southeastern Mackenzie Mountains; Latour et al. 2008)[1]. There is the potential for both Swan breeding and the presence of Yellow Rail, but not surveyed.
- Sundog Creek between km 25 and km 32 has an Arctic Grayling population which is greatly restricted in seasonal movements, as there is a waterfall above, and the creek below flows underground for much of the year. A serious spill in this area could potentially wipe out the entire local population.
- A spill between km17-40 may also have downstream impacts on a resident caribou population.

[1] Latour, P.B., J. Leger, J.E. Hines, M. Mallory, D.L. Mulders, H.G. Gilchrist, P.A. Smith, and D.L. Dickson. 2008. Key migratory bird terrestrial habitat sites in the Northwest Territories and Nunavut. Third Ed. Canadian Wildlife Service Occasional Paper No. 114.

POSTSCRIPT TO THE MCMASTER UNIVERSITY 1974 REPORT ON THE NAHANNI NORTH KARST

5 November 2001

Introduction

It is now 27 years since George Brook and I prepared the McMaster University report of 1974 on the North Karst region. During that time the importance of karst has come to be recognised worldwide. The number of researchers has increased approximately tenfold, many books and some hundreds of scientific papers are published annually. Particularly important has been the opening up to western visitors of China, which has the greatest tropical and temperate karstlands, and of Russia, the only nation besides Canada with large expanses of karst rocks in sub-arctic and arctic settings. I have had the opportunity of travelling, studying and consulting extensively in both of those countries, including parts of the northern Russian and Siberian terrains. I have also conducted or directed karst research projects throughout Canada, the U.S.A, Caribbean, Mexico, Brazil, most European nations, Turkey, Iran, Malaysia, Australia and New Zealand.

The purpose of this Postscript is to comment upon the North Karst from the perspective granted by this worldwide experience, evaluating its features in comparison with those seen at other places. Numbers (e.g. #33) cited below refer to numbered geographic locations placed on 1:50,000 topographic maps covering this area during a meeting with Claude Mondor, Parks Canada, that took place in Ottawa on November 1 2001.

Karst drainage basins as basic areal units for conservation and control.

The distinctive groundwater hydrology of karst terrains has become the most important subfield within global karst research today. This is because of its immense applied importance – more than one billion people are partly to entirely dependent on water stored in natural karst cavities.

From the management and conservation perspective there are two particularly important differences between karst aquifers and others. The first is that karst waters are collected and discharged through well integrated systems of solutionally enlarged fissures and caves. The waters flow underground tens to thousands of times more rapidly than they do in aquifers in insoluble rocks or in unconsolidated sands, gravels, etc. One consequence is that hazardous contaminants can spread quickly and with negligible degradation in karst aquifers. For example, in the Walkerton, Ontario, disaster of May 2000, lethal concentrations of *E.colii* are believed to have traveled from source to groundwater well within 48 hours via karst cavities, whereas in a standard insoluble rock aquifer with the same hydraulic gradients travel time would have been ~120 days: the *E. coli* bacterium decomposes after about 30 days underground. Because of the very responsive, fragile character of karstic aquifers, karst hydrogeologists throughout the world are now agreed that the basic areal unit for aquifer management should be the entire karst drainage basin and, where there are tributary streams draining into it from non-karst rocks, those tributary basins also. In the Nahanni North Karst context, this implies that all terrain draining to the two principal springs, Bubbling Springs (map ref #19, SW flank of Ram Plateau) and White Spray (First Canyon) should be included within the expanded Park.

The second important difference between karstic and other groundwater basins is that, very often, the boundaries of karst basins do not coincide with topographic divides. If a divide is in karst rock such as the limestone and dolostone of Nahanni, water may pass underneath it via solutional caves. For example, at many places in Crowsnest Pass water sinks underground on the B.C side of the Continental Divide and resurges at springs in Alberta. To establish the precise limits of karst groundwater basins requires substantial programmes of groundwater tracing with special dyes which, in the Nahanni case, would be a very expensive undertaking. However, basin boundaries can often be reasonably approximated by considering the combination of local topography, structural geology, karst spring responses to heavy rains, and the findings of partial tracing programmes. I consider that the boundaries for groundwater drainage to Bubbling Springs and White Spray that were set out in the 1974 McMaster report are of sufficient accuracy for general planning purposes. Most of the sigificant landforms in the North Karst are within these boundaries. The exceptions are two karst canyons on the SW side of Ram Plateau, which will also be protected if the Plateau is included in the Park expansion.

The distinctiveness of the North Karst drainage, caves and surface landforms.

Here I evaluate both (a) individual landforms such as particular sinkholes and (b) genetic groupings of features in a given area within the North Karst, for example, Cenote Col and its sinkholes. They are placed within the following three categories of distinction:-

(1) common or unexceptional features by world standards;
(2) outstandingly good examples of features that are common to rare elsewhere, i.e. "textbook examples".
(3) Unique - no features as good as these (or closely similar) are known to me or clearly described in the literature elsewhere.

<u>The Karst Basin Hydrogeologic Organisation.</u>

I give this a Category 2 "textbook example" rating for its simplicity and elegance. The North Karst is developed in 200 m of limestones and ~1000 m of dolostones underlying them. The dolostone is much less soluble here and does not display good karst landforms or (at the current level of exploration) caves of enterable size. However, it does drain karstically, via caves that are probably too small for human entry. The limestone is overlain by >80 m of black shales which are impermeable and serve as a roof prohibiting lengthy groundwater flow paths underneath them.

The beauty of the pattern of underground drainage here is that it is organised to flow to just two principal springs, at the northern and southern extremities of the karst belt respectively; (there are some much smaller springs within the karst where flow emerges, only to sink underground again after short distances and join the flow to the principals). In the North, Bubblings Springs are compelled to rise where they do because immediately to the N of them the limestone passes underneath the shale roof, which is dipping down under Sundog Creek. This spring is thus at the stratigraphic top of the karst strata. In contrast, the South spring, White Spray, is at the deepest point that South Nahanni River is entrenched into the dolostone in the eastern half of First Canyon. This is approximately 450 m below the top of the dolostone or 650 m below the shale roof. At the current stage of River entrenchment, there is no stratigraphically lower point at which the water could resurge to the open surface: (it probably emerged a few tens of metres lower at the White Spray position in the past but was raised when the Canyon was aggraded by glacial lake sediments).

The basic hydrogeologic organisation here is thus:- one North spring at the stratigraphic upper limit for spring emergence; one South spring at the topo-stratigraphic lower limit for spring emergence. Such simple organisation is very rare, especially over such a large area of underground drainage, and serves as an excellent teaching example.

The Caves.

Grotte Valerie (First Canyon, already in the Park) has classic dendritic passage organisation and Category 2 morphology. Recent developments in U series speleothem dating (a McMaster specialty) lead me to hope that we can now date the main phases of speleothem deposition in the cave, which I believe lie just beyond the 400,000 years B.P. range of older techniques; we shall use samples collected in 1973. This will make a major contribution to understanding the Ice Ages in Canada. This cave is quite the best example of cold cave climate diversity that is known anywhere in the world. I have wowed audiences in many countries with illustrations of it - an emphatic Category 3 rating!

The Grotte Louise- Grotte Mickey cave complex on the First Canyon/Lafferty Creek shoulder has been very well studied by Professor Jacques Schroeder, Universite de Quebec a Montreal. It is a multi-level (-sequence) system of a fairly common type but with a wealth of unusual sedimentary fills analysed by Schroeder – Category 2.

Grotte Andre (map ref# 39) lies just outside the present Park boundary. Its morphological features are similar to those of Grotte Valerie but less diversified. It contains a substantial spread of large hexagonal ice crystals that are perennial (and very fragile). Fewer than 20 other ice crystal caves of this type are known - Category 2.

Igloo Cave and other, shorter caves discovered in the North Karst and mapped and described in the 1974 report are not so remarkable - Category 1. I have seen many similar caves in north Norway, Russia, the Alps and Canadian Rockies. However, it must be pointed out that our explorations there in the summers of 1972 and 1973 were incomplete, due to lack of time, money and people. Hard campaigns using new types of equipment developed since 1973 would undoubtedly extend the discoveries. In particular we were never able to locate and penetrate the large caves with rivers flowing in them that must exist under the karst.

The Limestone Pavements.

These are extensive surfaces indented with karren, the smallest scale solution features found in surface karst. Pit and gutter forms are most common. Pavements are common where glacial scour removes rubble, as in the North Karst. Because they are very quickly drained, distinctive droughty ecological assemblages may be found on them – "alvars".

Development on the Nahanni pavements is quite limited due to severe cold, similar to many areas on the northern Russian Platform - Category 1. Pavements in Newfoundland, Quebec, Ontario and Manitoba are more significant from the morphologic perspective. The alvar ecology may be more interesting because of cold climate limitations, especially if it includes the type of laminated algal calcites recently discovered in an Old Crow karst by Professors Lauriol and Clark, University of Ottawa.

The Karst Canyons.

These are regular canyons entrenched by surface rivers that now lose most or all of their flow into sinkholes feeding cave systems. Such canyons are common in most mountain karst terrains in arctic and alpine, temperate and tropical environments. The many examples in the North Karst, from Lafferty Canyon in the south to Ram Plateau (#17, 18) in the north are all morphologically attractive. I would single out Lafferty for an example where underground capture of the water is still at a quite early stage – there is surface overflow and renewed river entrenchment during heavy rains several times each summer season although for 340+ days (?) of the year there is 100% abstraction underground. Its morphological change from an open v-form cross-section upstream in dolostone where the limestone has been stripped off to a narrow slot with vertical walls where the limestone is fully preserved at the downstream end is striking. It is a Category 2 feature, fully comparable to the famous limestone gorges of the Tarn and Lot in the Perigord district of France in my opinion.

Canal Canyon (#35) has the largest catchment of the Nahanni dry canyons. Its downstream sector and mouth are fully impounded by glacial sediments. All drainage passes underground, probably passing under the south wall to flow to White Spray spring. Its form, glacial and periglacial deposits are all most attractive, adding up to a unique assemblage – Category 3.

The Impounded Lakes.

These features (#28-31) originated as shallow box canyons that became impounded by glacial deposition at their mouths, creating lakes that developed karstic drainage into the canyon walls. It is believed that all of them discharge into the groundwater system supplying Bubbling Springs but there has been no definitive dye trace experiment to show this.

There are similar features at a few places in the Rockies and further north in the Franklin and Mackenzie Mountains around Norman Wells, and in the European Alps, etc. – Category 1.

Sinkholes.

There are two major types in the North Karst – very steep-walled sinkholes of mixed solution and collapse origin in limestone (including the large, squared "platea" of our 1974 report), and covered karst or suffosion sinkholes developed in thin veneers of the shale or of glacial sediments resting on the limestone.

Sinkholes are the diagnostic surface karst landform. I have seen thousands of striking examples in many different parts of the globe. Those in the North Karst are by no means the largest, deepest or most dynamic known to me but their morphologic form is always very clearcut. Many are Category 2.

The Raven Lake sinkhole (#23) with its large size, elegant elliptical form, depth and verticality, flanking cols and caves, and 70+ m oscillation of water level during the hydrologic year, adds up to an assemblage that is unique in my experience – another emphatic Category 3. The same is true of Cenote Col and its sinkholes (see 1974 report).

The Karst Labyrinth.

The main labyrinth lies between First Polje (#22) and Insel Tower (#25) in the North Karst. It includes the principal karst solution corridors or bogaz (termed "streets" in the 1974 report because of some features unknown in other corridor karst areas at the time), the Raven Lake, Cenote Col and other sinkhole groups. The individual corridors are not exceptionally long or deep by world standards but their assemblage and genetic association with the sinkholes and platea are unique in my experience. No other karst I have visited (including glaciated karst lands in Russia and in many alpine regions) displays such a rich variety and complexity of form and origin. There is a problematic relationship with glacial scabland formation that we did not fully resolve in our work and which is of great interest to geomorphologists. I note with pleasure that adventure outfitters have recently discovered the Labyrinth and are conducting walking tours in it. It is another Category 3 assemblage.

The Poljes.

In karst studies, a polje (a Serbo-Croat word meaning "field") describes a flat-floored closed depression that is seasonally inundated. The flat surface may be due to corrosion operating along the sides of the depression to widen it, or to alluvial deposition. A combination of the two processes is common. The greatest poljes are found in former Yugoslavia where some are several hundred square kilometres in area.

The three North Karst poljes are all very small by world standards but are textbook examples of the morphology and hydrologic behaviour of these landforms. Together they constitute an ideal sample of polje types and form – Category 2 individually, Category 3 as an assemblage that can be easily viewed in one day's walking.

First Polje is created by a shallow and symmetrical downfolding (syncline) in the stratigraphic top of the limestone. I have never seen a better example of this most simple kind of structural ("tectonic") polje.

Second Polje is exceptional because of its dissolutional benching and sharply defined high water line that is controlled by an overflow cave in its north wall, and by the dissection of its eastern (downstream) wall by drainage from the adjacent shale slopes.

Third Polje lies immediately south of Bubbling Springs. At low water its residual pond drains away at its south end and (presumably) the water flows back northwards underneath it in a cave. In high water it backs up progressively northwards at the surface until it is able to overspill as a short creek that submerges the Springs themselves. This is a unique pattern of behaviour in polje hydrology. The dissolutional notch or undercut at the high water level is the best I have seen in any polje.

Conclusion.

In the past 25 years I have studied karst in all the provinces and territories except PEI (which hasn't any) and Yukon. The Nahanni North Karst is the most striking and interesting karst terrain of them all. It exhibits many features and assemblages that I judge to be unique at the world scale. It is most strongly recommended that it be incorporated in its hydrologic entirety into South Nahanni National Park in order to preserve it and to advertise it to Canadians and the world.

Derek Ford, DPhil., FRSC,
Emeritus Professor of Geography and Geology, McMaster University.
Adjunct Professorof Hydrogeology, University of Waterloo.

B) Large Area

Value	Name	Nahanni_ROW_160422_Large				Nahanni_ROW_150224_Large			
		Count	Sq.m	Hectares	Percent	Count	Sq.m	Hectares	Percent
1	Alpine Herb Tundra and Meadow	1766	176600	17.66	1.23	1802	180200	18.02	1.25
3	Terrain or cloud shadow / Water	5249	524900	52.49	3.65	5118	511800	51.18	3.55
4	Subalpine Tall Shrub	112	11200	1.12	0.08	112	11200	1.12	0.08
7	Low Sparse Shrub	9729	972900	97.29	6.77	9669	966900	96.69	6.71
8	Rock - Lichen	13714	1371400	137.14	9.54	14062	1406200	140.62	9.76
9	Rock	3533	353300	35.33	2.46	3532	353200	35.32	2.45
10	Mixed Predominantly Coniferous Forest	24334	2433400	243.34	16.94	24371	2437100	243.71	16.92
12	Medium - Low Shrub	11731	1173100	117.31	8.16	11733	1173300	117.33	8.15
13	Coniferous Forest	27276	2727600	272.76	18.98	27635	2763500	276.35	19.19
14	Subalpine Coniferous Woodland	240	24000	2.4	0.17	240	24000	2.4	0.17
15	Subalpine Shrub – Sparse Trees	1237	123700	12.37	0.86	1221	122100	12.21	0.85
16	Spruce – Lichen Woodland	2028	202800	20.28	1.41	1999	199900	19.99	1.39
17	Spruce – Lichen- Moss Woodland	17425	1742500	174.25	12.13	16462	1646200	164.62	11.43
18	Wetland	1716	171600	17.16	1.19	1716	171600	17.16	1.19
19	Alluvial non-vegetated	286	28600	2.86	0.20	316	31600	3.16	0.22
23	Deciduous Forest / Tall Shrub	6907	690700	69.07	4.81	7170	717000	71.7	4.98
24	Mixed Predominantly Deciduous Forest / Tall Shrub	9661	966100	96.61	6.72	9792	979200	97.92	6.80
25	Recently Burnt	2681	268100	26.81	1.87	2794	279400	27.94	1.94
22	Water / Terrain shadow	15	1500	0.15	0.01	16	1600	0.16	0.01
28	Permanent Water	844	84400	8.44	0.59	844	84400	8.44	0.59
29	Intermitent Water	2296	229600	22.96	1.60	2528	252800	25.28	1.76
26	Ice / Snow	904	90400	9.04	0.63	909	90900	9.09	0.63
	TOTAL	143684	14368400	1436.84	100.00	144041	14404100	1440.41	100.00

A) Small Area

Value	Name	Nahanni_ROW_160422_Small				Nahanni_ROW_150224_Small			
		Count	Sq.m	Hectares	Percent	Count	Sq.m	Hectares	Percent
1	Alpine Herb Tundra and Meadow	602	60200	6.02	1.41	617	61700	6.17	1.45
3	Terrain or cloud shadow / Water	1436	143600	14.36	3.37	1326	132600	13.26	3.11
4	Subalpine Tall Shrub	62	6200	0.62	0.15	62	6200	0.62	0.15
7	Low Sparse Shrub	3089	308900	30.89	7.25	3072	307200	30.72	7.20
8	Rock - Lichen	3518	351800	35.18	8.26	3657	365700	36.57	8.57
9	Rock	1045	104500	10.45	2.45	1044	104400	10.44	2.45
10	Mixed Predominantly Coniferous Forest	7545	754500	75.45	17.71	7745	774500	77.45	18.14
12	Medium - Low Shrub	3466	346600	34.66	8.14	3497	349700	34.97	8.19
13	Coniferous Forest	6746	674600	67.46	15.84	6730	673000	67.30	15.76
14	Subalpine Coniferous Woodland	238	23800	2.38	0.56	238	23800	2.38	0.56
15	Subalpine Shrub – Sparse Trees	583	58300	5.83	1.37	580	58000	5.80	1.36
16	Spruce – Lichen Woodland	1000	100000	10	2.35	1001	100100	10.01	2.34
17	Spruce – Lichen- Moss Woodland	5680	568000	56.8	13.34	5271	527100	52.71	12.35
18	Wetland	596	59600	5.96	1.40	596	59600	5.96	1.40
19	Alluvial non-vegetated	76	7600	0.76	0.18	84	8400	0.84	0.20
23	Deciduous Forest / Tall Shrub	2575	257500	25.75	6.05	2644	264400	26.44	6.19
24	Mixed Predominantly Deciduous Forest / Tall Shrub	3357	335700	33.57	7.88	3451	345100	34.51	8.08
25	Recently Burnt	430	43000	4.3	1.01	439	43900	4.39	1.03
22	Water / Terrain shadow	4	400	0.04	0.01	4	400	0.04	0.01
28	Permanent Water	200	20000	2	0.47	200	20000	2.00	0.47
29	Intermitent Water	345	34500	3.45	0.81	433	43300	4.33	1.01
26	Ice / Snow	234	23400	2.34	0.55	234	23400	2.34	0.55
	TOTAL	42827	4282700	428.27	100.55	42925	4292500	429.25	100.55

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Environmental Protection Operations Directorate (EPOD)
Prairie & Northern Region (PNR)
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June 30, 2016

EC File: 5100 000 014/012
MVEIRB File: EA1415-01

Chuck Hubert
Senior Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
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Via email submission

RE: EA14154-01 – Canadian Zinc Corp. – Prairie Creek All Season Road – Undertaking #35 Response

Attention: Chuck Hubert

Please find below Environment and Climate Change Canada's (ECCC) response in full to EA1415-01 Prairie Creek All Season Road Environmental Assessment Undertaking #35 from the Technical Session which took place in Yellowknife from June 13-16 2016.

Undertaking #35:

"ECCC to provide examples of mitigation measures to prevent release of contaminants during transport of lead zinc concentrate along roadways, including references to relevant Red Dog and Pine Point examples."

Response:

Transport trailers with hydraulically operated steel covers and solid sides were used at the Red Dog mine in order to reduce dust released during transport and should be considered for use at the Prairie Creek Mine.

Beyond just wheel washing, truck washing bays when leaving site after loading should be used to ensure no residual contaminants are on the trucks.

ECCC also recommends the use of secondary containment for product being transported. This would mean that ore leaving the mine site would be contained first within sealed bags and then within sealed trucking containers.

ECCC also recommends a further upgrade to the monitoring program that will be used to asses environmental loading. Monitoring should not be limited to collecting soil samples and should also include snow sampling, dust fall sampling, and information on ambient Total Suspended Particulates (TSP). Emphasis should be put on sensitive receptors such as the many creek crossings. Appropriate thresholds to trigger adaptive management and contingency plans should also be identified.

ECCC is providing the following attachment to provide further examples of mitigation measures at the Red Dog mine. Many are not relevant to the Prairie Creek proposed project as they deal with shipping however several are relevant.

ECCC's specialist advice is provided based on our mandate pursuant to the *Canadian Environmental Protection Act*, the pollution prevention provisions of the *Fisheries Act*, the *Migratory Birds Convention Act*, and the *Species at Risk Act*.

Should you require further information, please do not hesitate to contact me at (867) 669-4707 or Bradley.Summerfield@Canada.ca

Sincerely,

Bradley Summerfield
Environmental Assessment Coordinator, Environmental Assessment North (NT and NU), EPOD-PNR

Attachment: DMTS Fugitive Dust Risk Assessment Volume 1-Report prepared by Exponent for Teck Cominco Alaska Incorporated Appendix L, Chronology of Dust Control Improvements to the DMTS Road and Port Operations, November 2007

cc: Loretta Ransom, A/Head, Environmental Assessment North, PNR-EPOD
Dave Fox, Air Pollution Management Analyst, PNR-EPOD
Brian Asher, Air Pollution Analyst, PNR-EPOD

Appendix L

Chronology of Dust Control Improvements to the DMTS Road and Port Operations

Chronology of Dust Control Improvements to the DMTS Road and Port Operation

The following is a summary of improvements that have been made to the DMTS road and port operations for dust control.

Summer 1990

- Added vibrators to concentrate trailers to reduce carry-out from the truck unloading building (TUB)
- Tested the application of calcium chloride to road gravel for dust control.

Spring 1991

- Added a drop-tube to the P11 shiploader discharge to minimize fugitive dust while loading lightering barges.

Summer 1991

- Installed additional dust collection in gallery and transfer points
- Enclosed all transfer points
- Installed a floor on the first level of the surge bin
- Improved the truck unloading station ventilation
- Installed equipment wash bay building to the concentrate storage building (CSB)
- Installed new doors for existing CSB
- Installed improved doors on the TUB.

Fall 1991

- Began application of calcium chloride for dust control on port road.

Spring 1992

- Began application of calcium chloride for dust control on port site yards.

Summer 1992

- Outfitted all port system conveyors, except for shiploader, with canvas tent style enclosures (Conveyors P7, P8, and P10)
- Installed module over P10 conveyor drive unit
- Installed plywood covers over tail ends of P8 and P10 conveyors.

Fall 1992–June 1993

- Installed entirely new P11 shiploader conveyor with improved enclosure.

June–July 1994

- Installed additional siding to enclose P9-A and P9-B (surge bin) conveyors.

August–September 1994

- Further enclosed conveying system surge bin.

Winter 1996–1997

- Changed trailer wing deflectors to stainless steel for reduced adhesion and carry-out from the TUB.

1996–1997

- Conducted port site expansion and upgrade (production rate increase)
- Upgraded most of the conveyor system (new conveyors enclosed in steel tubes and additional baghouses at P22, P22-A, P23, P27, P28) and added second CSB
- Placed P7/P8 (Transfer Tower #4) transfer in enclosed steel building.

Winter 1998–1999

- Began using Chem-Loc® release agent in concentrate trailers to minimize residuals and carry-out following dumping (reduced need for air-lancing residual concentrate from trailers)
- Switched to improved reinforced covers on concentrate trailers
- Began using Bobcat loader to clean up TUB dumping platform between dump events to reduce potential concentrate track-out from TUB.

Spring 1999

- Added a spill deflector gate in the TUB and removed deflector wings from concentrate truck trailers to minimize carry-out from TUB.

Fall 1999

- Added concrete apron to south door of TUB.

Spring 2000

- Added man–door to TUB control room to allow personnel to enter/exit building without opening large equipment doors.

Spring–Summer 2001

- Enclosed P8 conveyor (CSB#1 to Surge Bin) in metal tube (completed prior to 2001 shipping season). The conveyor was previously enclosed with a canvas tent-style enclosure system.
- Replaced covers on P11 shiploader conveyor
- Upgraded to motorized conveyor belt scrapers from standard blade scrapers
- Installed and utilized a truck wash outside of the TUB exit for use during non-freezing conditions
- Began to utilize new self-dumping trailers with hydraulically operated hard covers and no side doors to eliminate potential for concentrate leakage.

August 2001

- Installed temporary stilling curtains over the TUB hopper to promote dust settling, until a permanent more complex arrangement was installed.

June–November 2001

- Initiated a change out of the concentrate haulage fleet during the summer of 2001 (Teck Cominco and NANA Lynden Logistics). Existing A-train 85-ton haulage units with side-opening doors were replaced by B-train 130-ton haulage units. Fleet change out completed in November 2001. The new self-dumping trailers include:
  - Hydraulically operated steel covers to minimize spills
  - No side doors to eliminate potential for concentrate leakage
  - More stability, thereby reducing risk of accidents.

Winter 2001–2002

- Updated standard operating procedures for concentrate handling
- TUB improvements:
  - Extended 26 ft to accommodate length of new trailers
  - Installed enhanced stilling curtains over the TUB hopper to promote dust settling
  - Installed temporary baghouse (14,500 cfm) at truck dump hopper
  - Eliminated air lancing of trucks.
- Port CSB improvements:
  - Equipped loader and dozers with exhaust particulate filters.

Spring 2002

- Equipped the four loading hoppers inside of the CSBs with passive stilling bin hoods and curtains to reduce dust generation inside the CSB during shiploading operations. Modifications completed prior to 2002 shipping season.

July 2002

- Conducted a test paving program utilizing a "Hi-Float" product on approximately 2.5 miles of the DMTS haul road from the fuel island to the New Heart Creek Bridge. Also placed Hi-Float at the access to the CSBs, TUB, and on limited operating areas.

Spring 2002

- Completed surge bin dust control modification prior to 2002 shipping season. Modifications include:
  - Re-routed baghouse ducting for better dust capture
  - Insulated ducting to reduce potential of dust "caking"
  - Installed improved baghouse controls

- Improved sealing on surge bin
- Improved sample door seals
- Installed belt skirting.

July–November 2002

- Installed new TUB "air wash" dust control system incorporating a 55,000 cfm baghouse that draws dust-laden air from the truck unloading hopper and concurrently uses positive airflow across the concentrate trailer to minimize the potential of dust adhering to the concentrate haul trucks during the unloading process.

June 2003

- Completed shiploader dust control modification, including:
  - Installed new P10/P11 transfer chute baghouse
  - Installed new P10/P11 transfer chute seals
  - Redesigned and upgraded the cover tail end, extension hood, conveyor belt cover and enclosure, chute and ducting of the P11 conveyor
  - Upgraded skirting, scrapers and inspection doors on P11 conveyor
  - Enclosed the P10 drive house.

July 2003

- Modified barge dust control systems (installed prior to shipping season). Modifications include:
  - Installed baghouse systems on each barge to control dust at transfer points
  - Raised and improved the seal on the barge canopy system
  - Modified the boom conveyor scraper system to eliminate carry-back
  - Modified the boom conveyor discharge chute
  - Upgraded scrapers and skirting on other conveyors.

Fisheries and Oceans Canada | Pêches et Océans Canada

301-5204 50th Ave.
Yellowknife, NT
X1A 1E2

Your file *Votre référence*
EA1415-01

Our file *Notre référence*
08-HCAA-CA6-00114

June 28, 2016

Mackenzie Valley Environmental Impact Review Board
ATTN: Chuck Hubert
Senior Environmental Assessment Officer
P.O. Box 938, #200 Scotia Centre
5102-50th Ave., Yellowknife, NT
X1A 2N7

Dear Mr. Hubert:

Subject: Prairie Creek All Season Road Technical Session Undertaking #6

Fisheries Protection Program of Fisheries and Oceans Canada (DFO-FPP) would like to thank the Mackenzie Valley Environmental Impact Review Board (MVEIRB) for the opportunity to provide this undertaking, which arose from the Prairie Creek All Season Road Project technical sessions held June 13—16, 2016.

Undertaking 6

DFO will provide report on No Net Loss projects and monitoring statistics.

Fisheries and Oceans Canada Response

The following publication, which was discussed during the technical sessions on June 13, 2016, is attached.

> Quigley JT, Harper DJ (2006) Effectiveness of fish habitat compensation in Canada in achieving no net loss. Environmental Management 37(3):351—366.

Since this report was issued, a number of changes have occurred with respect to how impacts to fish and fish habitat are managed by Fisheries and Oceans Canada. It should be noted that fish habitat compensation measures are now termed offsetting measures.

Under the new fisheries protection provisions of the *Fisheries Act*, which came into force in November 2013 and are administered by the Fisheries Protection Program, the following key changes ensure that offsetting projects successfully balance project impacts.

1. *Fisheries Act* Authorizations must contain contingency measures and associated monitoring measures that will be put into place if offsetting is not successful (SOR/2013-191, Schedule 1, Section 13(*f*)).
2. A mandatory Letter of Credit must be included, which ensures that if conditions of the *Fisheries Act* Authorization are not completed, Fisheries and Oceans Canada can access funds to implement all remaining elements of the offsetting plan and monitoring program (DFO, 2013a; SOR/2013-191, Section 3(*b*))
3. Conditions describing offsetting, mitigation, monitoring and contingency measures in *Fisheries Act* Authorizations are now enforceable (DFO, 2013b; *Fisheries Act* Section 40(3)(*a*)).
4. The Science branch of Fisheries and Oceans Canada has also provided recent and updated guidance on how to appropriately construct and assess effectiveness of offsetting measures (Clark and Bradford, 2014; de Kerckhove, 2015; DFO, 2014; DFO, 2015; Smokorowski et al., 2015). This helps support the Fisheries Protection Program's mission to provide expertise to Canadians through forward-looking, evidence-based policy, and to make regulatory decisions informed by the best available science, technical information and traditional knowledge.

Additionally, starting this fiscal year (2016—2017), as a part of a National Compliance Monitoring Framework, Fisheries and Oceans Canada is verifying the effectiveness of avoidance, mitigation and offsetting measures established for projects impacting fish and fish habitat across Canada. All *Fisheries Act* Authorizations (which each include offsetting measures) are targeted for monitoring.

Previously, in fiscal year 2015—2016, the Fisheries Protection Program in the Central and Arctic Region monitored 97 projects that have *Fisheries Act* Authorizations, 79 projects that received Letters of Advice, and 67 projects that had been determined to have no requirement for review by Fisheries and Oceans Canada, exceeding targets of 40, 50 and 50 projects respectively.

In conclusion, it is also important to note that offsetting plans, and the associated monitoring, must be negotiated on a case-by-case basis including consultation with Aboriginal groups and other interested stakeholders. The Fisheries Protection Program is guided by the application of precaution and a risk-based approach to decision-making that considers the ecosystem context of each project, in order to best achieve meaningful, credible and effective results.

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If you have any questions, please contact Julie Marentette at 867-669-4934, or by email at Julie.Marentette@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with DFO-FPP.

Yours sincerely,

Martyn Curtis
A/Regional Manager, Regulatory Reviews
Fisheries Protection Program

ATTACHMENT LIST:
Quigley Harper 2006 Effectiveness of habitat comp in Canada NNL.pdf

COPY LIST:
Julie Marentette (DFO)

DOI: 10.1007/s00267-004-0263-y

Effectiveness of Fish Habitat Compensation in Canada in Achieving No Net Loss

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ABSTRACT / Fish habitat loss has been prevalent over the last century in Canada. To prevent further erosion of the resource base and ensure sustainable development, Fisheries and Oceans Canada enacted the habitat provisions of the *Fisheries Act* in 1976. In 1986, this was articulated by a policy that a "harmful alteration, disruption, or destruction to fish habitat" (HADD) cannot occur unless authorised with legally binding compensatory habitat to offset the HADD. Despite Canada's progressive conservation policies, the effectiveness of compensation habitat in replicating ecosystem function has never been tested on a national scale. The effectiveness of habitat compensation projects in achieving no net loss of habitat productivity (NNL) was evaluated at 16 sites across Canada. Periphyton biomass, invertebrate density, fish biomass, and riparian vegetation density were used as indicators of habitat productivity. Approximately 63% of projects resulted in net losses in habitat productivity. These projects were characterised by mean compensation ratios (area gain:area loss) of 0.7:1. Twenty-five percent of projects achieved NNL and 12% of projects achieved a net gain in habitat productivity. These projects were characterised by mean ratios of 1.1:1 and 4.8:1, respectively. We demonstrated that artificially increasing ratios to 2:1 was not sufficient to achieve NNL for all projects. The ability to replicate ecosystem function is clearly limited. Improvements in both compensation science and institutional approaches are recommended to achieve Canada's conservation goal.

Canada contains approximately one quarter of the world's wetlands (Rubec 1994), which support a rich biodiversity of more than 198 fish species (Scott and Crossman 1998). Losses of wetlands have occurred at an alarming rate in the last century. In fact, approximately one seventh (20 million ha) of Canada's wetlands have been lost (Rubec 1994). Habitat loss has been identified as a key factor in the decline of Canada's freshwater fisheries resources (Pearse 1988; Beamish and others 1986). In North American freshwaters, 73% of fish extinctions can be attributed to habitat alterations (Miller and others 1989).

To prevent further erosion of the resource base, in 1976 Fisheries and Oceans Canada (DFO) enacted the habitat provisions of the *Fisheries Act*, one of the strongest pieces of environmental legislation in Canada. A "harmful alteration, disruption, or destruction to fish habitat" (HADD) cannot occur unless authorised via Section 35(2) of the *Fisheries Act*. In 1986, the Policy for the Management of Fish Habitats (hereafter the Habitat Policy; DFO 1986) was implemented to ensure sustainable development by requiring authorised HADDs to be offset by legally binding habitat compensation. The guiding principle behind the requirement for habitat compensation is the achievement of no net loss (NNL) of the productive capacity of fish habitats, the primary conservation goal of the Habitat Policy.

Thus, the putative solution for conserving Canada's rich biodiversity of fish and the habitats they depend upon, while allowing development to continue, is through compensation habitat. Canada has received accolades for its progressive conservation policies (Brouha 1993), yet in practice, the effectiveness of compensation habitat in achieving NNL has never been tested on a national scale. Excessive workload in DFO results in reactive, crisis habitat management such that follow-up monitoring and adaptive management do not occur (Harper and Quigley 2005a). In fact, nationally only 2.1% of DFO's habitat management workload is spent conducting follow-up monitoring to

KEY WORDS: Habitat compensation; Effectiveness; No Net Loss; Field evaluation; *Fisheries Act*; Authorisation; Habitat productivity; Policy; Canada

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determine efficacy of compensatory works (Drodge and others 1999). Independent evaluations of the effectiveness of compensation habitat in Canada are even rarer (Harper and Quigley 2005b). Furthermore, the vast majority of evaluations and monitoring that have occurred has been short term (1–3 yrs), judgement based, and qualitative rather than quantitative (Harper and Quigley 2005a). Most studies have based their NNL determinations simply upon area gained or lost rather than scientifically defensible assessments of the true productive capacity of fish habitats. A possible reason for this is the difficulty in assessing productive capacity as it is defined in the Habitat Policy.

Productive capacity is characterised as "the maximum biomass of organisms that can be sustained on a long term basis by a given habitat, analogous to carrying capacity" and "the measure of a habitat to produce fish and/or food organisms in natural or restored conditions" (DFO 1998). Indeed, the difficulty in operationally defining and assessing productive capacity has been recognized (Jones and others 1996; Levings and others 1997) since the inception of the Habitat Policy and has likely impeded applied, practical research into the performance of DFO's conservation policy. Efforts in providing operational definitions of productive capacity have received considerable resources and effort (Minns and Moore 2003; Minns 1995, 1997; Levings and others 1997), as have inventories of the productive capacity of various habitats (Gordon and others 1997; Amiro 1997; Welch 1997; Williams and others 1997). However, with respect to compensation habitat, DFO's core mechanism to conserve habitat, practical evaluations of the attainment of NNL of the productive capacity of fish habitats have rarely been undertaken, and if so have been local in scope (Scruton 1996; Minns and others 1995; Levings and Nishimura 1996).

Productive capacity was intended to measure the capacity of the habitat (carrying capacity potential) and not solely current fish production (Scruton 1996). We agree with Minns (1997) and Levings and others (1997) that the Habitat Policy was drafted to conserve habitat quality and ecosystem productivity akin to the United States' legislation (Section 404, *Clean Water Act*) designed to conserve wetland functionality. Productive capacity can be considered an intrinsic potential property of habitat, which is not only difficult to quantify but is "logically inoperable" (Minns 1997). However, the ability of DFO to achieve NNL of future productivity may be a moot issue if current habitat productivity is not being effectively conserved. Indeed, the productivity of compensation habitats relative to impacted habitats is the key unanswered question of habitat managers in Canada (Metikosh 1997).

As such, we investigated the effectiveness of habitat compensation in achieving NNL of current habitat productivity by measuring both the area and the productivity of compensatory habitats. Consistent with the latest trends in conservation biology (Underwood 1995; Walters and Holling 1990), we treated DFO's management actions with respect to habitat conservation (i.e., compensation projects) across Canada as experiments. In this article, we describe a field evaluation of fish habitat compensation projects completed across Canada to determine effectiveness of compensation projects in achieving NNL of habitat productivity.

Methods

Habitat compensation projects were selected randomly across Canada with geographic stratification in five provinces: British Columbia, Manitoba, Ontario, New Brunswick, and Nova Scotia. Field evaluations were completed from May to October of 2000 and 2001. We selected projects that had been completed between 1994 and 1997, which ensured a postconstruction age range of 4 to 8 years.

A hierarchy of compensation options, from most to least preferred, that compare the habitat type and ecological unit of compensation habitat relative to the lost habitat is provided in the Habitat Policy (DFO 1986, 1998). We described compensation projects based on a modified hierarchy of preferences. This included three basic classifications: (1) like for like habitat: create similar habitat at or near the site in the same ecological unit (e.g., replace off-channel habitat with off-channel habitat); (2) like for unlike habitat: create or increase the productivity of unlike habitat in the same ecological unit (e.g., replace in-channel habitat with off-channel habitat); (3) increasing like habitat productivity: increase the productivity of like habitat at or near the site (e.g., enhance existing in-channel habitat to compensate for in-channel habitat loss). Ecological unit was defined as "populations of organisms considered together with their physical environment and the interacting processes amongst them" (DFO 2002a).

Each compensation project was partitioned into treatment sites ($n = 2–4$). Unimpacted reference sites ($n = 2–4$) were selected to represent the HADD site prior to the impact. Pre-impact assessment reports, photographs, and on-site visits with the DFO biologist responsible for the authorisation assisted in reference site selection. In some compensation projects, the HADD site and the compensation habitat were spatially distinct. In these cases, treatment sites were selected in both the HADD site ($n = 2–4$) and the compensatory site (n = 2–4) and data were pooled to develop mean response values. In this way, we were able to evaluate the habitat productivity of the compensatory, modified (HADD site), and lost habitats (reference site).

For each project, the evaluations consisted of two general components: determining the overall areal extent of habitat change and the magnitude of change per unit area (Minns 1995). Total surface area of gains and losses in habitat were measured and compensation ratios (habitat area gained:habitat area lost) were calculated (*sensu* Quigley and Harper 2005).

Taking an ecosystem approach, we selected four variables as a proxy to productive capacity to quantify magnitude of change in habitat productivity. This multimetric approach included biomass of periphyton, macroinvertebrate density, fish biomass, and areal cover of riparian vegetation. These variables were measured at both treatment and reference sites. For some projects, all four variables were not measured because of logistical constraints or because a given indicator was not applicable for a particular project.

Treatment and reference sites were netted off and the areas were measured so that response variables could be quantified per unit area. Periphyton was sampled from each site by selecting five rocks, using a random stratified approach along a transect in the centre of the channel. Sediment was first removed from each rock with a washbottle. Then a cordless drill with nylon brush was used to emulsify periphyton from a known area on each rock defined by 3.8-cm sections of polyvinyl chloride pipe of varying diameters (5.08 cm, 7.62 cm, or 10.16 cm, depending upon substrate size). Emulsified periphyton was rinsed into sample bottles and quantified in the laboratory by filtration (g/m^2). Five invertebrate samples were randomly taken per site using a Surber sampler (RIC 1997). Densities ($number/m^2$) and diversity of invertebrates were recorded. Fish were sampled by electroshocker (Smith Root 12C), and densities were calculated using a two-pass removal method (Seber and LeCren 1967). Fish biomass (g/m^2) and species diversity were recorded for each site. Riparian vegetation was sampled at each site using a random stratified approach along a transect parallel to the channel. Total percent coverage of 1-m^2 quadrats as well as diversity of woody and nonwoody riparian species were quantified at five locations per site.

Treatment response variables were weighted by the difference in area between the compensation and HADD areas (i.e., compensation ratio). For example, if the total compensation area exceeded the HADD area by a factor of 1.2, then all of the mean treatment response variables would be multiplied by 1.2 to estimate the total production for that variable. Response variables were contrasted between treatment and reference sites. Most projects were composed of an in-channel and a riparian component, which were evaluated separately. A project was deemed to have resulted in a net gain if one or more of the response variables were statistically greater in treatment sites than reference sites and the remaining variables were not different. A project was deemed to have resulted in a net loss if one or more variables were statistically greater in reference sites than treatment sites. Projects achieved NNL if all of their response variables did not differ between reference and treatment sites.

Two additional sets of analyses were also completed whereby artificial ratios of 1:1 and 2:1 were used with the mean treatment response variables rather than the actual compensation ratios measured. These analyses were completed because many projects had compensation ratios less than 1:1 and we wanted to ascertain the effect that larger compensation ratios might have on the achievement of NNL.

It is possible to have no change in production (biomass) in a particular indicator but have a shift in species composition. Diversity of fish species, invertebrate orders, and riparian nonwoody and woody species was measured to capture changes in community structure.

Data Analyses

Data were visually inspected for normality and homogeneous variances. We used log transformations to minimise heterogeneous variances. For each compensation project, we used analysis of variance to compare response variables between reference and treatment sites. Least-square means were used to calculate means for graphical presentations. Values are reported as means ± 1 standard error (SE). Statistical analyses were completed using SAS statistical software, release 8.02 (SAS Institute 2001). All tests were considered to be significant to a $P \leq 0.05$.

Results

A total of 16 habitat compensation projects were evaluated across Canada in British Columbia (n = 7), Manitoba (n = 3), Ontario (n = 2), New Brunswick (n = 2), and Nova Scotia (n = 2) (Figure 1). This sample represents approximately 13% of the total number of authorisations (N = 124) issued in these provinces during 1994 to 1997 inclusive. The mean age of projects was 4.3 years (SE = 0.5) (Table 1). Habitat compensation projects evaluated were a result of the

Figure 1. Location of compensation projects evaluated across Canada (n = 16).

following development activities: roads and highways (n = 7), urban development (n = 4), forestry (n = 3), agriculture (n = 1), and oil and gas (n = 1) (Table 1). The HADDs and compensatory habitats occurred in two habitat categories: in-channel and riparian. Many projects included HADDs and compensation in both habitat categories. Common compensation techniques included riparian revegetation, channel creation, and habitat complexing through addition of boulders, large woody debris, or pools (Table 1).

In the in-channel habitat category, approximately 58% of projects had HADD areas that were larger than authorised. Smaller-than-authorised HADD areas were less common, occurring 8% of the time (Figure 2A). The mean size of the authorised and actual HADDs was 2493 m^2 and 5393 m^2, respectively. In contrast, compensation habitat tended to be smaller than required. Approximately 50% of projects had compensation habitat smaller than required, whereas 17% were larger than required (Figure 2B). The mean size of the

Table 1. Descriptive information for compensation projects studied across Canada

Project	Province	Age (yrs)	HADD description	Compensation description	Hierarchy option
1	Manitoba	5	Highway realignment resulted in a loss of in-channel riverine habitat and of riparian habitat.	River diversion created in-channel riverine habitat and riparian habitat. Constructed riffles and deep pools incorporated as compensation features.	Like for like
2	British Columbia	3	Forestry road realignment and culvert installation resulted in a loss of in-channel riverine habitat and riparian habitat.	Creation of in-channel riverine habitat and riparian habitat. Habitat complexing with large woody debris was a compensation feature.	Like for like
3	Nova Scotia	7	Highway twinning resulted in stream diversion and culvert installation destroying in-channel riverine habitat and riparian habitat.	Habitat complexing was completed to enhance productivity by installing digger logs.	Increase like productivity
4	Ontario	7	Municipal road construction and bridge installation resulted in stream channelisation and diversion. In-channel riverine habitat and riparian habitat was lost.	Creation of in-channel riverine habitat and riparian habitat.	Like for like
5	Manitoba	3	Construction of a dam and spillway to create an agricultural water reservoir resulted in a loss of riverine in-channel habitat and riparian habitat.	Creation of lacustrine/reservoir habitat, riparian habitat and fishway.	Like for unlike
6	British Columbia	3	Installation of an outfall structure for discharge from a water treatment plant resulted in a loss of riparian habitat.	Riparian revegetation.	Like for like
7	New Brunswick	4	Highway construction and installation of twin bridges resulted in a river diversion and channelisation and a loss of riparian and in-channel habitat.	Creation of in-channel habitat complexed with digger logs, boulders, and large woody debris.	Like for like
8	Ontario	3	Road construction, culvert installation and stormwater retention pond to service new subdivision resulted in a loss of in-channel riverine habitat and riparian habitat.	Riparian revegetation and creation of in-channel habitat complexed with large woody debris.	Like for like
9	New Brunswick	2	Highway construction and installation of four culverts, channelisation, and two stream diversions resulted in a loss of in-channel riverine habitat and riparian habitat.	Riparian revegetation and creation of in-channel habitat complexed with digger logs, boulders, and large woody debris.	Like for like
10	British Columbia	3	Major river channelisation and creation of a spur-dyke to protect downstream forestry mill resulted in a loss of in-channel riverine habitat and riparian habitat.	Riparian revegetation and preservation of adjacent side-channel access. Irregular edge habitat and groynes incorporated into rip-rap design as compensation features.	Like for like
11	British Columbia	2	Condominium development resulted in a loss of riparian habitat.	Riparian revegetation.	Like for like

Continued

Table 1. Continued

Project	Province	Age (yrs)	HADD description	Compensation description	Hierarchy option
12	British Columbia	7	River diversion to protect forestry mill resulted in a loss of in-channel riverine habitat and riparian habitat.	Riparian revegetation and creation of in-channel habitat complexed with boulders and large woody debris.	Like for like
13	Nova Scotia	9	Highway construction, culvert installation, and stream diversion and realignment resulted in a loss of in-channel riverine habitat and riparian habitat.	Enhanced productivity of in-channel habitat through installation of digger logs.	Increase like productivity
14	Manitoba	5	Road construction, stream realignment, and bridge installation resulted in a loss of in-channel riverine habitat and riparian habitat.	Creation of in-channel habitat complexed with boulders and deep pools.	Like for like
15	British Columbia	3	River channel hardening and straightening with rip-rap to protect gas pipeline resulted in a loss of in-channel riverine habitat and riparian habitat.	Creation of off-channel habitat complexed with large woody debris and pools and riparian revegetation.	Like for unlike
16	British Columbia	3	Road realignment and channelisation resulted in a loss of riparian habitat.	Riparian revegetation and incorporation of groynes in the rip-rap to create edge habitat.	Like for like

required and actual compensation habitats was 16,245 m^2 and 14,865 m^2, respectively. Overall, 75% of compensation projects had either larger HADD and/or smaller compensation areas than authorised. Consequently, 64% of projects had smaller compensation ratios than authorised, whereas only 27% were larger (Figure 2C). The mean compensation ratio required was 6.8:1 compared to an actual ratio of 1.5:1.

In the riparian habitat category, the trends were similar. Approximately 56% of projects had HADD areas that were larger than authorised. Smaller-than-authorised HADD areas occurred at 13% of the projects (Figure 2D). The mean size of the authorised and actual HADDs was 11,535 m^2 and 11,446 m^2, respectively. Compensation habitat was smaller than required on 50% of projects and larger for 25% (Figure 2E). The mean size of the required and actual compensation habitats was 7667 m^2 and 6730 m^2, respectively. Overall, 88% of compensation projects had either larger HADD and/or smaller compensation areas than authorised. As a result, 75% of projects had compensation ratios smaller than authorised and 19% were larger (Figure 2F). The mean compensation ratio required was 1.2:1 compared to an actual ratio of 0.8:1.

In terms of habitat productivity, 12% (2) of the projects achieved a net gain based on the actual compensation ratios. The mean compensation ratio for these projects was 4.8:1. Approximately 25% (4) of the projects achieved NNL. The mean compensation ratio for these projects was 1.08:1. Approximately 63% (10) of the projects resulted in a net loss of habitat productivity (Figure 3A, Table 2). These projects had a mean compensation ratio of 0.74:1.

Interestingly, with an artificial ratio of 1.0:1, none of the projects would have achieved a net gain, 56% would achieve NNL, and 44% would result in a net loss of habitat productivity (Figure 3B, Table 2). With an artificial ratio of 2.0:1, approximately 31% of projects would achieve a net gain, 50% would achieve NNL, and 19% would result in a net loss of habitat productivity (Figure 3C, Table 2).

We detected a difference in mean periphyton biomass in 50% of compensation projects where it was sampled (Figure 4A) and a difference in macroinvertebrate density in 25% of projects where it was sampled (Figure 4B). A difference in fish biomass was only detected in 8% of projects where it was sampled (Figure 4C). It appears that riparian habitats are much more difficult to compensate for because 57% of projects sampled for this variable resulted in a net loss and no projects achieved a net gain (Figure 4D, Table 2). The differences in riparian productivity were large and unequivocal in these eight projects.

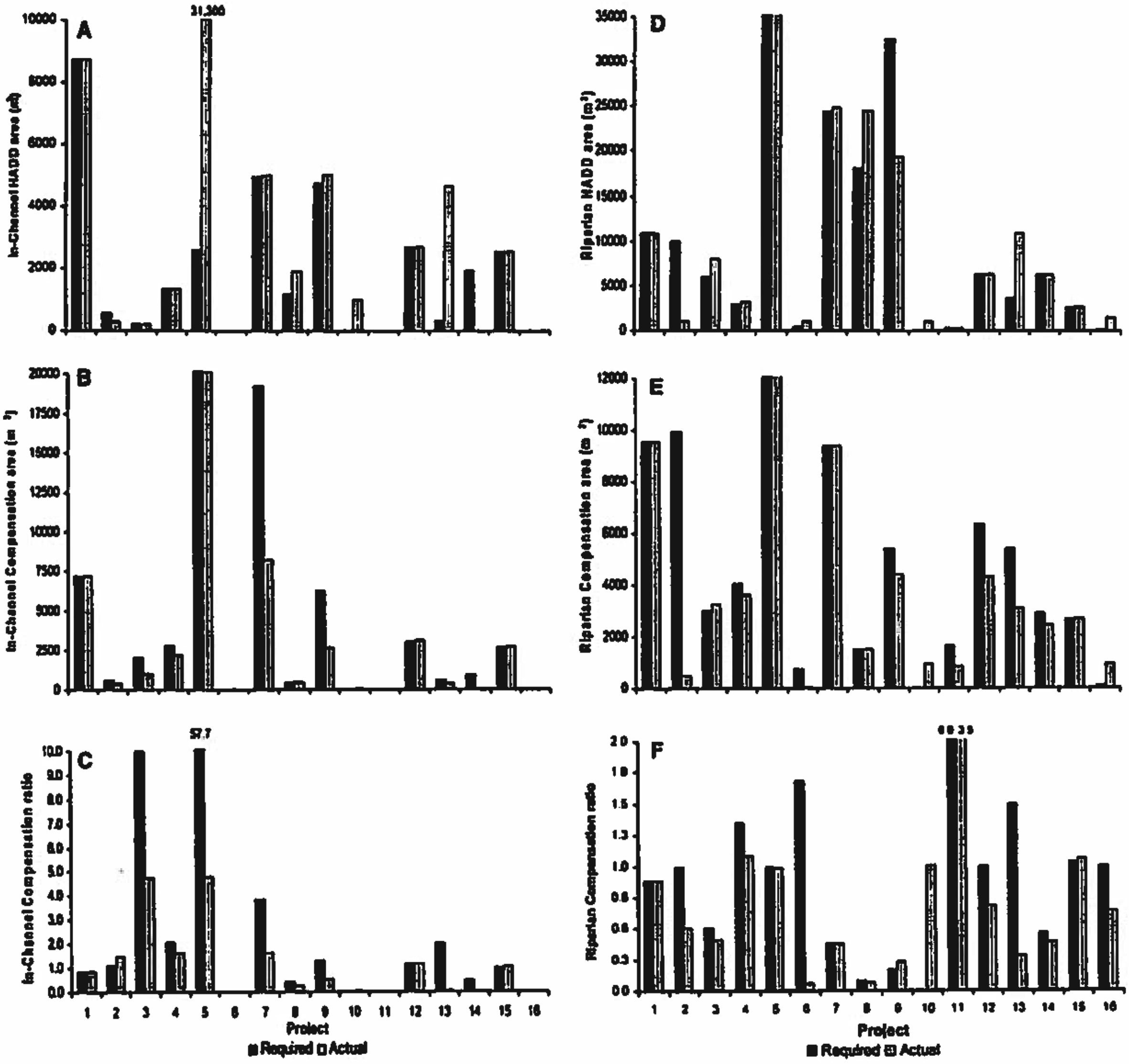

Figure 2. Required and actual HADD areas (A, D), compensation areas (B, E), and compensation ratios (area gained:area lost) (C, F) in the in-channel and riparian habitat categories. Values that exceeded the scale are indicated above the bar except for project 5, which had a required HADD of 60,000 m^2 and an actual HADD of 60,931 m^2 in the riparian category (D). Project 5 had a required and actual in-channel compensation area (B) of 150,000 m^2 and riparian compensation area (E) of 60,000 m^2, respectively. Bars that are absent indicate a zero value except for project 14, in which actual HADD and compensation areas were not measured in the in-channel category.

There were no differences in diversity of fish or invertebrates between treatment and reference sites in any of the projects (Table 3). Three compensation projects had differences in diversity of riparian vegetation between treatment and reference sites. Project 10 had a greater diversity of nonwoody riparian species in reference sites (0.67/m^2) in comparison to treatment sites (0.33/ m^2). Project 6 had a greater diversity of woody riparian species in reference sites (3/m^2) compared to treatment sites (0.5/m^2). Project 11 had a greater diversity of nonwoody species in treatment sites (2.1/m^2) relative to reference sites (0/m^2), yet had a greater diversity of woody species in reference sites (2.0/m^2) compared to treatment sites (0.45/m^2) (Table 3). There were no differences between diversity of nonwoody or woody riparian species in any of the other projects.

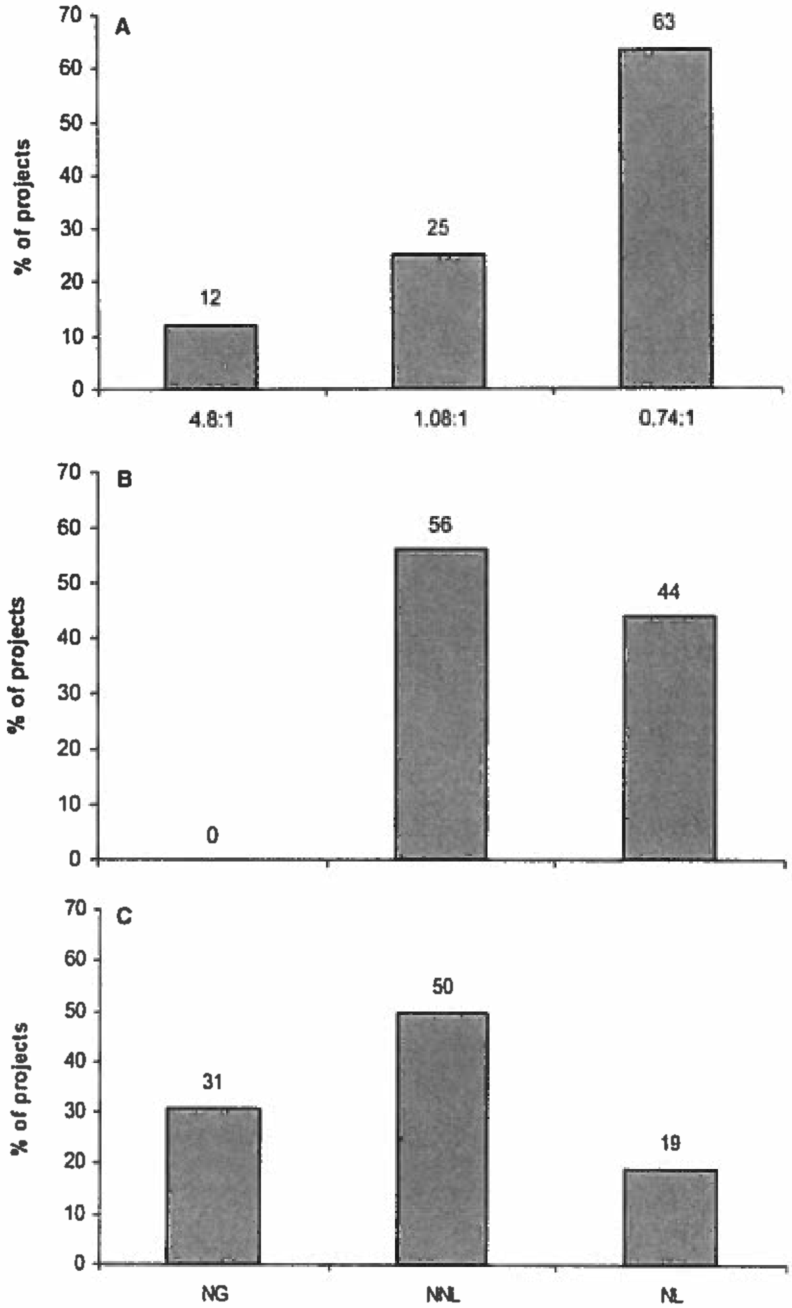

Figure 3. Percentage of projects achieving a net gain (NG), no net loss (NNL), and a net loss (NL) of habitat productivity based on the mean actual compensation ratios (A) indicated under each bar, and artificial ratios of 1:1 (B) and 2:1 (C).

Discussion

Inherent ecosystem variability meant that differences had to be large in order to detect responses. In this respect, our results can be considered conservative because we defaulted to a NNL outcome on many projects that may not have achieved this goal. Indeed, Mapstone (1995) reports that many environmental impact assessments conclude that a development had no effect because an 80–100% change in the measured variable would have been required to detect change. Although more replicates would have assisted in

Table 2. Model statistics for habitat productivity variables to determine if compensation projects achieved a Net Gain (NG), No Net Loss (NNL), or Net Loss (NL) in habitat productivity based on actual compensation ratios (CR) and artificial ratios (ACR) of 1:1 and 2:1.[a] O = Outcome

Project	Variable	Actual CR	*P* value	O	ACR	*P* value	O	ACR	*P* value	O
1	Riparian coverage	0.88:1	0.5507	NNL	1:1	0.6525	NNL	2:1	0.639	NNL
	Periphyton biomass	0.82:1	0.9138	NNL	1:1	0.758	NNL	2:1	0.4323	NNL
	Invertebrate density	0.82:1	0.2575	NNL	1:1	0.1694	NNL	2:1	0.0563	NNL
	Fish biomass	0.82:1	0.9287	NNL	1:1	0.7341	NNL	2:1	0.3102	NNL
2	Riparian coverage	0.5:1	0.0848	NNL	1:1	0.4226	NNL	2:1	0.9129	NNL
	Invertebrate density	1.48:1*	0.0101	NL	1:1*	0.0036	NL	2:1*	0.0239	NG
	Fish biomass	1.48:1	0.1605	NNL	1:1	0.2758	NNL	2:1	0.1197	NNL
3	Periphyton biomass	4.76:1*	0.0179	NG	1:1	0.4977	NNL	2:1	0.0776	NNL
	Invertebrate density	4.76:1	0.2409	NNL	1:1	0.3268	NNL	2:1	0.3331	NNL
	Fish biomass	4.76:1	0.4851	NNL	1:1	0.7906	NNL	2:1	0.8187	NNL
4	Riparian coverage	1.09:1	0.327	NNL	1:1	0.2667	NNL	2:1	0.9842	NNL
	Invertebrate density	1.62:1	0.7373	NNL	1:1	0.9045	NNL	2:1	0.6423	NNL
	Fish biomass	1.62:1	0.2972	NNL	1:1	0.8362	NNL	2:1	0.1719	NNL
5	Riparian coverage	0.98:1	0.9868	NNL	1:1	0.6666	NNL	2:1	0.0001	NG
	Invertebrate density	4.79:1*	0.0524	NG	1:1	0.4188	NNL	2:1	0.1139	NNL
	Fish biomass	4.79:1	0.7441	NNL	1:1	0.5244	NNL	2:1	0.9479	NNL
6	Riparian coverage	0.06:1*	0.0001	NL	1:1*	0.0103	NL	2:1	0.6202	NNL
7	Riparian coverage	0.38:1*	0.0415	NL	1:1	0.4855	NNL	2:1	0.7673	NNL
	Periphyton biomass	1.65:1	0.7521	NNL	1:1	0.2735	NNL	2:1	0.8426	NNL
	Invertebrate density	1.65:1	0.8311	NNL	1:1	0.274	NNL	2:1	0.5191	NNL
	Fish biomass	1.65:1	0.4651	NNL	1:1	0.1865	NNL	2:1	0.7677	NNL
8	Riparian coverage	0.06:1*	0.0011	NL	1:1	0.4341	NNL	2:1	0.9897	NNL
	Invertebrate density	0.26:1	0.3191	NNL	1:1	0.4601	NNL	2:1	0.7227	NNL
	Fish biomass	0.26:1	0.3353	NNL	1:1	0.7581	NNL	2:1	0.8191	NNL
9	Riparian coverage	0.23:1*	0.0008	NL	1:1	0.1624	NNL	2:1	0.1086	NNL
	Periphyton biomass	0.53:1	0.1294	NNL	1:1	0.8587	NNL	2:1	0.2309	NNL
	Invertebrate density	0.53:1	0.398	NNL	1:1	0.2916	NNL	2:1	0.248	NNL
	Fish biomass	0.53:1*	0.0333	NL	1:1*	0.0422	NL	2:1	0.0777	NNL
10	Riparian coverage	1.0:1*	0.0023	NL	1:1*	0.0023	NL	2:1*	0.0112	NL
11	Riparian coverage	3.52:1*	<0.0001	NL	1:1*	0.0001	NL	2:1*	0.0001	NL
12	Riparian coverage	0.68:1	0.4781	NNL	1:1	0.4781	NNL	2:1*	0.0052	NG
	Invertebrate density	1.14:1	0.579	NNL	1:1	0.6143	NNL	2:1	0.4815	NNL
	Fish biomass	1.14:1	0.3896	NNL	1:1	0.2966	NNL	2:1	0.8097	NNL
13	Periphyton biomass	0.08:1*	0.0031	NL	1:1	0.2783	NNL	2:1*	0.0208	NG
	Invertebrate density	0.08:1*	0.0452	NL	1:1	0.7186	NNL	2:1*	0.0397	NG
	Fish biomass	0.08:1	0.1543	NNL	1:1	0.4096	NNL	2:1	0.9046	NNL
14	Riparian coverage	0.39:1*	0.0469	NL	1:1	0.4226	NNL	2:1	0.9268	NNL
	Periphyton biomass	0.5:1*	0.019	NL	1:1*	0.0216	NL	2:1*	0.0299	NL
	Invertebrate density	0.5:1	0.3743	NNL	1:1	0.2084	NNL	2:1	0.1608	NNL
	Fish biomass	0.5:1	0.5667	NNL	1:1	0.4871	NNL	2:1	0.4521	NNL
15	Riparian coverage	1.06:1	0.1633	NNL	1:1	0.1449	NNL	2:1	0.6769	NNL
	Invertebrate density	1.06:1	0.0781	NNL	1:1	0.0739	NNL	2:1	0.1924	NNL
	Fish biomass	1.06:1	0.203	NNL	1:1	0.1829	NNL	2:1	0.8192	NNL
16	Riparian coverage	0.64:1*	0.0002	NL	1:1*	0.0012	NL	2:1*	0.0411	NG

[a]For each compensation ratio, an asterisk indicates variables that differed between treatment and reference sites ($P < 0.05$).

determining differences in habitat productivity, the gross disparity in physical area of compensated versus impacted habitats was an overriding factor for many projects. Unquestionably it is exceedingly difficult to achieve equivalent habitat productivity when replacing only a fraction of the habitat impacted (Quigley and Harper 2005).

However, even if compliance was 100% it is unlikely that the compensation projects would have achieved NNL. Ambrose (2000) also demonstrated that compliance success does not ensure ecological success and highlighted the importance of quantitative rather than subjective evaluations. National guidelines recommend that DFO should "aim for minimum compensation ratios of 1:1" (DFO 2002a), yet in our study close to half of the projects would not have achieved NNL with this ratio. In order to achieve NNL, Minns and Moore (2003) advocate compensation ratios larger than 2:1.

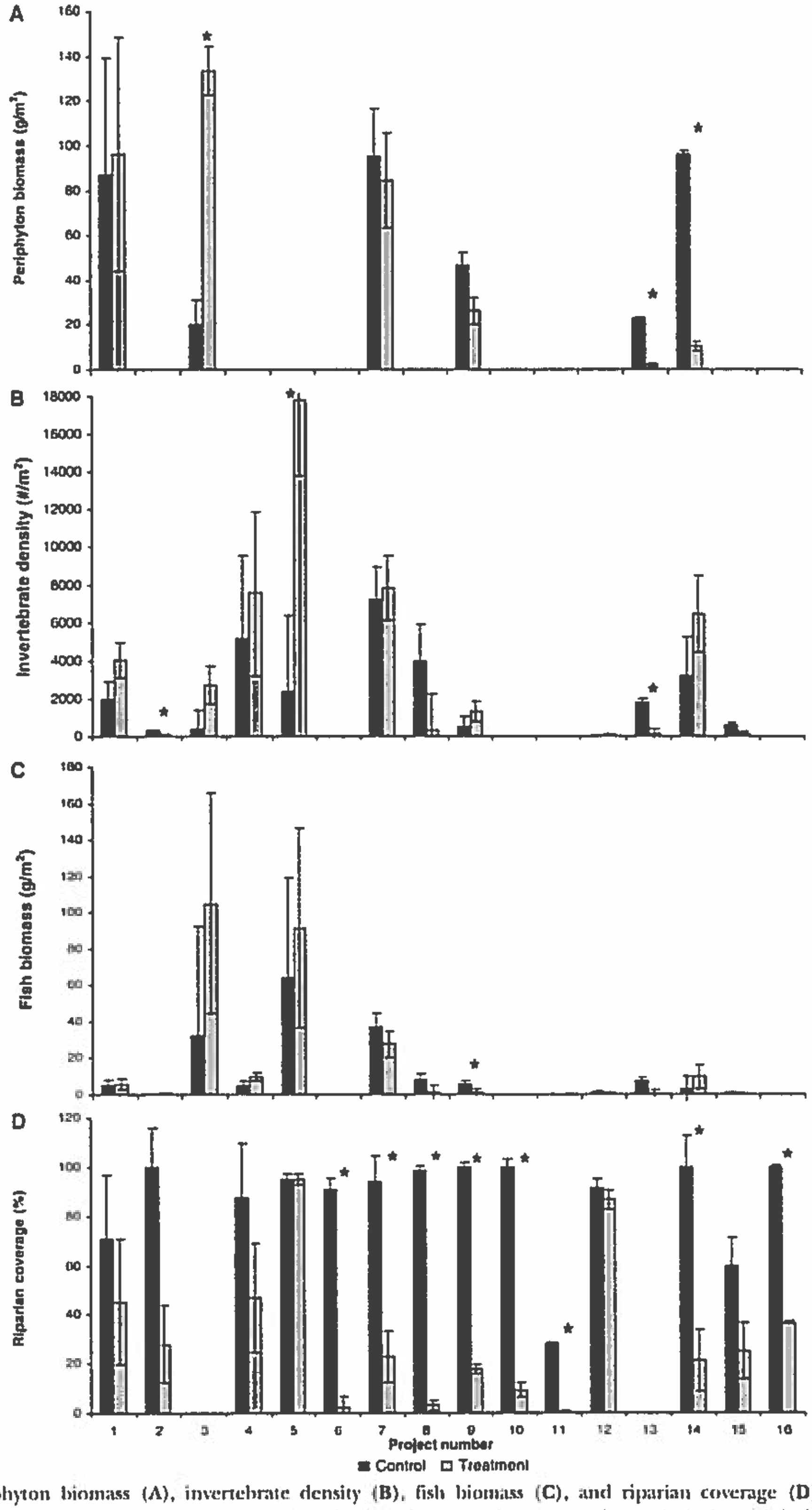

Figure 4. Periphyton biomass (A), invertebrate density (B), fish biomass (C), and riparian coverage (D) in control and treatment sites of compensation projects across Canada (based on actual compensation ratios). Asterisk indicates means that differed. Means are based on the number of reference and treatment sites in each project (n = 2–4). Error bars represent 1 SE.

Table 3. Analysis of variance model statistics, their degrees of freedom, and probability levels of significance for the diversity of fish, invertebrates, woody and nonwoody riparian species[a]

Project	Variable	*df*	*F* statistic	*P* value
1	Woody riparian	1,2	13.18	0.0682
	Nonwoody riparian	1,2	0.04	0.8532
	Invertebrate	1,2	0.18	0.7112
	Fish	1,2	0.34	0.6207
2	Woody riparian	1,2	1.46	0.3504
	Nonwoody riparian	1,2	8.54	0.0999
	Invertebrate	1,2	0.00	0.9786
	Fish	1,4	n/a	n/a
3	Invertebrate	1,2	1.71	0.3210
	Fish	1,2	1.88	0.3041
4	Woody riparian	1,2	3.75	0.1924
	Nonwoody riparian	1,2	0.06	0.8301
	Invertebrate	1,2	0.52	0.5459
	Fish	1,2	2.31	0.2678
5	Woody riparian	1,4	0.56	0.4944
	Nonwoody riparian	1,4	0.39	0.5669
	Invertebrate	1,4	0.09	0.777o
	Fish	1,4	3.65	0.1286
6	Woody riparian*	1,4	69.23	0.0011
	Nonwoody riparian	1,4	6.95	0.0578
7	Woody riparian	1,2	9.54	0.0908
	Nonwoody riparian	1,2	0.08	0.8017
	Invertebrate	1,2	0.08	0.8081
	Fish	1,2	0.17	0.7217
8	Woody riparian	1,2	0.14	0.7433
	Nonwoody riparian	1,2	1.02	0.4189
	Invertebrate	1,2	6.48	0.1258
	Fish	1,2	0.01	0.9182
9	Woody riparian	1,2	0.12	0.7577
	Nonwoody riparian	1,2	0.52	0.5466
	Invertebrate	1,2	1.47	0.3495
	Fish	1,2	1.00	0.4226
10	Woody riparian	1,2	4.49	0.1682
	Nonwoody riparian*	1,2	Infinity	<0.0001
11	Woody riparian*	1,2	199.17	0.0050
	Nonwoody riparian*	1,2	587.91	0.0017
12	Woody riparian	1,2	0.63	0.5101
	Nonwoody riparian	1,2	0.22	0.6823
	Invertebrate	1,2	0.44	0.5773
	Fish	1,2	0.00	1.000
13	Invertebrate	1,2	0.00	1.000
	Fish	1,2	0.00	1.000
14	Woody riparian	1,2	0.63	0.5092
	Nonwoody riparian	1,2	3.70	0.1942
	Invertebrate	1,2	1.62	0.3310
	Fish	1,2	0.06	0.8306
15	Woody riparian	1,2	1.73	0.3192
	Nonwoody riparian	1,2	2.27	0.2708
	Invertebrate	1,2	0.56	0.5314
	Fish	1,2	1.97	0.2954
16	Woody riparian	1,2	1.00	0.4226
	Nonwoody riparian	1,2	7.47	0.1118

[a]Asterisk indicates variables that differed between treatment and reference sites ($P < 0.05$). Note that Project 2 contained a single fish species in all sites rendering diversity comparisons between treatment and reference sites not applicable (n/a).

We found that although success improved with artificial ratios of 2:1, a substantial proportion of compensation projects still did not achieve NNL, a finding supported by others (Kistritz 1996). Thus, even if projects were entirely compliant and created twice as much compensation habitat compared to the HADD, the

Habitat Policy goal of NNL would still not always be achieved. This is alarming considering that the average compensation ratio for all projects completed in Canada between 1994 and 1997 was 1.1:1 (Harper and Quigley 2005a), indicating that many projects did not achieve NNL. In the present study, projects that successfully achieved a net gain in habitat productivity were characterised by actual ratios of approximately 5:1, although required ratios were up to an order of magnitude larger for these projects. The need for larger compensation ratios has been echoed in the United States (Allen and Feddema 1996; Brown and Lant 1999).

Based on the simple metric of habitat area, it would appear that Canada should be achieving a net gain of habitat productivity (Harper and Quigley 2005a). However, upon closer analyses, the actual areas of compensation habitats are much less than required and actual HADD areas are much larger than that stated in authorisations (Quigley and Harper 2005). Poor compliance rates, and the inability of file reviews to determine actual gains in habitat areas, are common findings in the United States as well (Ambrose 2000; Zedler and others 2001). In Canada, not only is NNL not being met spatially, but it is also not being achieved temporally and functionally. Temporal losses of habitat productivity are inevitable when compensation habitats are developed after the HADD occurs. Furthermore, temporal losses are exacerbated due to the time lag until compensatory habitats function ecologically in a manner comparable to preimpact conditions. In many cases, the time lag may be considerable because some projects will likely never achieve equivalent functionality. Time between HADD occurrence, compensation development, and compensation functionality was not a leading (and in many cases present) consideration in the authorisations we studied. Similar shortcomings have been identified in the United States (Brown and Veneman 2001; Kunz and others 1988; Zedler 1996).

It seems clear that compensatory works were not successful in completely offsetting the losses of habitat, although they were successful in slowing the rate of habitat loss. This is not altogether surprising, considering the general consensus of habitat managers in Canada is that DFO is not achieving NNL (DFO 1997; Metikosh 1997). Most fish habitat managers and scientists agree that we are losing, and will continue to lose, habitats and species if the magnitude, frequency, and type of anthropogenic disturbances continue (Applegate and others 1996).

However, limited success in achieving NNL to date does not erode or invalidate the value of this goal of the Habitat Policy; rather, it provides an impetus for change. It is important to note that in our study, more than one third of projects evaluated achieved either a net gain or NNL in habitat productivity, indicating potential to build on these successes. Challenges in achieving functional equivalency at compensatory habitats have also been reported in the United States (Sudol and Ambrose 2002), and recommendations for improvement have been compiled (Zedler and others 2001). It is conceivable that NNL may be attained if some fundamental changes to compensation science and institutional approaches are incorporated into DFO's habitat management program. Modifying management approaches based on the results of monitoring and evaluation programs is a critical component of adaptive management, yet often neglected (La Peyre and others 2001). Although broad environmental policy reviews utilising ecological indicators at the national and international level are increasing, they have yet to be integrated into daily environmental decision-making (La Peyre and others 2001). It is critical for Canada's fisheries resources for DFO to engage and respond to feedback loops that foster the refinement, and in particular the implementation, of environmental policies.

Productivity can be considered the current yield of a habitat (Gordon and others 1997), whereas productive capacity incorporates the future potential. Our evaluations were only a snapshot in time, and it could be argued that some of the compensatory habitats will achieve NNL in the future or at a different season of the year. However, the HADDs exist year-round and will doubtless last into perpetuity in many cases. We would argue that compensatory habitats should offset the HADD today, tomorrow, and into perpetuity, rather than in any particular season or future period. Simply stated, compensatory habitat should be achieving NNL on any given day. Otherwise, Canada's habitat base will slowly erode due to accumulating temporal losses of fish habitat.

Lack of pre-impact assessment baseline data and limited monitoring data have challenged researchers' abilities to draw conclusions in NNL studies (Cole and Shafer 2002; Kentula and others 1992; Harper and Quigley 2005a). Only one compensation project we evaluated had quantitative pre-impact data (fish biomass), and none had previously determined reference sites. Ability to detect changes in productivity and power of statistical analyses would be greatly improved if reference sites (Brinson and Rheinhardt 1996) and quantitative pre-impact data were routinely required for compensation projects and rigorous experimental designs were employed in monitoring programs (Underwood 1991, 1993; Stewart-Oaten and Bence 2001; Pearson and others 2005).

The fact that we did not detect considerable differences in diversity of species may be due to the tendency for most of the projects to have implemented in-kind compensation (rather than like for unlike). This practice has been lauded due to its propensity to maintain biodiversity (Race and Fonseca 1996; Allen and Feddema 1996). Lack of an in-kind replacement policy in the United States has resulted in an increase in homogeneous wetland types and a decline in vegetation diversity (Allen and Feddema 1996). However, insistence on like for like in highly disturbed landscapes (such as urbanised areas) is not always advisable because the original landscape has essentially disappeared (Race and Fonseca 1996) and other ecological or biophysical bottlenecks may frustrate compensation attempts. Attention to limiting factors and compensation options lower on the hierarchy of preferences (DFO 1998) would likely be more successful in these instances.

In general, we found that compensation sites were selected opportunistically rather than based on ecological bottlenecks and potential for success, which influenced the success of compensation habitats in achieving equivalent productivity. Natural sites selected for compensation often had environmental and biological limitations that were largely ignored. For example, compensation sites selected for riparian planting tended to have very low success in the present study and others (Cole and Shafer 2002; Robb 2002; Race 1985). The difficulty in establishing vegetation at barren sites is not altogether surprising, because there are generally good reasons why riparian vegetation is not currently flourishing at these locations. An absence of vegetation maintenance programs such as irrigation, fertilisation, and weeding is likely a contributing factor. Vegetation survival and therefore replacement of functional values can be successful in compensation projects that employ maintenance programs (e.g., a large-scale drip irrigation system) (Allen and Feddema 1996; Sudol and Ambrose 2002). However, requiring sites that do not currently support riparian vegetation to be artificially irrigated may not be a wise strategy. If natural hydrologic processes do not support a riparian community, requirements to irrigate may only achieve a partial community and result in sites that are unlikely to be self-sustaining (Sudol and Ambrose 2002). Furthermore, considering poor compliance rates (Quigley and Harper 2005; Zedler and others 2001), irrigation may never occur or certainly be short lived and therefore the site will eventually revert to the natural community it supported prior to compensation efforts.

Our paper quantitatively examined four components of fish habitat, at three distinct trophic levels, to determine efficacy of compensatory habitat in replicating habitat quality. In our study, it appeared that indicators lower on the trophic level such as periphyton and invertebrates were more responsive and/or less variable and thus better at representing gross differences in habitat productivity than fish biomass. However, invertebrates and periphyton are rarely measured in assessments of compensatory projects (Breaux and Serefiddin 1999); rather, fish biomass (Scruton 1996; Scruton and others 1997) and vegetative cover (Allen and Feddema 1996; Breaux and Serefiddin 1999) have primarily been used to infer habitat productivity. Our multimetric approach provided a more complete picture of habitat productivity, rather than simply using fish biomass as an indicator. Invariably, habitat alterations do not exclusively affect a particular species in isolation of other biota (Minns and others 1996). Furthermore, fish can be rather poor indicator species because of their mobility, cyclical populations, exposure to confounding influences (ocean productivity, fisheries, etc.), and divergent life histories. Indeed, for anadromous species it is possible to have low escapements and pristine freshwater habitat, as is the reciprocal.

An array of ecological indicators is preferable to detect responses to habitat alterations (Minns and others 1996). In many cases, selecting one surrogate of habitat productivity, rather than an array of ecological indicators at different trophic levels, would have led to erroneous conclusions. For example, in Project 2, greater biomass of fish was measured at the impacted habitat (culvert) in comparison to the compensatory habitat. However, invertebrate density and riparian vegetation were all negligible at the HADD site in contrast to robust populations in the compensatory habitat. Had we only evaluated fish as an indicator, we would have missed important attributes of the ecological picture of this site.

Compensation science and institutional approaches need to improve in Canada if the conservation policy of NNL of habitat productivity is to be met, as evidenced by the compensation projects assessed in this study, of which only 37% achieved this goal. In the United States as well, replacement of functional values of wetlands has been limited (Sudol and Ambrose 2002; Ambrose 2000; Race and Fonseca 1996; Zedler and others 2001). Canada's poor performance in achieving NNL is especially sobering considering that our study only focused on site-specific impacts and ignored hydrological affects and disruption to landscape processes. Indeed, Hartman and Miles (1997) demonstrated that one of the earliest compensatory spawning channels (created in 1956) failed half a century later due to cumulative watershed impacts from other development activities. The NNL policy would be best practiced in a watershed or ecosystem-based management context to ensure that landscape processes that build and maintain habitats are considered. Although cumulative impacts due to poor performance of Section 35(2) *Fisheries Act* authorisations and associated compensation habitats are likely occurring, our study and the monitoring requirements for habitat compensation in Canada are poorly scaled to capture long-term (>50 yrs) and cumulative ecosystem effects.

Institutional shortcomings such as lack of monitoring and maintenance have been identified as the causes for poor compliance with required compensation areas (Shabman and others 1996; Brown and Lant 1999). Race and Fonseca (1996) argue that "concerns about function are eclipsed by concerns about generating habitat in the first place." The focus on habitat quantity only may be flawed because we demonstrated that artificially increasing compensation areas to ratios of 2:1, by itself, was not sufficient to achieve a net gain in habitat productivity for all projects. Likewise, Sudol and Ambrose (2002) demonstrated compliance with regulatory requirements was not sufficient to replace wetland functions in the United States. Clearly, the ability to replicate ecosystem function is limited, and both improvements in compensation science and institutional approaches are necessary. Recommendations to improve success include larger compensation ratios, creation and documentation of the functionality of compensation habitats prior to and concurrent with HADDs, maintenance programs, increased monitoring and enforcement, and attention to limiting factors on a watershed basis (Zedler and others 2001). Improvements in these areas will advance the success of habitat compensation toward NNL. However, it is important to acknowledge that it is simply not possible to compensate for some habitats. Therefore, the option to compensate for HADDs may not be viable for some development proposals demanding careful exploration of alternative options including redesign, relocation, or rejection. Failure to acknowledge the limitations of compensatory science will hinder Canada's efforts to conserve fish habitat and achieve the goal of NNL.

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Fisheries and Oceans Canada | Pêches et Océans Canada

301-5204 50th Ave.
Yellowknife, NT
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June 28, 2016

Your file *Votre référence*
EA1415-01

Our file *Notre référence*
08-HCAA-CA6-00114

Mackenzie Valley Environmental Impact Review Board
ATTN: Chuck Hubert
Senior Environmental Assessment Officer
P.O. Box 938, #200 Scotia Centre
5102-50th Ave., Yellowknife, NT
X1A 2N7

Dear Mr. Hubert:

Subject: Prairie Creek All Season Road Technical Session Undertaking #7

Fisheries Protection Program of Fisheries and Oceans Canada (DFO-FPP) would like to thank the Mackenzie Valley Environmental Impact Review Board (MVEIRB) for the opportunity to provide this undertaking, which arose from the Prairie Creek All Season Road Project technical sessions held June 13—16, 2016.

Undertaking 7

CanZinc, DFO and Parks Canada will communicate on outstanding information requirements and analysis related to fish and fish habitat loss/gain (including impacts of blasting), to enable DFO to reach a determination and inform the board prior to the hearing phase (before technical reports). DFN/LKFN would like to be part of this conversation as well – but not the technical aspects.

Fisheries and Oceans Canada Response

DFO-FPP held a conference call with Parks Canada and Canadian Zinc Corporation on Tuesday, June 28, 2016. The attached information package was provided to all parties, describing outstanding information requirements related to fish and fish habitat loss and gain, including the definition of floodplains. DFO-FPP recommended that a Blast Management Plan be developed by the proponent during the regulatory phase for review. Parties agreed to a follow-up call in July to discuss new information to be provided.

Additional Forms and Guidelines

DFO-FPP also provided to all parties the following regulatory forms and guidelines to all parties to give further guidance on the types of information required by Fisheries and Oceans Canada for projects under regulatory review.

- Request for Review Form. Available at: http://dfo-mpo.gc.ca/pnw-ppe/reviews-revues/index-eng.html
- Application for Authorization Form. Available at: http://www.dfo-mpo.gc.ca/pnw-ppe/reviews-revues/authorization-autorisation-eng.html
- An Applicant's Guide to Submitting an Application for Authorization under Paragraph 25(2)(*b*) of the Fisheries Act. Available at: http://www.dfo-mpo.gc.ca/pnw-ppe/reviews-revues/application-eng.html

If you have any questions, please contact Julie Marentette at 867-669-4934, or by email at Julie.Marentette@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with DFO-FPP.

Yours sincerely,

Martyn Curtis
A/Regional Manager, Regulatory Reviews
Fisheries Protection Program

ATTACHMENT LIST:
08-HCAA-CA6-00114 DFO Undertaking 7 Information Package.pdf

COPY LIST:
Julie Marentette (DFO)

Prairie Creek All Season Road – Technical Session Undertaking #7

Fisheries and Oceans Canada (DFO)
Information Package and Submission

Undertaking #7 states:

> *CanZinc, DFO and Parks Canada will communicate on outstanding information requirements and analysis related to fish and fish habitat loss/gain (including impacts of blasting), to enable DFO to reach a determination and inform the board prior to the hearing phase (before technical reports). DFN/LKFN would like to be part of this conversation as well – but not the technical aspects.*

DFO Information Requirements

The intent is to identify each individual impact of the proposed Road on fish-bearing water bodies (water crossing, encroachment, realignment, water withdrawal). This includes the type and size of the impact, the fish species affected and the type and amount of fish habitat affected.

DFO understands that information requested below will also relate to Undertakings 4, 9, 23 and 26.

If information such as the most recent or applicable habitat assessment or engineering design is contained within the DAR, DAR Addendum, associated Appendices or Information Request responses, the appropriate link to an individual crossing, encroachment or realignment may be provided in a table.

<u>Information Requirements for each Impact</u>

- Name and type of waterbody, and location
- Size of the impact (in m^2) below the high water mark (HWM)
- Whether the impact constitutes habitat destruction or permanent alteration

- Describe the aquatic environment at the site of the proposed work, undertaking, or activity (WUA), including the floodplain
    - Fish species present, including life-stage
    - Fish habitat, including depth, substrate, cover, vegetation, flow regime, etc. If multiple types of habitat are affected (e.g., stream channel versus floodplain), then these should be clearly differentiated

Water Crossings

- Type, location and size of each crossing, number of pipes if culvert-based
- Footprints of habitat destruction and alteration (including abutments, and any infilling attributed to rip rap or dike construction within the stream channel or floodplain)

Road Encroachments

- Type, location and size of each encroachment i.e., the length along the road and along the impacted stream)
- Footprints of habitat destruction and alteration (e.g., infilling attributed to road prism or armouring within the stream channel or floodplain)

Stream Realignments

- Type, location and size of each realignment (i.e., the length along the road and along the impacted stream)
- Footprint of newly-constructed or excavated channel, including a description of the fish habitat created (depth, substrate, flow, etc).
- Footprints of habitat destruction and alteration (e.g., infilling of impacted channel, or habitat that will undergo alterations to flow regime in the impacted channel if that channel is still expected to contain water during freshet or floods)

Water Withdrawals

- Name, location, type and size of waterbody (including mean/maximum depth, volume, bathymetry)
- Fish species present
- Volume and timing of withdrawal
- Change in depth expected for maximum predicted water withdrawal

- Any predicted negative impacts to fish habitat

Suggested Table

Please see attached Excel sheet for an example table.

Forms and Guidelines

These are intended to give further guidance on the types of information required by Fisheries and Oceans Canada for projects under regulatory review.

- Request for Review Form (attached)
- Application for Authorization Form (attached)
- An Applicant's Guide to Submitting an Application for Authorization under Paragraph 35(2)(b) of the *Fisheries Act* (November 2013; attached)

Fish Habitat Definitions (DFO's Request for Review)

Fish habitat: Means spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes.

High Water Mark: The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to leave a mark on the land.

Permanent alteration to fish habitat: An alteration of fish habitat of a special scale and a duration that limits or diminishes the ability of fish to use as spawning grounds for nursery or rearing, or as food supply, or as a migration corridor in order to carry out one or more of their life processes.

REQUEST FROM DFO: A precise definition for key terms used to categorize floodplains (active, secondary, braided, old, historic) is also requested, along with photographs that clearly show how floodplain types are delineated. Is there a distinct type of vegetation that categorizes old or historic floodplain?

Fisheries and Oceans Canada | Pêches et Océans Canada

301-5204 50th Ave.
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June 28, 2016

Your file *Votre référence*
EA1415-01
Our file *Notre référence*
08-HCAA-CA6-00114

Mackenzie Valley Environmental Impact Review Board
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