ASSESSMENT REPORT on YEAR-2008
Environmental Baseline Investigations and other work
Completed on Property Access Route

on the

NORTHERN DANCER PROPERTY

NTS Sheet 105B/4

Latitude 60°00'10"N; Longitude 131°37'00"W

100% Owner: Archer Cathro & Associates (1981) Limited
for **Strategic Metals Ltd.**

Operator: Largo Resources Ltd.

in

British Columbia, Canada

February 9, 2009

For: Largo Resources Ltd.
65 Queen Street West
Suite 820, P.O. Box 71
Toronto, Ontario M5H 2M5
Tel (Office): (416) 861-5896
Fax: (416) 861-8165
rcampbell@largoresources.com

By: Kevin Brewer
Project Manager, Northern Dancer Project
Largo Resources Ltd
3151 B 3rd Ave
Whitehorse, Yukon Y1A 3M5
Tel: 867-633-4260
Fax: 867-668-7127
kbrewer@largoresources.com

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1.0 Introduction

Largo Resources Ltd. is the operator of the Northern Dancer project hosting the Northern Dancer tungsten-molybdenum deposit, located along the north side of the Yukon-British Columbia border about 240 kilometres east of Whitehorse, Yukon, Canada.

In 2008 Largo conducted a diamond drilling program of approximately 11,509 metres on the property area within Yukon, focusing primarily on upgrading of the resource classification of the deposit. In addition, Largo completed several environmental baseline studies and investigations on potential tailings sites in locations within British Columbia.

This report will document the environmental baseline investigations and tailing site assessment activities along with a detailing of expenditures of activities that took place within British Columbia.

This report was written to satisfy requirements by the Northwest Regional Office, Minerals Titles Branch, Department of Energy Mines and Resources, Government of British Columbia.

1.1 Underlying Agreements

On February 15, 2006, Largo entered into an option agreement with Strategic Metals Ltd, to acquire an initial 70% interest in the Dansar 1-23 claims and three land tenures through completion of CDN$5.0 million in exploration expenditures by the third anniversary of the agreement (April, 2009), including $1.5 million incurred by the first anniversary. The agreement included issuance of 2,000,000 common shares to Strategic Metals upon execution of the agreement, followed by a further 1,000,000 common shares for each of the next two anniversary dates, for a total of 4,000,000 common shares. Strategic Metals retains a 3% Net Smelter Royalty (NSR), 2% of which may be obtained by Largo. Within 12 months of earning the initial 70% interest, Largo has the right to purchase the remaining 30% interest in the property for an additional $5.0 million or equivalent value in stock.

1.2 Involvement of the Qualified Person

Mr. R. Campbell, Vice President of Exploration and Qualified Person for the project, conducted a number of property visits of several days each, during 2008.

Kevin Brewer, a Registered Professional Geoscientist with the British Columbia Association of Professional Engineers and Geoscientists, is the author of this report. Mr Brewer was the General Manager on a contract basis through mineral exploration contracting firm 39627 Yukon Inc. Mr. Brewer was on site for roughly 40% of the field portion of the program, extending from May 15 to September 28, and managed all aspects of the field program and subsequent report for efforts in British Columbia.

2.0 Property Location and Claim Blocks

The Northern Dancer property consists of 23 full and fractional quartz mining claims covering roughly 420 hectares (1,037 acres) in Yukon and three land tenures covering 1150.8 hectares. The property is accessible by a rough road extending north from the Alaska Highway. Largo Resources is also the operator of three adjoining mineral tenures contiguous with the Dansar block; these extend along the access road within the British Columbia side of the border.

The three land tenures included within British Columbia are:

Name	**Tenure No.**	**Ha**
Logtung 1	509951	388.69
Logtung 2	527199	405.19
Logtung 3	527200	356.97

2.1 Claim Status

The following table provides a summary of the claim status for the land tenures in British Columbia

Table 1: Land Tenure Status, as of February 9, 2009

Northern Dancer Project, Largo Resources Ltd.

Tenure No's	Claim Names	Issue date	Good to date
509951	Logtung 1	31/03/2005	14/03/2013
527199	Logtung 2	07/02/2006	07/02/2009
527200	Logtung 3	07/02/2006	07/02/2009

* Good to dates prior to submission of assessment report

3.0 Access, Physiography and Climate

The Northern Dancer property straddles a north-northeast trending ridge separating the headwaters of West Logjam Creek, flowing to the southeast, from a tributary of Two Ladders Creek, unofficially known as "Marilyn Creek", which flows to the northwest. The terrain is fairly steep, with some inaccessible areas particularly along the northwest side of the ridge, although most of the southeast facing side and lower elevations to the northwest at the headwaters of Marilyn Creek are accessible. Elevations within the Yukon property portion range from about 1,350 metres to roughly 1,750 metres towards the southwestern boundary. The ridgeline has an average height of about 1,600 metres.

Stunted sub-alpine forest extends to about the 1,500 meter level along the southeast side; the rest of the property is covered by alpine tundra vegetation or is essentially un-vegetated. The entire area has been glaciated.

The climate is sub-alpine, with abundant rainfall and snowfall, particularly by Yukon standards. The area is covered by snow from late September to early June; snowfall amounts typical exceed 2.0 metres by late March.

The property is accessible from about early June to late September by a 13-kilometer access road extending north from the Alaska Highway at Km 1176. The Alaska Highway is a major roadway linking Alaska and the Yukon with southern Canada. The access road is somewhat rough, and is intended for 4 x 4 vehicles, although it has been improved through regular maintenance and at times may also be suitable for two wheel drive vehicles with good clearance. It is also usable by larger service vehicles. The road was upgraded somewhat in 2007, with the installation of culverts at all sizable stream crossings, and a clear-span bridge across West Logjam Creek about 1.5 km south of the Yukon-B.C. border.

The operations camp was located just north of the border in Yukon. The access road extends from this point to the deposit area, and extends across the ridge to the northwest side. The road is inaccessible until early June, with the northwest side inaccessible until late June unless plowed.

The property covers previous underground workings by Amax Potash Ltd, which excavated about 494 metres of underground workings. Tailings, sorted into several rows according to depth of excavations, are located along a flat area near the adit mouth. No visible acid mine drainage is emanating from the adit mouth, although a small amount of seepage of clear water does occur. No tailings areas occur on the property.

Flat areas within the property occur along both flanks of the ridge, although these are likely to be too small to host sizable mill and other infrastructure workings, and are certainly too small to host large tailings impoundments. The nearest electrical infrastructure is at the Village of Teslin about 75 kilometres to the west; however, this community obtains its power from an electrical grid based at Whitehorse. Electrical power is also available at Watson Lake, roughly 160 kilometres to the east. Neither source can currently supply adequate power for future mining operations. Water is fairly abundant within property boundaries, although no streams extend across the deposit itself, due to its location along a height of land. Some drill sites require water to be trucked, rather than pumped, to the site.

A limited work force is available in the Village of Teslin, population about 500. A much larger workforce, including skilled personnel, as well as complete service facilities, exists at Whitehorse, roughly 240 km west of the Northern Dancer site. Whitehorse has a major international airport, and is located along the Alaska Highway.

4.0 History of Exploration

The following section is based largely on the January, 2007 assessment report authored by D. Eaton on 2006 activities by Strategic Metals and Largo Resources. Additional information is provided in a 1984 report by Noble, Spooner and Harris.

Exploration in the Northern Dancer area focused initially on lead-zinc-silver veining roughly 3 km to the northeast, within the present "Logjam" property. The Hudson Bay Exploration and Development Company Ltd conducted 2,070 metres of diamond drilling and 763 metres of underground workings from 1944 through 1967 (Noble, Spooner and Harris, 1984).

Exploration within the present property boundaries began in 1975, when Cordilleran Engineering, in service to the Bath Uranium Partnership, identified anomalous tungsten values from stream sediment sampling along West Logjam Creek. The following year Bath traced the anomalies to the now-delineated Northern Dancer deposit and staked a large claim block straddling the B.C.-Yukon border. Following preliminary prospecting, ownership of the property was transferred to Logjam Resources Ltd., which optioned it to Amax Potash Ltd in 1977. Between 1977 and 1981 Amax built the road to the property and conducted geological mapping, soil geochemistry, IP surveying, and completed 11,869 m of diamond drilling in 51 holes. Amax also excavated 496 metres of underground workings and, from this, obtained a bulk sample for metallurgical testing. Amax also released a resource estimate of 162 million tonnes grading 0.13% WO_3 and 0.052% MoS_2 (Noble, Spooner and Harris, 1984).

Although surface work was done on both sides of the border, only four holes totalling 474 m were collared on B.C. claims. Most of the drilling focused on the present deposit area about 300 metres north of the B.C.-Yukon (Eaton, 2007).

In 1983 Amax transferred its interest to Canamax Resources Inc. which then prepared a preliminary feasibility study that concluded the deposit was uneconomic. In 1984 airborne magnetic and electromagnetic surveys were conducted. Canamax dropped its option in 1986, allowing most of the Yukon and all of the B.C. claims to lapse (Eaton, 2007).

In 1993 NDU Resources Ltd. optioned the remaining claims for the bulk tonnage gold potential, modeled on the Fort Knox Deposit in Alaska (Eaton, 1994). That program consisted of soil geochemical surveys and prospecting on both sides of the border plus 234 metres of diamond drilling in two holes. Soil sampling outlined large areas of moderately to strongly anomalous tungsten, bismuth and gold values; however results from surface rock sampling and drilling were disappointing. The option was allowed to expire (Eaton, 2007).

In 1998 Nordac Resources Ltd. (renamed Strategic Metals Ltd. in 2001) re-staked the deposit and performed additional prospecting and limited rock sampling, directed primarily toward beryllium potential. Strategic conducted a digital data compilation and performed more prospecting in 2001 (Eaton, 2002), prospecting and hand trenching in 2003 (Eaton, 2004), and excavator trenching and road construction in 2004 (Eaton, 2005).

Largo Resources Ltd. entered into its current option agreement with Strategic Metals in February 2006. During the 2006 field season, Largo conducted a 17 hole, 3,943.8 m diamond drill program, focusing on upgrading of the resource estimate to be in compliance with standards of National Instrument 43-101. Following this program, Largo released an updated resource estimate consisting of an inferred resource of 242.0 million tonnes grading 0.10% WO3 and 0.047% MoS2 (Largo News Release April 2, 2007).

In 2007 Largo conducted a diamond drilling program of 8,494 metres in 26 holes, focusing primarily on upgrading of the resource classification of the deposit. As a result, on April 10, 2008, Largo released resource upgrade figures, consisting of an indicated resource of 140.8 million tonnes grading 0.10% WO_3 (tungsten tri-oxide) and 0.026% molybdenum (Mo), with an additional inferred resource of 253.2 million tonnes grading 0.10% WO_3 and 0.022% Mo. Largo initiated metallurgical testing through SGS Laboratories of Waterloo, Canada and other research on the potential economics associated with the project. They also made various improvements to the access road including the installation of culverts and minor creek crossings and a bridge crossing on the upper portion of Logjam Creek.

In 2008, Largo continued its advanced exploration effort. A diamond drilling program of 11,509 metres in 38 holes focused on continuing to upgrade the resource classification and overall grade/tonnage of the deposit, and as well to identify and delineate higher grade zones of tungsten and molybdenum mineralization. Other work conducted included the initiation of environmental baseline studies (water quality, fisheries and wildlife investigations), ongoing road maintenance and improvement, a preliminary evaluation of the access route and aggregate quality assessment, and an assessment of potential tailings sites.

A portion of these activities were conducted within the three tenures in British Columbia currently owned by Strategic Metals Ltd and option to Largo Resources Ltd. with the exception of the drilling which was completed in Yukon and will therefore not be detailed in this report.

This report is prepared to meet the reporting requirements of the Minerals Title Online Division in northern British Columbia.

5.0 Geology

5.1 Regional Geology

The Northern Dancer property is located within a thrust-fault bounded package of Carboniferous volcanic and sedimentary rocks of the Quesnellia terrane. The Quesnellia terrane, an adjoining package of Yukon –Tanana Terrane immediately to the southwest, and a package of Slide Mountain terrane just to the northeast, form part of a major sequence of accreted super terrane along the southwest side of the Tintina Fault about 110 km to the northeast. The northwest-southeast trending Tintina Fault separates the accreted terrane from the Ancient North American Continent, with a dextral displacement of about 450 km. Tectonic activity within the accreted terrane, as well as deformation, commenced during the early Mesozoic; accretion onto the ancient continent occurred during early Tertiary time.

More specifically, the Northern Dancer property is underlain by the Mississippian Klinkit assemblage, consisting primarily of mafic volcanic, epiclastic sediments, phyllites and quartzites, and carbonate lenses (Open files 3754, 2001-1, GSC), the latter two categories underlying much of the immediate area. Carbonate units are comprised largely of sandy limestones and dolomites, interbedded with graphitic argillites and phyllites (Noble et al, 1984); quartzites also comprise a major constituent.

The Carboniferous stratigraphy has undergone intrusion by two major suites of intrusive rocks. The earlier suite consists of diorites to ultramafic intrusions given a Jurassic age based on K-Ar age dating of comparable intrusions in the Jennings River area (Gabrielse, 1968 and Abbott, 1981), although diorite dykes in the area were given a Triassic age of 245 +/- 32 million years (Stewart, 1983). The younger intrusions have been categorized as belonging to the mid-Cretaceous Cassiar Suite, consisting primarily of porphyritic quartz monzonite to monzodioritic intrusions (Noble, et al, 1084) with an age range of 100 to 120 million years. This suite includes the Seagull Batholith about 10 km to the northeast, which straddles the boundary between Quesnellia and Slide Mountain terrane rocks.

5.2 Property Geology

The property is located within a fault-bounded package of Quesnellia Terrane volcanic, limestone and calcareous clastic sedimentary rocks, comprising part of the accreted terrane bounding the southwest side of the Tintina Fault. Two major intrusive events resulted in emplacement of a suite of Jurassic ultramafic to dioritic intrusions, followed by the mid-Cretaceous Cassiar Suite of porphyritic quartz monzonite to monzodioritic intrusions, including the Seagull and Hake Batholiths.

Specifically, the property covers a package of limestone through silty limestone and calcareous fine clastics intruded by a Jurassic diorite stock in the southwestern area. A Cretaceous quartz monzonite stock occurs just south of the border, and is likely comagmatic with a felsic porphyritic dyke system northeast of the diorite stock. The porphyry dyke system is central to the deposit, which extends north-northeast from the diorite stock for roughly 1,200 metres along a northeast trending ridgeline. The deposit, essentially representing a porphyry-style setting, is hosted by several lithological settings, including the dyke system and adjacent "skarn" mineralization within altered calcareous sediments.

In addition to the further upgraded resource estimate of April 10, 2008, Largo concluded that potential remains for enlargement of the known deposit dimensions, particularly along flanks of the ridge. Several holes also returned higher grade tungsten intercepts at shallower depths than expected, indicating potential for shallow higher grade zones. Mineralogy, occurring within four vein sets, is influenced by host lithology. The skarn setting is the only one to host an abundance of all four vein sets. Molybdenum, occurring primarily as quartz-molybdenite veins, is controlled by the central porphyry dyke system, with Mo grades increasing with depth. Mineral potential also occurs in areas outside of the deposit, including the vicinity of the Marilyn Creek occurrence identified in 2007.

As previously noted, the primary focus of the 2008 program was on a diamond drilling program of approximately 11,800 metres, designed to confirm and up-grade the classification of the existing resource base to the Measured and Indicated categories. Largo also initiated a Preliminary Economic Assessment with associated metallurgical reviews, project engineering, and marketing studies, to determine future or advancement of the project. The study has not yet been completed but will include a preliminary economic evaluation involving all main parameters ranging from actual mining to marketing and sale of products, and conceptual engineering and site layout.

5.3 Mineralization

The Northern Dancer deposit forms a kidney-shaped zone centered on a porphyritic quartz monzonite dyke system north of the Yukon – BC border, roughly 500 metres outbound of the Cretaceous quartz monzogranite stock. The zone extends north-northeast from the earlier Jurassic diorite stock a distance of roughly 1,200 metres, somewhat beyond the limits of the porphyry dyke system. Earlier workers state the porphyritic dykes are Cretaceous, and thus coeval with the stock (Noble, et al, 1984) although later workers ascribe an early Tertiary age for both intrusive systems (Eaton, 2007); both estimates indicate the dykes and stocks are comagmatic. The essentially unmineralized monzogranite stock contains highly anomalous levels of primary tungsten, averaging 111 ppm (9 determinations) and attaining 510 ppm, and molybdenum, averaging 46 ppm, up to 235 ppm. This strongly suggests the stock is the source of W-Mo mineralization, hydrothermally transported from it into the porphyry dyke system and adjacent reactive sediments (Noble et al, 1984).

Mineralization is hosted largely by the multi-episodic vein system crosscutting the stock and calc-silicate-altered calcareous units. Much of the veining comprises a sheeted vein system, oriented at about 020°E, and dipping steeply southward. Veins are largely of centimetre to sub-centimetre scale, although thicker veins in the 5-10-cm range are common, particularly within the Jurassic diorite stock in southwestern areas. One vein averaging about 30 cm in thickness extends north-northeast for several hundred meetings from the diorite stock north-northeast into the calcareous sediments.

At least four major episodes of veining, caused by repeated pulses of hydrothermal fluid emplacement following fracturing of the host stratigraphy, have been identified.

Largo has released three resource estimates on the Northern Dancer deposit in April 2007, April 2008 and as recent as March of 2009. The latest release noted that at a cut-off grade of 0.06% WO3, **Measured** mineral resources were estimated at 30.8 million tones grading 0.114% WO3 and 0.030% Mo, and **Indicated** mineral resources of 192.6 million tones grading 0.100% WO3 and 0.029% Mo. The Measured and Indicated mineral resource estimate contains 500.1 million pounds of WO3 (226.9 k tonnes) and 143.8 million pounds of Mo (65.2 k tonnes). Inferred mineral resources were estimated to be 201.2 million tonnes grading 0.089% WO3 and 0.024% Mo containing 393.1 million pounds of WO3 (178.3 k tonnes) and 107.7 million pounds of Mo (48.9 k tonnes).

Of significance is that the 2008 drilling program provided a much better definition of the higher grade zone within the deposit, which is estimated to contained a Measured and Indicated resource of 60.3 million tonnes grading 0.137% WO3 and 0.045% Mo (WO3 equivalent 0.215%) and an Inferred mineral resources of 5.4 million tonnes grading 0.134% WO3 and 0.047% Mo (WO3 equivalent 0.214%) at a 0.17% equivalent WO3 cut-off grade.

This drilling indicated that the higher grade zone averages 50 metres in width, extends along strike for approximately 1,200 metres and extends from surface to an average depth of 350 vertical metres. This higher grade zone is consistently mineralized over the full extent drilled to date and is open along strike to the southwest and at depth. Soil geochemical work indicates that the mineralized system likely extends for at least a further 400 metres along strike.

6.0 Work Program

6.1 Personnel

39627 Yukon Inc. managed camp construction, on-site operations and de-mobilization, as well as post-season core logging and sampling, under direction of Mr. Robert (Andy) Campbell, Vice President - Exploration and Qualified Person for the Northern Dancer project.

The following personnel were employed by or sub-contracted to Largo Resources Ltd.:

Kevin Brewer:	General Manager
Farshid Ghazanfari:	Geological Technical Coordinator
Thomas Clarke:	Geologist
Parviz Rajaei:	Geologist
Fredy Marino:	Geologist
Laragh Taylor:	Geotechnician
Ronald (Gus) Morberg:	Geotechnician
Morgan Smarch:	Geotechnician
Andrew Barnett:	Core Cutter
Josh Lamb:	Core Cutter
Earl Douville:	Core Cutter

Matthew Campbell:	Core Cutter
Arthur Johnston:	Core Cutter
Ryan Clark:	Core Cutter
Tom Dickson:	Core Cutter
Eric Francoeur:	Core Cutter
Robert A. Campbell:	Core Cutter
Kyle Smith:	Core Cutter
Daniel Smarch:	Core Cutter
Randy Douville:	Core Cutter
Cody Nadeau:	Core Cutter
Benjamin Vinet:	Core Cutter/Asst Cook
Casey Cardinal:	Technician
Lisa Prosser:	Asst Cook
Jacqueline Hanna:	Cook
Joyce Douville:	Cook
Scott Baker:	Asst Camp Manager
Riley Gibson:	Camp Manager/Geotechnician
Rob Gareau:	Camp Manager

Grocery services were provided by Sunspun/Superstore and Nisutlin Trading Post of Teslin; some other expediting was provided by Small's Expediting Services of Whitehorse.

6.2 Work Program

The work program in 2008 included an:

- Geological investigations including an 11,509 meter drill program;
- Preliminary engineering studies in support of the completion of a "Scoping Study"/Preliminary Economic Assessment;
- Environmental baseline studies;
- Tailings site assessment study;
- Access Road and Aggregate Quality Investigation; and,
- Access Road Maintenance.

As previously noted, the geological investigations and drill program were not completed on land tenures in British Columbia, and the applicability of the Scoping Study is difficult to apply costs to land tenures. Therefore, neither of these activities will be further described in this assessment report nor any associated expenditures.

Environmental baseline studies including water sampling, fisheries studies, and wildlife investigations. They were conducted by a team of personnel from Access Consulting Ltd., Whitehorse, Yukon.

Assessment of potential tailings sites was conducted by Mr. John Lemieux, Journeaux, Bedard & Assoc. Inc., Point Claire, Que.

An assessment of the access route including a preliminary examination of the suitability of aggregate sources for construction and road building purposes was completed by Mr. Erik Nyland, P.Eng, Whitehorse, Yukon.

Maintenance of the access road was completed by several subcontractors including Kluane Drilling Limited, and local contractors in Teslin and Snow Lake.

7.0 Environmental Baseline Studies

Environmental baseline studies during the 2008 field program comprised of:

- Water sampling program of all drainages from the Northern Dancer deposit and some regional testing sites;
- Fisheries investigations of the proposed access route and primary drainages in the local watershed; and,
- Wildlife investigations of the local watershed and outlying areas.

7.1 Water Sampling Program

In April of 2008, Largo Resources Ltd. (Largo) contracted Access Consulting Group ('Access') to develop and implement a baseline environmental monitoring program in support of their Northern Dancer Project (Project) in the south central Yukon. The following memorandum provides a brief summary and analysis of the field activities and data collected under the water quality and fisheries components of this program. Although hydrology and wildlife studies were also undertaken, they are not addressed herein.

As part of the field baseline studies, Access conducted site visits in 2008 on the following dates:

- June 16, 2008 (Water Quality, Fisheries)
- July 12, 2008 (Water Quality)
- August 13, 2008 (Water Quality)
- September 25, 2008 (Water Quality)
- October 1, 2008 (Fisheries)

7.1.1. Sampling Procedure

All samples were collected using standard field and custody QA/QC measures, and were analyzed at Maxxam Analytics Inc. in Burnaby, British Columbia for the following parameters:

- Physical parameters (conductivity, pH, total suspended solids, colour, hardness, total and dissolved solids, turbidity);
- Nutrients (ammonia, nitrogen, phosphate);
- Organics (alkalinity, hydroxide, carbonate, total organic carbon);
- Cyanide; and,

- Total and dissolved metals (suite of 33 metals, including all parameters found in the CCME and MMER guidelines).

All data is summarized in table format along with the detailed sampling procedure and is included in Appendix 5.

7.1.2 General Description of Site Water Quality

In all sampling events over three different periods, water quality has been considered typical of streams in undisturbed, alpine drainages underlain primarily by igneous and metamorphic rock. The water was soft, weakly buffered and low in dissolved solids with pH in the range of 6.7 to 8.35. Hardness, alkalinity and dissolved solids fluctuated in concentration in an inverse manner to stream flow – indicating dilution from runoff during high flow periods, and the greater influence of groundwater during low flow periods. In the headwater creeks, chemical constituents were slightly elevated, but, with few exceptions, were indicative of good quality water for supporting aquatic life – only aluminum approached lethal threshold levels for fish. The 2008 sampling program conducted a more consistent sampling effort of water chemistry over the spring-fall period. A more diligent testing regime was also implemented during this testing program which is described in Section 7.1.4.

7.1.3 Sampling Station: ND-LJ2.5

Sampling station ND-LJ2.5 is located 100 metres southeast of the bridge crossing on the Northern Dancer access road and was the only sampling site within the claim tenures in the Province of British Columbia. Access to the station is located at km 11, where the main access road forks. Follow the road that follows in a northeasterly direction. The ND-LJ2.5 sampling station is located adjacent to this access road. Flagging is well defined and easy to see. This station is located downstream from the main camp and exploration area. This station is located south of the Property, adjacent to the main access road to the Property. This stream drains the southeast area of the deposit and the camp area, which is at its headwaters on the divide between the Two Ladder and Logjam Creeks.

ND-LJ2.5– looking upstream

ND-LJ2.5 – looking downstream

7.1.4 Water Quality Results

Access collected water quality samples at 13 sites covering all drainages associates with the Northern Dancer site and regional test locations. The locations of these sites are indicated on the map attached (see Map 1, Appendix 8).

Sites were chosen to include:

- downstream areas in drainages that have the potential to be affected by exploration activities and/or future mine development; and,
- reference sites upstream of any potential development, whose data would be useful in determining if changes in water quality were development related.

Once the test results were received, Access completed a comparative analysis of 2008 water quality data with both Metal Mining Effluent Regulations (MMER) *Schedule 4: Authorized Limits of Deleterious Substances,* and Canadian Council of Ministers on the Environment (CCME) *Guidelines for the Protection of Freshwater Aquatic Life.*

Although the Project is not currently subject to authorizations with associated discharge criteria (MMER or Water Licences), the MMER limits were included for comparison with a view towards providing a comprehensive water quality description of the local watershed for potential project permitting. While some water quality parameters did exceed CCME guidelines, it is important to that these are in fact guidelines only, and not enforceable criteria.

All parameters for all samples and sites were below the MMER limits for deleterious substances. Notable comparisons with the CCME guidelines are summarized as follows:

- Two Ladder Creek contained elevated levels of cadmium and selenium at all three stations (including reference) indicating natural metal loading of this system, presumably from host mineralization in the upper reaches of the drainage;
- Some stations on Smart River and North Creek (ND-SM 1.5 and ND-NC1 .5 respectively) returned slightly elevated concentrations of selenium and cadmium; this load in Smart River at ND-SM 1.5 is likely due to the influence of Two Ladder Creek;
- One station located on Logjam Creek (ND-LJ2.5), 500 meters below the bridge crossing on the access road to the camp, contained elevated levels of aluminum (2 events) and cadmium (all 4 events). In addition, the analysis of samples collected on July 13, 2008 returning elevated levels of aluminum, cadmium, chromium, copper, iron and lead. This may have been a result of peak natural runoff conditions as an elevated total suspended solids (TSS) concentration of 25 mg/l was also noted at that sampling event;
- The peak of total suspended solids was possibly influenced by upstream disturbances associated with increased levels of activity on the access road and exploration trails to drill sites;

- Upstream reference and downstream water quality parameter concentrations for Log Jam Creek were all below CCME guidelines; and,
- All results from Screw Creek sampling returned results below CCME guidelines;

These data show natural related exceedencies of CCME guidelines. Natural exceedencies of aluminum, cadmium, copper, and selenium were documented by Nordin (2006) on a water sample collected on the northern side of the Northern Dancer deposit. As this locality was isolated from all project related activities, it clearly indicates that elevated exceedencies of various elements result from natural runoff in the area. It also indicates that further study is required to appropriately delineate natural versus project related exceedencies in the area.

Elevated TSS concentrations can correlate with elevated metal concentrations. TSS-related metal loading during the exploration program can be mitigated though best management practices for run-off, erosion and sediment control. Largo has identified two potential sediment sources near the camp on the access road (100 m below the camp) and drill exploration trails (approximately 50 meters north of the core cutting shack) that may have contributed to project related elevated TSS concentrations resultant from increased vehicular traffic in the area. In this regard, Largo has committed to install culverts at these locations when further exploration activity and related traffic on these routes is to be conducted.

7.2 Fisheries Investigations

Investigations into fish and fish habitat in the vicinity of the Northern Dancer deposit and all possible associated drainages, were conducted in July 16-18, 2008. With the exception of the Smart River, documentation of previous fisheries investigations in this area was not discovered. It appears that very little to date is known about the fisheries resources of this part of the Smart River/Swift River watershed. The current study conducted by Access Consulting for Largo Resources Ltd in 2008 investigated fish and fish habitat at numerous sites along the Smart River/Swift River drainage, including Logjam Creek, Two Ladder Creek, "Dorsey Creek" (a temporary name assigned to an unnamed creek, and the Smart River. The only fisheries/fish habitat investigations conducted within the three tenures in British Columbia included sites along the western portion of Logjam Creek and all other small creeks along the access route.

No previous fisheries work had been carried in West Logjam Creek or Two Ladder Creek or along the access road route. A total of six species of fish had been recorded in the Swift and Smart Rivers in the vicinity of the mining property:

- Arctic grayling (*Thymallus arcticus;*
- Chinook salmon (*Oncorhynchus tshawytscha;*
- Dolly Varden char (*Salvelin us malma;*
- Humpback whitefish (*Coregonus clupeaformis;*
- Longnose suckers (*Catostomus catostomus;* and,
- Slimy Sculpin (*Cottus cognatus).*

The magnitude of the Chinook salmon run in the Swift River was considered moderate, at between 50 to 100 individuals. However, spawning was considered minimal. The Swift River was known to be used by Arctic grayling for spawning proposes. The Smart River was considered a productive stream. For fish, providing over-wintering areas, although the Chinook salmon run was considered to be less than 50.

7.2.1 Sampling Method

Sites were initially assessed by helicopter reconnaissance for potential suitability as fish habitat and to determine utilization of fish at the various sampling sites in the designated environmental baseline area. Sites then deemed as potential fish habitat were then visited via ground reconnaissance teams. At each site, gee minnow traps were then used to determine any possible fish presence, and if appropriate and safe, electro-fishing techniques were used. When minnow traps were used, up to three traps were placed in suitable habitat in close proximity to each other. Yukon River origin Chinook salmon roe were used as an attractant.

Where stream/river conditions allowed, certain sites were electro fished using a Smith/Root@ back-back electro fishing unit. Conductivity, pH, temperature and dissolved oxygen were measured at each site.

Angling effort was not applied at any sites due to the lack of observable suitable fish habitat. The Smart River provided suitable habitat but the fishery resource had previously been well documented.

All fish captured were identified and enumerated. Fork length was measured before release.

Habitat observations were made at each site visited and noted on stream side checklist forms. Incidental observations of fish or wildlife were also recorded.

7.2.2 Fish Habitat and Water Quality Sampling Sites

Sites examined for fish habitat and water quality in the entire environmental baseline study area included:

- Dorsey Creek Valley (4 sites – ND-DC-F1 - F4)
- Alaska Highway – Logjam Creek (1 site – LJ-F1)
- Access Road to Exploration site (6 sites LJF2 – F6 and "Camp Set")
- Two Ladder Creek (2 sites ND-TL-1.5-F1 and ND-TL-2.0-F2)
- Smart River (2 sites (ND-SM-1.5-F2 and ND-SM-F1)

The access road sites are of concern in this report.

7.2.2.1. Fish Habitat – Access Road

Six (6) sites were tested with minnow traps along the access road extending from the Alaska Highway to the BC-Yukon border immediately south of the Northern Dancer deposit. There were no species captured in any of the traps. A majority of the creeks, with the exception of Logjam Creek, comprised of very small, intermittent drainages that provide very limited or no suitable habitat for fish. These creek crossings along the road appear to be the result of extensive and extended rainfall in the area and are also known to exist during spring runoff. Most of these streams would typically diminish significantly during a normal summer season precipitation levels and hence result in poor fish habitat (Petkovich, 2008). Logjam Creek is characterized as having swift, high gradient systems that cascade off the mountain with rocky bottoms and have very limited or no suitable habitat for fish. (Petkovich, 2008).

Table 2: Access Road – Stream Crossings. Results of Minnow Trap Surveys.

Date	Location	1/8" mesh	¼" mesh	Soak Time (hrs)	Species Captured	Number Captured
July 16	LJ-F2	0	1	20	0	0
July 16	LJ-F3	0	2	20	0	0
July 16	LJ-F4	0	2	20	0	0
July 16	LJ-F5	0	2	20	0	0
July 16	LJ-F6	0	3	18	0	0
July 16	Camp Set	0	1	23	0	0

None of these sites were suitable for electro-fishing.

7.2.2.2. Water Quality – Access Road

In situ water quality measurements are tabled below.

Temperatures within the sample areas ranged from 3.4 to 9.7 degrees Celsius. The warmest temperature was found in Logjam Creek.

Conductivity ranged from a low of 50 *uS/cm* in Logjam Creek to a high of 320 *uS/cm*.

The pH measurements varied moderately from 7.8 to 8.4, but overall indicated a basic environment. With Logjam Creek draining directly off the Northern Dancer deposit, this appears to be an initial indicator that there are no current or past naturally occurring ARD drainage events.

Dissolved oxygen levels ranged between a low of 6.2 to a high if 11.8 mg/l (ppm).

Table 3: Access Road - Results of In-Situ Water Quality Sampling

Site	Date	Temp (C)	pH	Cond (uS/cm)	D.O. (mg/l)
LJF1	July 16	*	8.4	120	11.8
LJF2	July 16	9.7	8.2	320	6.2
LJF3	July 16	*	8.2	180	10.8
LJF4	July 16	5.2	7.8	100	11
LJF5	July 16	4.6	8.3	110	11.5
LJF6	July 16	3.4	7.8	50	11.5

7.3 Wildlife Investigations

Based upon interviews with Yukon game biologists and field observations, the area does not appear to be important as wildlife habitat, especially for large mammals such as Dall's sheep. Only a few woodland caribou migrate to the area during the summer. Moose were fairly common at lower elevations. Grizzly bears appeared few in numbers, although wolves were fairly common. Little data was collected with respect to birds, furbearers or small mammals (Canamax, 1983).

To further verify the initial findings on the presence of wildlife in the area, Largo contracted Dr. Grant Lortie and observers to conduct a helicopter reconnaissance for wildlife within the environmental baseline study area. The survey was conducted from July 17-18, 2008.

The July 17 survey focused on upland terrain above tree line, with the primary effort examining areas to the unnamed westerly flowing tributary that enters the Smart River.

The July 18 covered areas to the south, including the access road and areas westward to Smart River, south to Swift River, and east to Roy and North Wind Lakes.

The study area is included within the Pelly Mountains Ecoregion (1780 of which a comprehensive description can be found in Smith et. Al (2004). The higher elevation survey revealed residual snow patches on southern aspects with persistent snow cornices and patches on north aspects in areas of cirques and shaded tributary headwalls.

A mixed white spruce and subal pine fir dominates the lower and upper drainages and includes a dense under story of willow and dwarf birch. Verdant grass-forb meadows characterized openings along watercourses and upper drainages to the toe of the prominent scree slopes.

Lortie (2009) reported sighting several moose within the environmental baseline study area. Lortie noted that the moose were moving from lower elevations into the upper elevation in response to plant phenology and that the duration of their occupancy in higher elevations while variable, was likely highly dependent on arrival of prohibitive snow conditions. Lortie (2008) concluded that due to the dense conifer cover, a determination of the actual moose population and rut activity in the environmental study area would require a fall survey after early snowfall (i.e. October).

Lortie (2008) also reported no past or current evidence of mountain sheep or mountain goat in the environmental baseline study area. Sheep trails on upper scree slopes and ridges were absent. He did note that the presence of these species is known to occur further north in the mountains east of Dorsey Lake but this is outside of the environmental baseline study area. In addition, Lortie (2008) noted there was also a lack of evidence of golden eagle and gyrofalcon in the study area. He noted the reliance of gyrofalcom on ptarmigan and that those populations may be limited by snow depth and hence the lack of gyrofalcon. He also speculated that even though vegetation in areas such as on a dry ridge to the immediate southeast of the drilling areas at Northern Dancer provided suitable habitat for ground squirrels which are prey for eagles and gryrofalcons, there populations may also be limited by other factors.

Several moose, one grizzly with a two year old cub, and an inactive beaver house were identified within the environmental baseline study area.

8.0 Tailings Site Investigations

Largo engaged Mr. John Lemieux of Journeaux Bedard & Associates Inc., Montreal, Quebec to conduct an assessment of potential tailings sites for the Northern Dancer Project. Mr. Lemieux visited the site in July, 2008.

A total of six (6) sites, along with two variations to two of the six sites, for a total of 8 suites were studied (see drawing S-08-2133, Appendix 3). The assessment initially examined the potential handling volume of each site using a tailings deposition angle of 0%. Using an estimated volume of 200 million tonnes of tailings to be stored with an assumed 1.5 tons per cubic meter with uniform silt with a specific gravity of approximately 2.8, it was estimated that the space required for tailings storage was approximately 150 million cubic meters. The scenario considered assumed that the tailings could be transported via pipeline as 40% solid slurry. Water would be decanted from the tailings and returned to mill for recycle.

Based on these assumptions, Lemieux (2008) concluded that all eight (8) options examined could provide the required storage area. To compare the sites a typical dam cross-section was used.

Major considerations of the assessment then included several factors such as:

- Cost of construction, operation and maintenance;
- Minimizing risks associated with high dams, liquefiable tails, earthquakes, landslides, avalanches, and flash floods;
- Foundation issues;
- Accessibility; and,
- Aggregate quality and proximal supply.

8.1 Surficial Materials

Lemieux (2008) also examined the surficial geology of the area. From this examination he noted that it was clear that granular material was abundant, whereas fine impermeable material was limited to dense, sandy, humid, boulder till that could be difficult to excavate.

8.2 Dam Type and Construction Materials

For assessment purposes, a granular fill dam was selected as the dam type. This form of dam would use run of pit granular material costed at $7 per cubic meter as the mass of the dam. Engineered granular material costed at $15 per cubic meter would sandwich a geomembrane costed at $37.50 per square meter, on the upstream slope. Rip rap, comprising of crushed stone from the pit and/or natural boulders costed at $15 per cubic meter, would cover everything. Stripping for the foundation key of the membrane at a one (1) meter thickness was estimated to cost $7.50 per square meter. Lemieux (2008) noted that a possible option to a membrane could be a good till but whether suitable tills existed in the region of the tailings site was not examined during the short field visit. Lemieux did not include any cost estimates associated with foundation preparation such as dealing with bedrock, soil injection, rock injection or other possible key considerations.

8.3 Potential Site Volumes and Other Site Characteristics

For each of the 8 sites, Lemieux (2008) noted the potential contained quantity, site elevation, maximum height, and preliminary cost estimate for the tailing site as can be seen in Table 4 below.

Table 4: Preliminary Tailings Site Assessment

Option	*Contained Quantity (Mt)*	*Elevation (meters)*	*Maximum Height (meters)*	*Cost ($Can)*
North-east (1)	128,499,185	1230	70	$86,834,354
North-east (2)	126,959,810	1280	70	$89,291,519
South-east (1)	127,125,691	1082.5	82.5	$105,297,318
South-east (2)	127,134,380	1080	60	$166,442,208
South-west (1)	134,977,283	1220	85	$294,237,169
South-west (2)	130,079,230	1165	85	$155,332,759
North-west (1)	131,830,511	1227	67	$130,720,523
North-west (2)	134,730,867	1245	85	$153,523,423
Additional Options				
North-east (1-2)	131,506,025	1210	51	$38,707,804
South-east (1-2)	130,808,080	1070	71	$67,053,571

Lemieux (2008) noted that these costs were not absolute construction costs but should be considered as comparative cost index values (CCIV). The basis of the cost assumption was to provide a full comparison of the sites for scoping study purposes, with the need for further evaluation to provide a better definition of costs in further studies likely associated with a prefeasibility assessment of the Northern Dancer Project.

Lemieux (2008) then narrowed down the options on a preliminary basis to narrow down further studies in his preliminary assessment as follows:

- South-west (1) and South-east (2) were eliminated on a cost basis;
- The north-west sites were eliminated due to the challenge of a valley in the area heading to the west which would result in tailings being dumped from both ends of the valley and therefore two dam structures and hence deemed uneconomical;
- North-east (2) and South-west (2) were both very sensitive to tailings deposition angle and were therefore concluded as sites with costs that would increase exponentially over time coincident with steeper depositional angles; and,
- North-east (1) and South-east (1) were deemed as being potential sites on the basis of topographical characteristics and associated costs. These were then aptly named Upper Screw Creek and Lower Screw Creek, respectively.

As a result further analysis was conducted on Upper Screw Creek (North-east (1)) and Lower Screw Creek (South-west (2)), potential tailings sites.

At this point, Lemieux (2008) recalculated the fill plan using a tailings deposition angle of 1%. This angle was considered to possibly be a bit high by Lemieux (2008) but a reasonable estimate for this level of examination.

Lemieux (2008) appears to have focused attention primarily on the Upper Screw Creek Option due to factors such as the initial higher cost of dam construction and the length of tailings pipe/water return that would be associated with Lower Screw Creek.

8.4 Upper Screw Creek

At Upper Screw Creek, Lemieux (2008) noted that the effect of the tailings deposition angle is pronounced due to the considerable length of the valley (1% over 5 kilometres = 50 meters). This results in a reduction of the required dam height, an approach used in projects such as Highland Valley Copper. Therefore there would be the initial raising of the single dam required at the southern end of the proposed tailings site and over the mine life a maximum dam height for the tailings site would eventually reach 51 meters. With an estimated 30 year mine life, the maximum lift per year would be less than 2 meters per year. However Lemieux did note that the initial dam height would be in the range of 20-30 meters at start-up stage to provide for such factors as turbidity treatment of process water, water storage requirement to run the mill during winter conditions, and to provide required environmental protection, especially in meeting regulations required to meeting, or exceeding, contained design flood conditions. Lemieux noted that over time the dam would need to be lifted to compensate for the infilling of the site with tailings and to maintain the minimum volume requirement to mitigate any environmental concerns and to meet, or exceed, regulatory conditions.

Based on a helicopter reconnaissance and basic topographic analysis, a preliminary pipeline route was selected (see Appendix 3). This routing is for a distance of approximately 15 km from the potential mill site to the tailings site. Lemieux (2008) noted that piping material of the assumed grain size with a distance under 20 kilometres was highly feasible along a steady slope and often can be accomplished with limited or no booster stations or drainage points. Lemieux (2008) referenced the PSI Pipeline associated with the Golden-Manitou project as an example of a pipeline project that has been successful and has an overall length of approximately 22 kilometres.

At Upper Screw Creek Lemieux (2008) has estimated that the pipeline deposition point would be at an estimated elevation of 1250 meters and the water return pipeline would be at an elevation of 1210 meters. As a specific mill location had not been determined, Lemieux noted that to have a mill above 1250 meters would help with frictional losses in the pipeline.

8.4.1 Estimated Cost

To provide a detailed estimated capital cost and Tailings Impoundment Investment Schedule, Lemieux (2008) provided a range of information including:

- Estimated critical and normal water balance;
- Preliminary stability (static and 0.08g seismic);
- Site layout plan;
- Tailings pipe, head loss, and profile;

- Process return pipe, head loss, and profile;
- Typical road/ditch/pipeline cross section;
- Typical cross section of dam; and,
- Volume elevation curve for polishing basin.

This data is all presented in Appendix 3.

Lemieux has estimated that the tailings impoundment dam and pipelines associated with the Upper Screw Creek will be approximately $115.6 million (CDN) or an investment of $0.88 per cubic meter of tailings. At the pre-production stage Lemieux (2008) has noted that an initial investment of $69.3 million CDN would be required. Additional investments arising from the need to elevate the dam structure and make other improvements to items such as the emergency/operation spillway would occur in years 7, 14, and 21 of operations and be approximately $8.5 million CDN, $13.25 million CDN and $24.75 million CDN, respectively (see Appendix 3).

For estimated operational costs of the tailings impoundment, Lemieux (2008) estimated and annual cost of approximately $8.1 million CDN, including costs for tailings deposition crew, process pump and pipelines, and tails pump and pipelines (See Appendix 3).

8.4.2 Project Considerations and Suitability

Lemieux noted that other considerations such as permitting issues, restoration elements, dust, detailed water balance, land ownership, climate data, and watershed characteristics are some of the elements that will require detailed examination in completing an assessment of the potential of Upper Screw Creek as a tailings site for the Northern Dancer Project.

9.0 Access Road Investigations

Largo retained Erik Nyland, P. Eng of Whitehorse in September, 2008 to provide route assessment and preliminary cost estimating services for the construction of an all weather - all season access road from km 1168 Alaska Highway to the proposed mine site. Additional parts of the assessment were to provide route assessment and a preliminary cost estimate to construct a roadway for pipeline construction from the proposed mine site to the proposed tailings facility at Upper Screw Creek, and to examine a southern extension of the access road to a potential water source to support mine operations at Swift River.

Information used to report included an examination of 1:50,000 scale NTDB map sheets, satellite imagery, site visits and personal discussion with K. Brewer, General Manager – Northern Dancer Project.

Nyland (2008) concluded that further investigations would be required prior to detailed design of the access road(s) being undertaken. These investigations would include, but not be limited to geotechnical, hydrological, terrain analysis, environmental, biophysical, and archaeological studies and also supported with detailed ground surveys. Cost estimates for the road access were therefore estimated to have a +/- 50% error rate.

9.1 Key Findings – Access Routes

Nyland (2008) noted that the Northern Dancer project would require construction of an approximately 13 km all weather access road from km 1168 of the Alaska Highway to the proposed mine site. Key findings and recommendations by Nyland (2008) were as follows:

- Access off the Alaska Highway appears to have sufficient sight lines although this will require field verification;
- The current existence of access will simplify permitting for the permanent access route;
- New construction to a great extent could follow the existing access route but would require a straighter alignment and improved grades throughout;
- The suggested standard for the proposed road design should meet or exceed Transportation Association of Canada (TAC) RLU 60 Single Lane Resource Road with intervisible to lane sections. This standard and all of its associated elements was included in Nyland (2008) and considered to be supportive of economy of construction, minimal environmental impact, and overall suitability for proposed operations;
- Drainage crossings appear to be minor with the exception of West Logjam Creek at km 11.5. The temporary bridge placed over this intersection does not appear to be sufficient for sustained heavy traffic. Further improvements and bridge construction at this site in the future will require hydrological and geotechnical assessments to fully determine the type of crossing required;
- All other stream and creek crossings can be sufficiently handled with culverts;
- Geotechnical conditions on site appear to be suitable for sub-grade construction; and,
- Suitable borrow sources for surfacing material appear to exist throughout the access route but do require further geotechnical analysis to determine sub-grade material quality and define borrow source locations.

9.2 Estimated Construction Cost

Nyland (2008) estimated that the construction cost for all routes, developed using historical unit costs and broad assumptions, was approximately $6.877 million with a +/- 50% error level.

9.3 Access Route Analysis

Nyland (2008) provided several recommendations for further analysis of all of the proposed routes as follows:

- Detailed topographical mapping of the site through the acquisition of air photography or satellite imagery should be completed. This would allow for 3d analysis of the imagery to produce a Digital Earth Model (DEM) of the site. The DEM should cover all areas of the project including access road(s), water source, mine site, tailings pipeline route and tailings pond;
- A hydrological assessment should be completed to predict water flows across the road and in all drainage areas. This assessment can then provide the information necessary to determine sizing of drainage crossing structures and prediction of scour;
- A hazard assessment should be conducted to provide information on the potential for land slides and avalanches, floods etc,. This is especially important close to the mine site, camp locations and tailings facilities;
- A geotechnical assessment should be conducted at the proposed locations of all structures and facilities. Pertaining to the access routes, a geotechnical assessment will be important to ensure that final route selection supports long term stability of the access road(s) and serve to identify suitable borrow sources;
- Acid rock drainage (ARD) potential of the abandoned borrow source at the junction of the Alaska Highway and at all potential borrow sources will help to further define suitability of borrow material for road surfacing and/or construction materials. These ARD tests typically consist of Shake Flak Tests and Acid Base Accounting Tests; and,

Other studies may be required by permitting authorities and could include, but not be limited to, various environmental studies, assessments of required traffic control, sediment and erosion control mitigation measures etc,.

10.0 Access Road Maintenance

Due to unusually high precipitation levels in the Northern Dancer area in 2008, additional maintenance of the road was required. Minor stretches (typically 100 metres or less) were provided with additional aggregate topping to stabilize the road and ensure it was passable by service and passenger vehicles. Otherwise, no major work was conducted during the 2008 program.

11.0 2008 Expenditure Summary

A statement of expenditures on mineral tenures 509951, 527199, and 527200 for the 2008 field season is as follows:

Access Road Investigation	$1,869.00
Access Road Maintenance	$20,000.00
Tailings Assessment	$3,032.65
Water Sampling	$5,985.26
Wildlife Investigations	$90.00
Fisheries Investigations	$12,718.20
Total	**$43,605.11**

11.0 Recommendations

Recommendations arising from this report include:

- The environmental baseline studies need to be continued in an effort to get at minimum a complete two-year set of data on water quality issues;
- Additional water quality studies are required to distinguish natural exceedencies (in terms of CCME standards) from exceedencies that may be created from project-related activities;
- The initial access road investigation should now be followed up with a more detailed analysis including ground surveys, DEM analysis, geotechnical analysis of potential borrow sites, hazard assessment, and hydrological assessment; and,
- The initial tailings investigation requires significantly more study on all project elements.

12.0 Conclusion

The 2008 program was very successful in outlining possible environmental factors that will need to be considered within British Columbia and also served to provide an indication that there are no known major concerns regarding water quality and other potential indicators of environmental impacts.

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United States Department of the Interior, Bureau of Reclamation, 1984. Water Measurement Manual, 2nd Edition. United States Government Printing Office, Denver.

Appendix 1. Certificate of Author

I, Kevin J. Brewer, PGeo, hereby certify that:

1) I am a self-employed Consulting Geologist and sole proprietor of:
39627 Yukon Inc. 6 Carnelian Court, Whitehorse, Yukon Y1A 6A3

2) I graduated with a Bachelor of Science (Honours) Degree in geology from Memorial University Of Newfoundland (MUN), St. John's, Newfoundland, in 1984.

3) I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC).

4) I have worked as a geologist for a total of 20 years since my graduation from MUN.

5) I have read the definition of "qualified person" set out in National Instrument 43-101 ("NI 43-101") and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purposes of NI 43-101.

6) I am responsible for preparation of all sections of this assessment report titled "Assessment Report on Environmental Baseline Investigations and other work Completed on Property Access Route" comprising the Northern Dancer project. I was active on-site during the majority of the 2008 exploration program.

7) I have not had prior involvement with the property that is the subject of the Assessment Report.

8) I am not aware of any material facts or material changes with respect to the subject matter of the assessment report not contained within the report, of which the omission to disclose makes the report misleading.

9) I am independent of the issuer applying all of the tests in section 1.5 of National Instrument 43-101.

10) I have read National Instrument 43-101 and Form 43-101F1; however, this Assessment Report has not been prepared in compliance with that instrument and form.

11) I consent to the filing of the Assessment Report with the British Columbia Mineral Titles, Ministry of Energy, Mines and Resources, Government of British Columbia.

12) The effective date of this report is February 9, 2009.

Dated this 6th day of February, 2009.

"Kevin Brewer"

Kevin Brewer, MBA, BSc (Hons), PGeo
Address: 6 Carnelian Court
Whitehorse, Yukon Y1A 6A3
Telephone: 867-633-4260
Fax: 867-668-7127
E-mail: kbrewer@largoresources.com

PROFESSIONAL
PROVINCE OF
K. J. BREWER
#31693
BRITISH COLUMBIA
GEOSCIENTIST

The expenditures by tenure relating to the 2008 field program are as follows;

Activity	**Expenditure by Tenure**		
	509951	527199	527200
Access Road Investigation	$623	$623	$623
Access Road Maintenance	$10,000	$10,000	
Tailings Assessment*	$3,032.65		
Water Sampling**	$5,895.26		
Wildlife Investigations***	$30	$30	$30
Fisheries Investigation****	$4,239.40	$4,239.40	$4,239.40
Total:	**$23,820.31**	**$14,892.40**	**$4,892.40**

Notes:

* Only 10% of the tailings assessment were assigned from the overall project report cost to Logtung 1 based on the examination of the pipeline route and related helicopter costs. Engineering costs, not including helicopter costs for the tailings site assessment were $30,326.49

** Their were a total of 13 water sample sites investigated during the 2008 field program. As only one water sample site was included within the tenure areas, approximately 8% of the total water sampling costs ($73,690.70) were assigned to the tenure on a proportional basis. No helicopter costs were included in these costs as the site within the tenure could be reached by ground.

***Costs for wildlife investigations totalled $1800 not including helicopter costs which have not been assigned. It was estimated that approximately 5% of the survey was conducted over the tenure areas.

****Their were a total of 12 fisheries sample sites investigated during the 2008 field program. Five (5) sample sites were included within the tenure areas, therefore approximately 42% of the total fisheries investigations costs ($30,281.46) were assigned to the tenure on a proportional basis.

Appendix 3: Report by Journeaux Bedard & Associates

Windows Live™

Northern Dancer Tailings Impoundment

From: **John Lemieux** (jlemieux@journeauxbedard.com)
Sent: July 21, 2008 6:14:20 PM
To: kbrewer80@hotmail.com; timothylmann@cogeco.ca
Cc: mvint@snowdengroup.ca
Attachments: S2133-1.pdf (631.3 KB), S2133-2.pdf (368.0 KB), volumes_pente_0%_.pdf (7.1 KB), volumes_pente_1%_.pdf (6.6 KB)

Security scan upon download TREND MICRO

Hi everyone,

Sorry for the delay. I know I promised my email last week ... I've been in the field Wed and Thur last week and all this week ... but I've got some results for duscussion.

INTRO AND DESIGN SPECS
JBA has been asked to find a economically and technically feasible place to store Moly/Tung (non reactive) tails for over 30 years of production using a conventional approach (ie. tails are transported via pipeline as a 40% solid slurry ... water is decanted and returned to mill for recycle). The total est. volume to be stored is 200 Mt. At 1.5 t/m3 (based on our own experience and email forwarded to me (can't remember the name nopw) we can calc 130 Mm3 of space is req. I've read the Mesh report and found some grain size info. I don't remember the exact numbers but if you look in the report you will find them ... basically I'm assuming it is the same as typ. gold mine in Abitibi, ie. uniform silt with about 2.8 SG. We have alot of data on Abitibi Tails.

It is important to note that it is important to keep impermeable dams low in height but also low in the valleys for the following reasons: cost of course but also to reduce risk associated with high dams, liquifiable tails, earthquake area, landslides, avalanche, flash floods, foundation prep. I`m assuming less foundation prep lower in the valley where normally thicker beds of finer materials can be found. This also helps preserve underground water.

METHODOLOGY
We did not pursue any of the 4 sites cureently suggested as JBA could not see how to make them economically and technically feasible. A series of 6 new sites plus 2 variations to 2 of the six for a total of 8 studied. Our first appoach is to simply confirm the vol. of each site at a tailings deposition angle of 0% (ie. water). In this type of terrain, this is definetly a worst case scenario. All the 8 options shown on S2133-1 contain the 130Mm3 req. To compare the sites a typ. dam x-section was used.
After consulting the surface deposit map for the area it is clear that granular material is in abundance whereas fine impermeable material is limited to dense, sandy, humid, boulder till that is hard to excavate. The typ. dam chosen is a granular fill dam using run of pit granular material (7$/m3) as the mass of the dam. Engineered granular material (15$/m3) will sandwich a geomembrane (37.50$/m2) on the upstream slope. Rip rap (crusehed stone from the pit or natural boulders, 15$/m3) will cover everything. Stripping for the foundation key of the membrane is estimated at 1 meter thickness (7.50$/m2). For speed of construction a membrane was used but if good till can be found the membrane could be replaced by till. Note that at this stage no cost has been associated with further foundation preparation such as bedrock prep or soil or rock injection or special key configurations.

RESULTS
We see the 8 sites studied on S2133-1 attatched. You will find a summary of the

results on volumes_pente_0%_.pdf. Keep in mind that the costs presented here do not relect absolute construction costs (at this stage) they should be referred to as comparitive cost index values (CCIV) or something of that nature. The objective being to simply compare sites. We quickly see that South-west 1 and south-east 2 are out due to cost or size. Several attempts were made to make the North-west site work (including dumping tailings from opposite ends of the valley) but it always ends up uneconomical because of the valley shooting out to the west. North-east 2 and south-west 2 are very sensitive to tailings deposition angle and will always be more expense with costs increasing expo with steeper dep angles. That leaves 2 sites outstanding: North-east 1 and south-east 1. Both of these sites have advantageus topo and the cost is right.

Both of these sites were pursued. The fill plan was recalculated using a tailings dep. angle of 1% (a bit high but possibly a good guess for this stage), see S2133-2. The effect of the dep. angle is pronounced at the North-East site where the considerable length of the valley (1% over 5 km = 50 meters) reduces the height of the dam considerably (see Highland Valley Copper for similar approach). Apart from raising the single dam required for each of the sites there is little or no operational functions. The summary table in volumes_pente_1%_.pdf shows the results. The costs are significantly reduced with the North-east 1 site at under 40M$CCIV and a max. dam height of 51 meters. That's less than 2 meters lift per year for 30 year mine life. Keep in mind that an initial dam of 20 to 30 meters must be built before start-up to provide for: turbidity treatment of process water, water storage req. to run mill during winter and to respect enviro regulations pertaining to the contained design flood. In later years the dam is lifted to compensate the infilling of the lake by tailings and maintain the minimum volume req to respect all of the 3 parameters mentionned. The North-East 1 site seems to be the best.

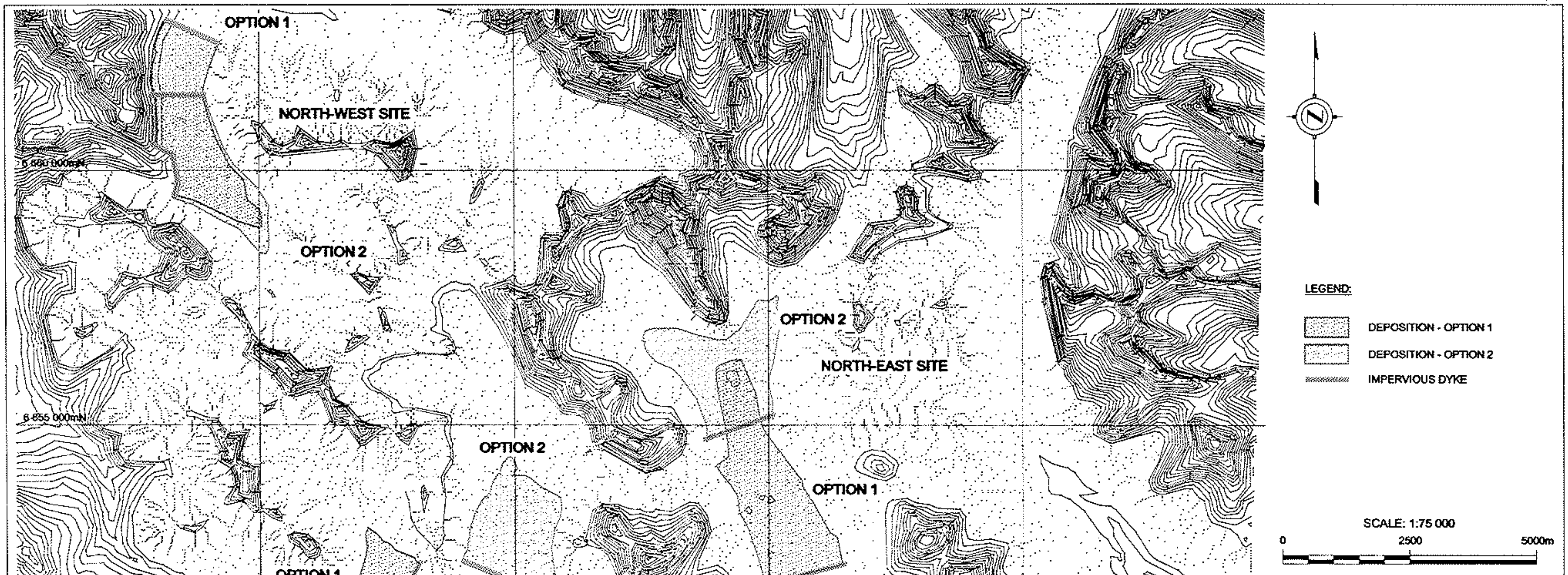
The site is far. The pipeline req. for the routing shown is about 15km. However, our experience, shows that piping material of this assumed grain size over 20 km is highly feasible (along a steady slope) and is accomplished at many sites (without booster stations or drainage points!!!) one of the most recent is the PSI pipeline for Goldex-Manitou project at over 22km. The deposition point is at 1250 meters and the return is at 1210 meters. A mill location was not available in the design spec but it is maybe possible to have the mill above 1250 meters to help as much as possible with frictional losses in the pipeline.

There are other parameters that have not been discussed here: enviro permits (sometimes very difficult), restoration elements, dust, detailed water balance, land ownership, climate data, watershed, etc. However, I think this info gives a nice starting point to start discussions for a scoping level study.

NEXT STEPS
First, I would like your comments and your confirmation as to which site(s) to pursue. Then I will get seismic info, climate info, enviro regulation info, etc. to complete the water balance and provide you with a detailed fill plan, cost estimate and investment schedule. Let me know if other steps or info are req. for you.

--

JOURNEAUX, BԱARD & ASSOC. INC.
1868 Boul. des Sources, Bureau 400
Pointe-Claire, Qu濒c,
H9R 5R2
T 514-426-4102, 224
F 514-426-1342



NOTE:

TOPO BASE MAP PROVIDED BY LARGO RESOURCES.

JOURNEAUX, BÉDARD & assoc.inc.

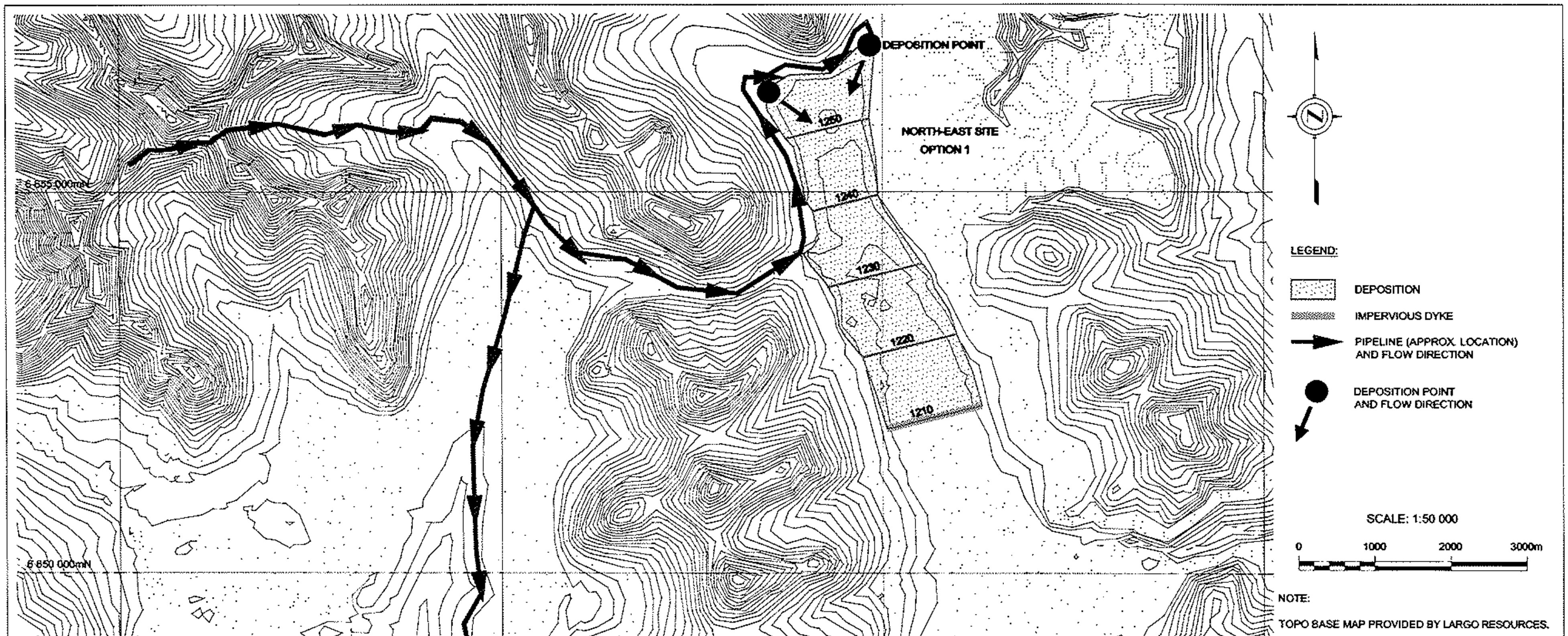
CLIENT: LARGO RESOURCES

PROJECT:
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PLAN VIEW OF SITE
OPTIONS UNDER STUDY
USING 0% SLOPE, VOLUME 130 Mm3
NORTHERN DANCER, YUKON TERRITORY

DATE	SCALE
08-07-21	1 75 000

DRAWN BY	C LAPLANTE, tech.
PROJECTED BY	J LEMIEUX, eng.
APPROVED BY	J LEMIEUX, eng

PROJECT No	DRAWING No	REV	
S-08-2133	S2133-1	A	-/-



NOTE:

TOPO BASE MAP PROVIDED BY LARGO RESOURCES.

JOURNEAUX, BÉDARD & assoc.inc.

CLIENT: LARGO RESOURCES

PROJECT:

NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PLAN VIEW OF SITE
COMPARISON OF THE 2 BEST OPTIONS
USING 1% SLOPE, VOLUME: 130 Mm3
NORTHERN DANCER, YUKON TERRITORY

DATE	SCALE
08-07-21	1 50 000

DRAWN BY :	C LAPLANTE, tech.
PROJECTED BY	J LEMIEUX, eng
APPROVED BY	J. LEMIEUX, eng

PROJECT No :	DRAWING No	REV	
S-08-2133	S2133-2	A	1/1

Option	Quantité contenue	Élévation	Hauteur max.	Coût de la (des) digue(s)
Nord-Est 1	128 499 185	1230	70	86 834 354 $
Nord-Est 2	126 959 810	1280	70	89 291 519 $
Sud-Est 1	127 125 691	1082.5	82.5	105 297 318 $
Sud-Est 2	127 134 380	1080	60	166 442 208 $
Sud-Ouest 1	134 977 283	1220	85	294 237 169 $
Sud-Ouest 2	130 079 230	1165	85	155 332 759 $
Nord -Ouest 1	131 830 511	1227	67	130 720 523 $
Nord-Ouest 2	134 730 867	1245	85	153 523 423 $

Option	Quantité contenue	Élévation	Hauteur max.	Coût de la digue
Nord-Est 1	131 506 025	1210	51m	38 707 804 $
Sud-Est 1	130 808 080	1070	71m	67 053 571 $

Kevin Brewer

From: John Lemieux [jlemieux@journeauxbedard.com]
Sent: September-09-08 2:10 PM
To: Tim Mann; Kevin Brewer
Subject: More info on tailings
Attachments: Tailings water balance-Northern Dancer.xls; S2133-105.pdf; S2133-101.pdf; S2133-102.pdf; S2133-103.pdf; S2133-104.pdf; Cost estimate.pdf; Largo Ressources - Preliminary stability analysis.pdf; Polishing basin volume-elevation curve.pdf

Hi,

You will find attatched all the work done to find the price, including :

1. Critical and normal water balance
2. Preliminary stability, static and 0.08g seismic
3. Site layout plan
4. Tailings pipe and head loss profile
5. Process return pipe return and head loss and profile
6. Typical road/ditch/pipeline cross section
7. Typical cross section of dam
8. Volume elevation curve for polishing bassin.
9. Capital cost

You are missing operating costs and investment schedule.

These will come later this week.

--
John Lemieux
JOURNEAUX, BÉDARD & ASSOC. INC.
1868 boul. des Sources, bureau 400
Pointe-Claire, Québec, H9R 5R2
T 514-426-4102, 224
F 514-426-1342

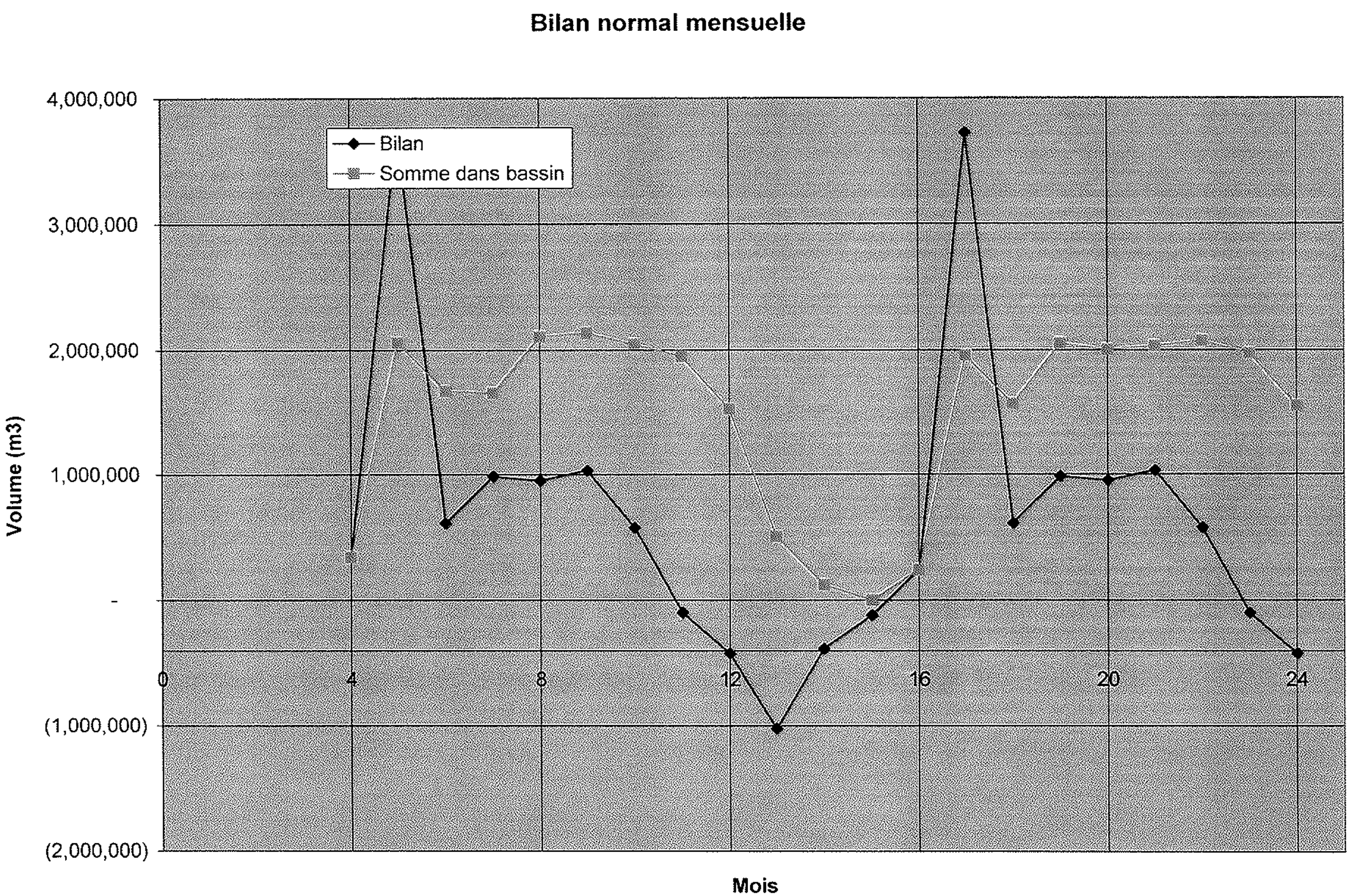
	janvier	février	mars	avril	mai	juin	juillet	août	septembre	octobre	novembre	décembre
	1	2	3	4	5	6	7	8	9	10	11	12
Jours	31	29	31	30	31	30	31	31	30	31	30	31
Pluie (mm)	0.2	0.1	0.2	3.2	20.7	29.1	45.9	43.1	41	19	1	0.2
Neige (cm)	29.4	18.3	16.5	6.8	1.8	0	0	0	1.9	19.9	26.2	27.4
Precip (mm)	27.3	17.2	15.6	9.8	22.5	29.1	45.9	43.1	42.9	37.9	25.9	26.1
Densité de neige (mm neige/mm eq	10.8	10.7	10.7	10.3	10.0				10.0	10.5	10.5	10.6
Évaporation (mm)						126	115	96				
Bassin Versant (m2)	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000
Bassin surface area for evap (m2)	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000
Coef. De Ruissellement	1	1	1	1	1	1	1	1	1	1	1	1
Volume de précip drainant vers rés	4 200	2 100	4 200	67 200	3 546 900	441 000	808 650	775 500	861 000	399 000	21 000	4 200
Starting volume accumulated during winter after construction				107 900								
Snowmelt from 100 year winter												
Rain from 100 year rainstorm												
Tonnage de résidus sec de l'usine				600 000	620 000	600 000	620 000	620 000	600 000	620 000	600 000	620 000
Besoins de l'usine				930 000	961 000	930 000	961 000	961 000	930 000	961 000	930 000	961 000
Eau de l'usine				1 164 000	1 202 800	1 164 000	1 202 800	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800
% provenant de l'usine qui gèle dans le parc				0%	0%	0%	0%	0%	0%	0%	25%	50%
% provenant de l'usine retenue dans les [illegible]				64 286	66 429	64 286	66 429	66 429	64 286	66 429	64 286	66 429
Bilan				339 814	3 722 271	610 714	984 021	960 871	1 030 714	574 371	(100 286)	(421 829)
Overflow to be treated as required					2 000 000	1 000 000	1 000 000	500 000	1 000 000	683 607		
Somme dans bassin				339 814	2 062 086	1 672 800	1 656 821	2 107 693	2 138 407	2 049 172	1 948 886	1 527 057

	janvier	février	mars	avril	mai	juin	juillet	août	septembre	octobre	novembre	décembre
	13	14	15	16	17	18	19	20	21	22	23	24
Jours	31	28	31	30	31	30	31	31	30	31	30	31
Pluie (mm)	0.2	0.1	0.2	3.2	20.7	29.1	45.9	43.1	41	19	1	0.2
Neige (cm)	29.4	18.3	16.5	6.8	1.8	0	0	0	1.9	19.9	26.2	27.4
Precip (mm)	27.3	17.2	15.6	9.8	22.5	29.1	45.9	43.1	42.9	37.9	25.9	26.1
Densité de neige (mm neige/mm eq	10.8	10.7	10.7	10.3	10.0				10.0	10.5	10.5	10.6
Évaporation (mm)						126	115	96				
Bassin Versant (m2)	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000
Bassin surface area for evap (m2)	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000
Coef. De Ruissellement	1	1	1	1	1	1	1	1	1	1	1	1
Volume de précip drainant vers rés	4 200	2 100	4 200	67 200	3 546 900	441 000	808 650	775 500	861 000	399 000	21 000	4 200
Starting volume accumulated during winter after construction												
Snowmelt from 100 year winter												
Rain from 100 year rainstorm												
Tonnage de résidus sec de l'usine	620 000	560 000	620 000	600 000	620 000	600 000	620 000	620 000	600 000	620 000	600 000	620 000
Besoins de l'usine	961 000	868 000	961 000	930 000	961 000	930 000	961 000	961 000	930 000	961 000	930 000	961 000
Eau de l'usine	1 202 800	1 086 400	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800
% provenant de l'usine qui gèle dans le parc	100%	50%	25%	0%	0%	0%	0%	0%	0%	0%	25%	50%
% provenant de l'usine retenue dans les [illegible]	66 429	60 000	66 429	64 286	66 429	64 286	66 429	66 429	64 286	66 429	64 286	66 429
Bilan	########	(382 700)	(121 129)	236 914	3 722 271	610 714	984 021	960 871	1 030 714	574 371	(100 286)	(421 829)
Overflow to be treated as required					2 000 000	1 000 000	500 000	1 000 000	1 000 000	533 379		
Somme dans bassin	503 429	121 129	0	236 914	1 959 186	1 569 900	2 053 922	2 004 793	2 035 507	2 076 000	1 975 714	1 553 885

	janvier	février	mars	avril	mai	juin	juillet	août	septembre	octobre	novembre	décembre
	25	26	27	28	29	30	31	32	33	34	35	36
Jours	31	29	31	30	31	30	31	31	30	31	30	31
Pluie (mm)	0.2	0.1	0.2	3.2	20.7	29.1	45.9	43.1	41	19	1	0.2
Neige (cm)	29.4	18.3	16.5	6.8	1.8	0	0	0	1.9	19.9	26.2	27.4
Precip (mm)	27.3	17.2	15.6	9.8	22.5	29.1	45.9	43.1	42.9	37.9	25.9	26.1
Densité de neige (mm neige/mm eq	10.8	10.7	10.7	10.3	10.0				10.0	10.5	10.5	10.6
Évaporation (mm)						126	115	96				
Bassin Versant (m2)	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000
Bassin surface area for evap (m2)	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000
Coef. De Ruissellement	1	1	1	1	1	1	1	1	1	1	1	1
Volume de précip drainant vers rés	4 200	2 100	4 200	67 200	3 546 900	441 000	808 650	775 500	861 000	399 000	21 000	4 200
Starting volume accumulated during winter after construction												
Snowmelt from 100 year winter												
Rain from 100 year rainstorm												
Tonnage de résidus sec de l'usine	620 000	580 000	620 000	600 000	620 000	600 000	620 000	620 000	600 000	620 000	600 000	620 000
Besoins de l'usine	961 000	899 000	961 000	930 000	961 000	930 000	961 000	961 000	930 000	961 000	930 000	961 000
Eau de l'usine	1 202 800	1 125 200	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800
% provenant de l'usine qui gèle dans le parc	100%	50%	25%	0%	0%	0%	0%	0%	0%	0%	25%	50%
% provenant de l'usine retenue dans les [illegible]	66 429	62 143	66 429	64 286	66 429	64 286	66 429	66 429	64 286	66 429	64 286	66 429
Bilan	########	(326 443)	(121 129)	236 914	3 722 271	610 714	984 021	960 871	1 030 714	574 371	(100 286)	(421 829)
Overflow to be treated as required				250 000	2 200 000	1 000 000	750 000	1 000 000	1 000 000	400 000		
Somme dans bassin	330 657	134 214	13 085	401	3 722 271	2 200 000	2 200 000	2 150 671	2 181 586	2 200 000	2 099 714	1 677 886

1 518
2 076 000

Peak overflow or treatment rate per hour based on 90% availability	3 006	m3/h
Average overflow or treatment rate per hour based on 90% availability	1 561	m3/h
Ice-free and pumpable volume required in polishing bassin	2 076 000	m3
Volume under pump that cannot be pumped	30 000	m3
Volume frozen in ice sheet	350 000	m3
Including Safety or flexibility factor of 25% Total volume in bassin is	3 070 000	m3



Bilan normal mensuelle
Bilan
Somme dans bassin
4,000,000
3,000,000
2,000,000
1,000,000
-
(1,000,000)
(2,000,000)
Volume (m3)
0
4
8
12
16
20
24
Mois

	janvier	février	mars	avril	mai	juin	juillet	août	septembre	octobre	novembre	décembre
	1	2	3	4	5	6	7	8	9	10	11	12
Jours	31	29	31	30	31	30	31	31	30	31	30	31
Pluie (mm)	0.2	0.1	0.2	3.2	20.7	29.1	45.9	43.1	41	19	1	0.2
Neige (cm)	29.4	18.3	16.5	6.6	1.8	0	0	0	1.9	19.9	26.2	27.4
Precip (mm)	27.3	17.2	15.6	9.8	22.5	29.1	45.9	43.1	42.9	37.9	25.9	26.1
Densité de neige (mm neige/mm eq)	10.8	10.7	10.7	10.3	10.0				10.0	10.5	10.5	10.6
Evaporation (mm)						126	115	96				
Bassin Versant (m2)	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000
Bassin surface area for evap (m2)	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000
Coef. De Ruissellement	1	1	1	1	1	1	1	1	1	1	1	1
Volume de precip drainant vers rés.	4 200	2 100	4 200	67 200	3 546 900	441 000	808 650	775 500	861 000	399 000	21 000	4 200
Starting volume accumulated during winter after construction				107 900								
Snowmelt from 100 year winter												
Rain from 100 year rain/30mm												
Tonnage de résidus sec de l'usine				600 000	620 000	600 000	620 000	620 000	600 000	620 000	600 000	620 000
Besoins de l'usine				930 000	961 000	930 000	961 000	961 000	930 000	961 000	930 000	961 000
Eau de l'usine				1 164 000	1 202 800	1 164 000	1 202 800	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800
% provenant de l'usine qui cède dans le parc				0%	0%	0%	0%	0%	0%	0%	25%	50%
% provenant de l'usine retenue dans les solides ...				64 286	66 429	64 286	66 429	66 429	64 286	66 429	64 286	66 429
Bilan				329 814	3 722 271	610 714	984 021	950 871	1 030 714	374 371	(100 286)	(421 629)
Overflow to be treated as required					2 200 000	1 000 000	500 000	800 000	1 000 000	663 607		
Somme dans bassin				329 814	1 852 086	1 472 800	1 956 821	2 107 693	2 138 407	2 049 172	1 948 886	1 527 067

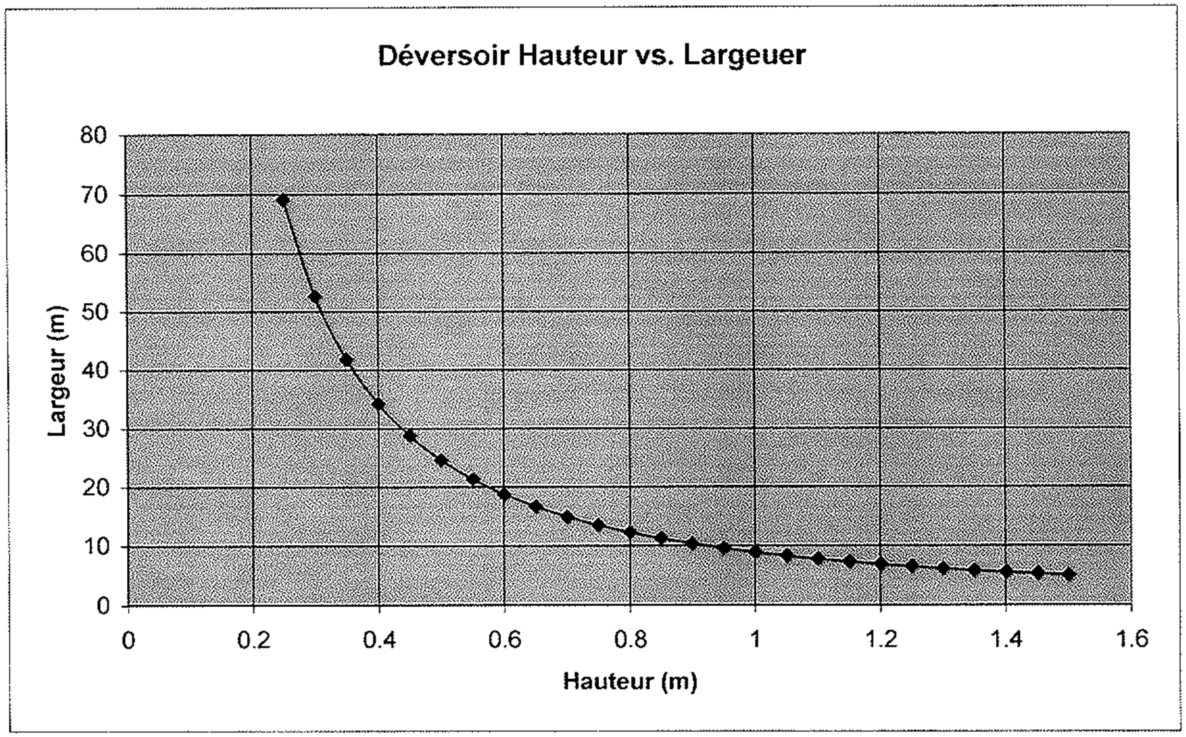
	janvier	février	mars	avril	mai	juin	juillet	août	septembre	octobre	novembre	décembre
	13	14	15	16	17	18	19	20	21	22	23	24
Jours	31	28	31	30	31	30	31	31	30	31	30	31
Pluie (mm)	0.2	0.1	0.2	3.2	20.7	29.1	45.9	43.1	41	19	1	0.2
Neige (cm)	29.4	18.3	16.5	6.6	1.8	0	0	0	1.9	19.9	26.2	27.4
Precip (mm)	27.3	17.2	15.6	9.8	22.5	29.1	45.9	43.1	42.9	37.9	25.9	26.1
Densité de neige (mm neige/mm eq)	10.8	10.7	10.7	10.3	10.0				10.0	10.5	10.5	10.6
Evaporation (mm)						126	115	96				
Bassin Versant (m2)	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000
Bassin surface area for evap (m2)	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000
Coef. De Ruissellement	1	1	1	1	1	1	1	1	1	1	1	1
Volume de precip drainant vers rés.	4 200	2 100	4 200	67 200	3 546 900	441 000	808 650	775 500	861 000	399 000	21 000	4 200
Starting volume accumulated during winter after construction												
Snowmelt from 100 year winter					394 800							
Rain from 100 year rain/30mm					819 000							
Tonnage de résidus sec de l'usine	620 000	560 000	620 000	600 000	620 000	600 000	620 000	620 000	600 000	620 000	600 000	620 000
Besoins de l'usine	961 000	868 000	961 000	930 000	961 000	930 000	961 000	961 000	930 000	961 000	930 000	961 000
Eau de l'usine	1 202 800	1 086 400	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800
% provenant de l'usine qui cède dans le parc	100%	50%	25%	0%	0%	0%	0%	0%	0%	0%	25%	50%
% provenant de l'usine retenue dans les solides ...	66 429	60 000	66 429	64 286	66 429	64 286	66 429	66 429	64 286	66 429	64 286	66 429
Bilan	########	(382 700)	(121 129)	236 914	4 936 071	610 714	984 021	950 871	1 030 714	374 371	(100 286)	(421 629)
Overflow to be treated as required				200 000	2 900 000	1 000 000	1 000 000	1 000 000	1 000 000	160 764		
Somme dans bassin	503 829	121 129	0	36 914	2 072 986	1 683 700	1 667 722	1 618 593	1 649 307	2 062 915	1 962 629	1 540 800

	janvier	février	mars	avril	mai	juin	juillet	août	septembre	octobre	novembre	décembre
	25	26	27	28	29	30	31	32	33	34	35	36
Jours	31	28	31	30	31	30	31	31	30	31	30	31
Pluie (mm)	0.2	0.1	0.2	3.2	20.7	29.1	45.9	43.1	41	19	1	0.2
Neige (cm)	29.4	18.3	16.5	6.6	1.8	0	0	0	1.9	19.9	26.2	27.4
Precip (mm)	27.3	17.2	15.6	9.8	22.5	29.1	45.9	43.1	42.9	37.9	25.9	26.1
Densité de neige (mm neige/mm eq)	10.8	10.7	10.7	10.3	10.0				10.0	10.5	10.5	10.6
Evaporation (mm)						126	115	96				
Bassin Versant (m2)	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000	21 000 000
Bassin surface area for evap (m2)	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000	1 350 000
Coef. De Ruissellement	1	1	1	1	1	1	1	1	1	1	1	1
Volume de precip drainant vers rés.	4 200	2 100	4 200	67 200	3 546 900	441 000	808 650	775 500	861 000	399 000	21 000	4 200
Starting volume accumulated during winter after construction												
Snowmelt from 100 year winter												
Rain from 100 year rain/30mm												
Tonnage de résidus sec de l'usine	620 000	580 000	620 000	600 000	620 000	600 000	620 000	620 000	600 000	620 000	600 000	620 000
Besoins de l'usine	961 000	899 000	961 000	930 000	961 000	930 000	961 000	961 000	930 000	961 000	930 000	961 000
Eau de l'usine	1 202 800	1 125 200	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800	1 202 800	1 164 000	1 202 800	1 164 000	1 202 800
% provenant de l'usine qui cède dans le parc	100%	50%	25%	0%	0%	0%	0%	0%	0%	0%	25%	50%
% provenant de l'usine retenue dans les solides ...	66 429	62 143	66 429	64 286	66 429	64 286	66 429	66 429	64 286	66 429	64 286	66 429
Bilan	########	(396 443)	(121 129)	236 914	3 722 271	610 714	984 021	950 871	1 030 714	374 371	(100 286)	(421 629)
Overflow to be treated as required					2 200 000	1 000 000	750 000	1 000 000	1 000 000	400 000		
Somme dans bassin	317 572	121 129	0	236 915	1 759 186	1 369 900	1 603 922	1 524 793	1 285 506	1 759 879	1 659 593	1 237 765

Peak overflow or treatment rate per hour based on 90% availability	4 473	m3/h
Average overflow or treatment rate per hour based on 90% availability	1 571	m3/h
Ice-free and pumpable volume required in polishing basin	2 062 915	m3
Volume under pump that cannot be pumped	30 000	m3
Volume frozen in ice sheet	350 000	m3
Including Safety or flexibility factor of 25% Total volume in basins	3 053 643	m3

1 571
2 062 915

			Broad crested weir correction factor
m3/h	m	m	0.7
Q	H	L	L
40000	0.25	48.40298	69.14711
40000	0.3	36.84336	52.63337
40000	0.35	29.2598	41.79972
40000	0.4	23.97149	34.24499
40000	0.45	20.11232	28.73189
40000	0.5	17.19536	24.5648
40000	0.55	14.92799	21.32569
40000	0.6	13.12488	18.74983
40000	0.65	11.66356	16.66222
40000	0.7	10.46015	14.94308
40000	0.75	9.455535	13.50791
40000	0.8	8.606917	12.2956
40000	0.85	7.882672	11.26096
40000	0.9	7.25896	10.36994
40000	0.95	6.717514	9.596449
40000	1	6.244122	8.920174
40000	1.05	5.82758	8.325115
40000	1.1	5.458949	7.798499
40000	1.15	5.13102	7.330028
40000	1.2	4.837919	6.911314
40000	1.25	4.574822	6.53546
40000	1.3	4.337727	6.196754
40000	1.35	4.123298	5.890425
40000	1.4	3.928725	5.612465
40000	1.45	3.751635	5.359478
40000	1.5	3.590003	5.128576



Largo Resources – Preliminary Stability analysis

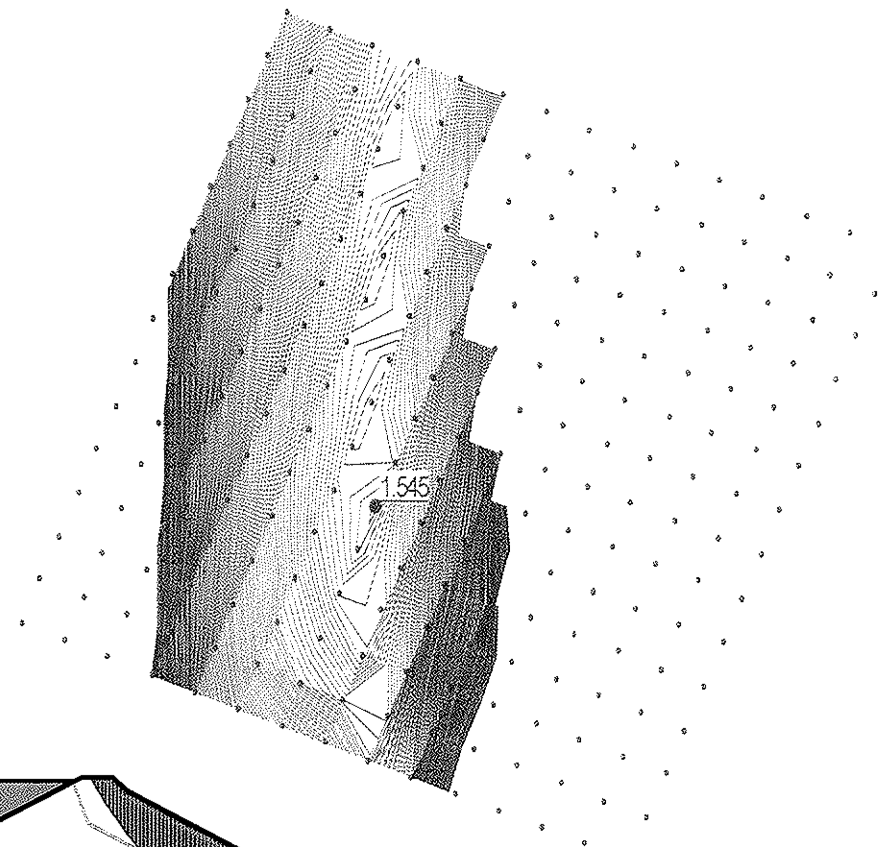
Static analysis
Height = **26 meters**
Safety Factor = **1.545**
Slip surface number = 729

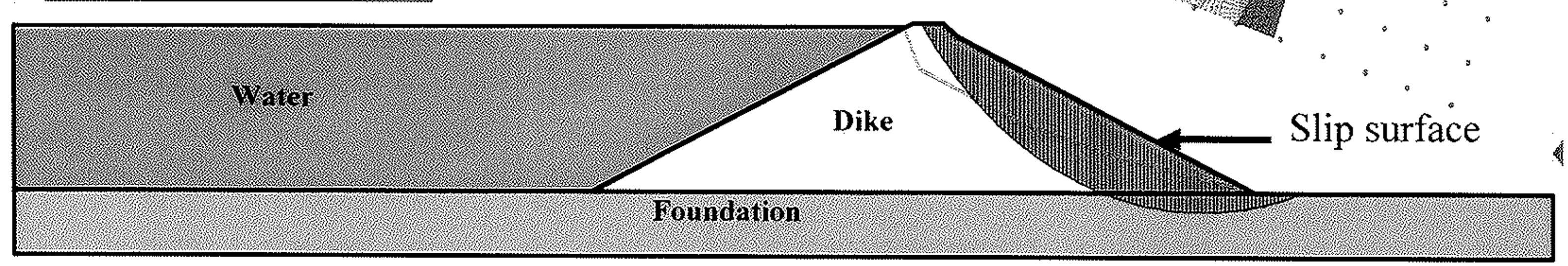
Dike (sand and gravel)
Estimated unit weight = 20 kN/m3
Ø = 33°
Cohesion = 0 kPa

Foundation (sand)
Estimated unit weight = 21 kN/m3
Ø = 35°
Cohesion = 0 kPa

Water
Unit weight = 9.807 kn/m3

---- Piezometric line





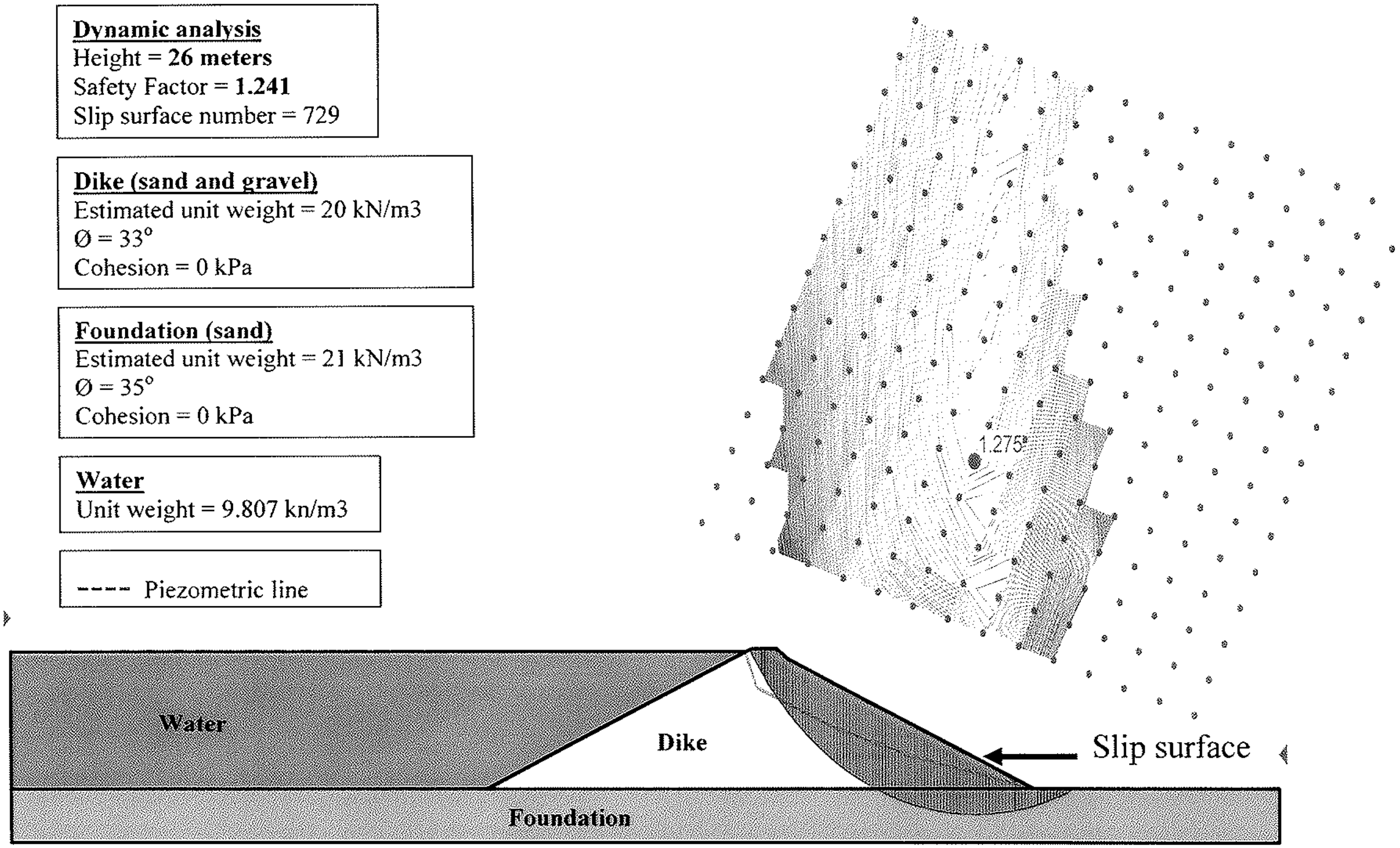
Dynamic analysis
Height = **26 meters**
Safety Factor = **1.241**
Slip surface number = 729

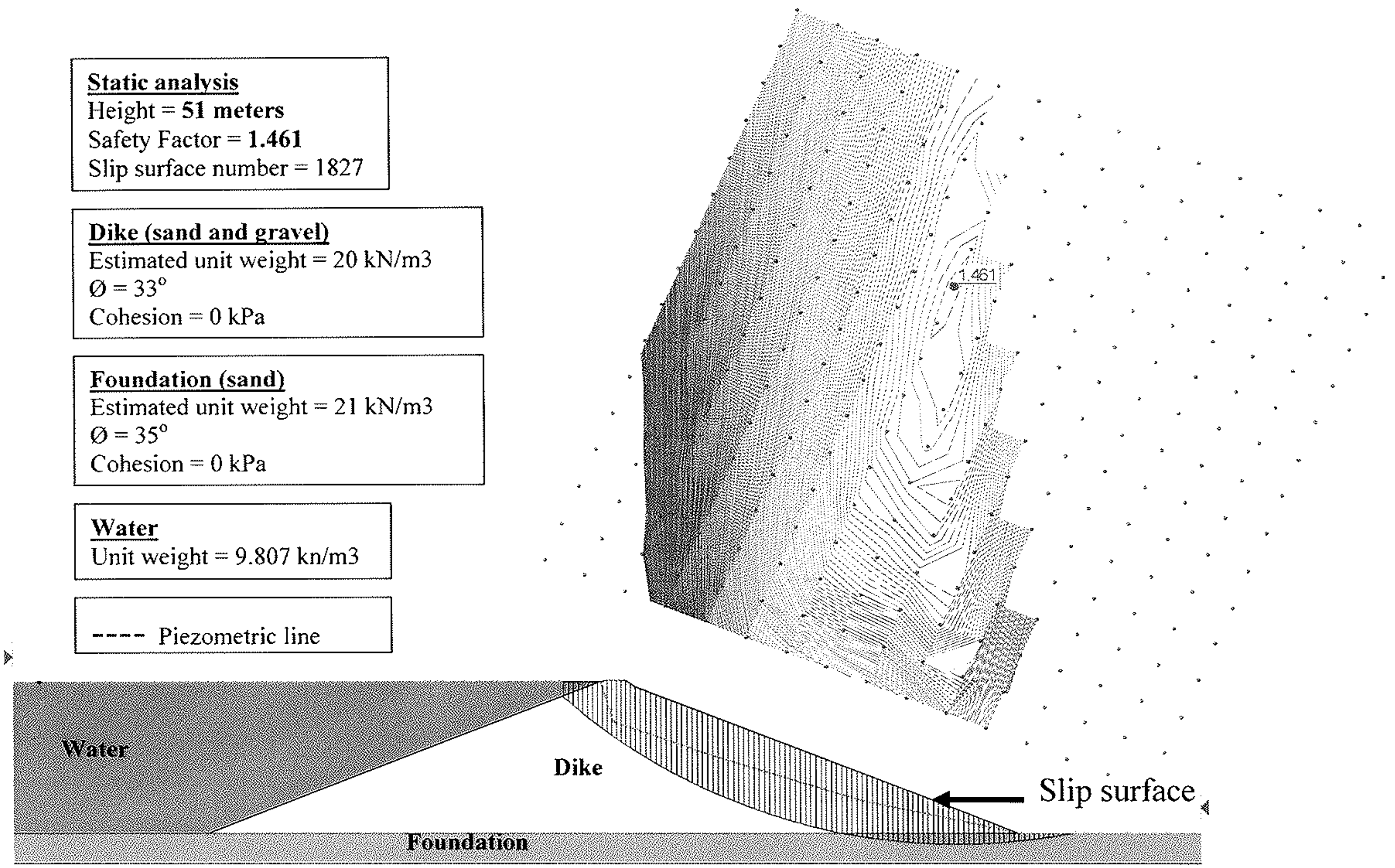
Dike (sand and gravel)
Estimated unit weight = 20 kN/m3
Ø = 33°
Cohesion = 0 kPa

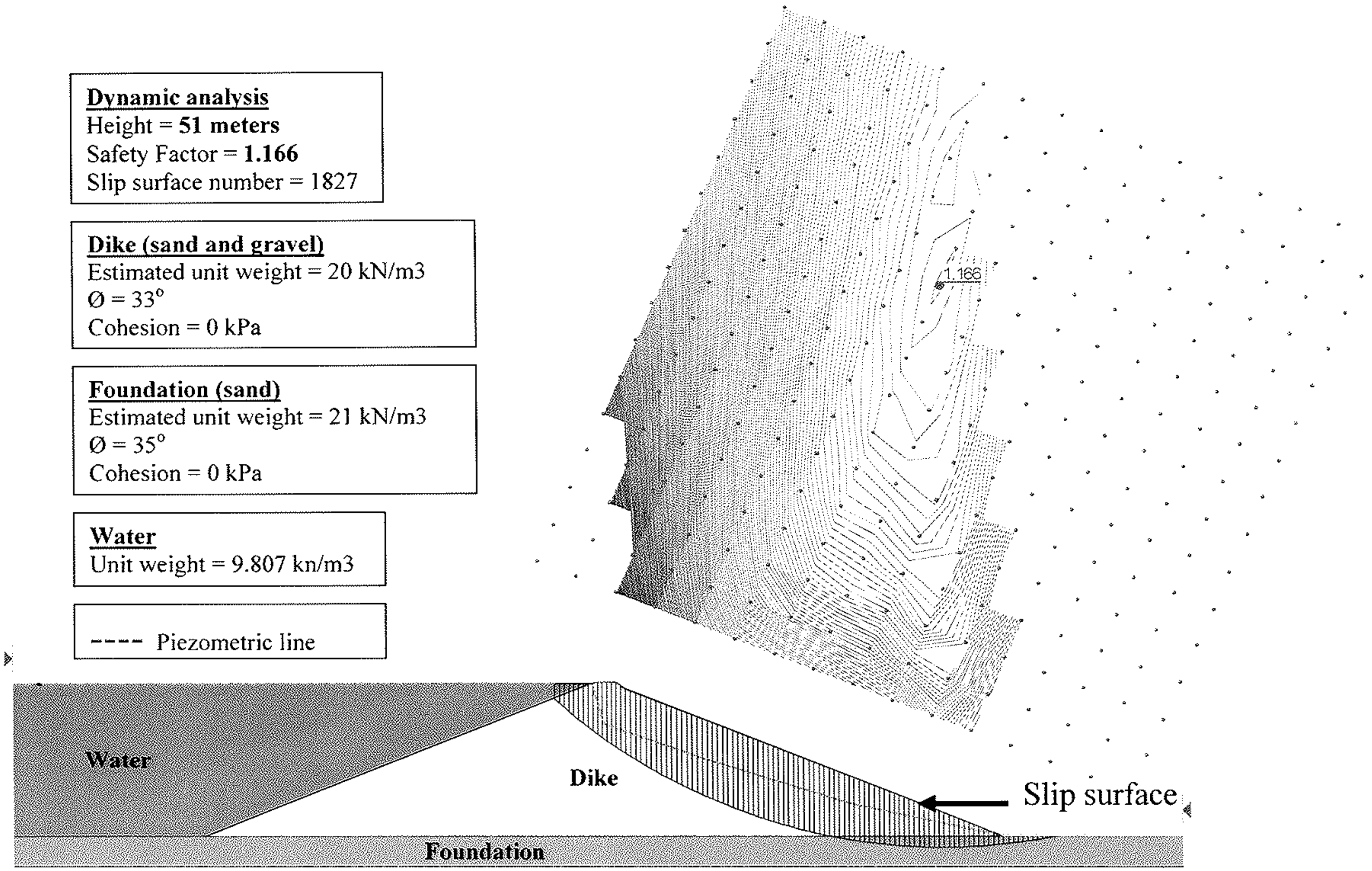
Foundation (sand)
Estimated unit weight = 21 kN/m3
Ø = 35°
Cohesion = 0 kPa

Water
Unit weight = 9.807 kn/m3

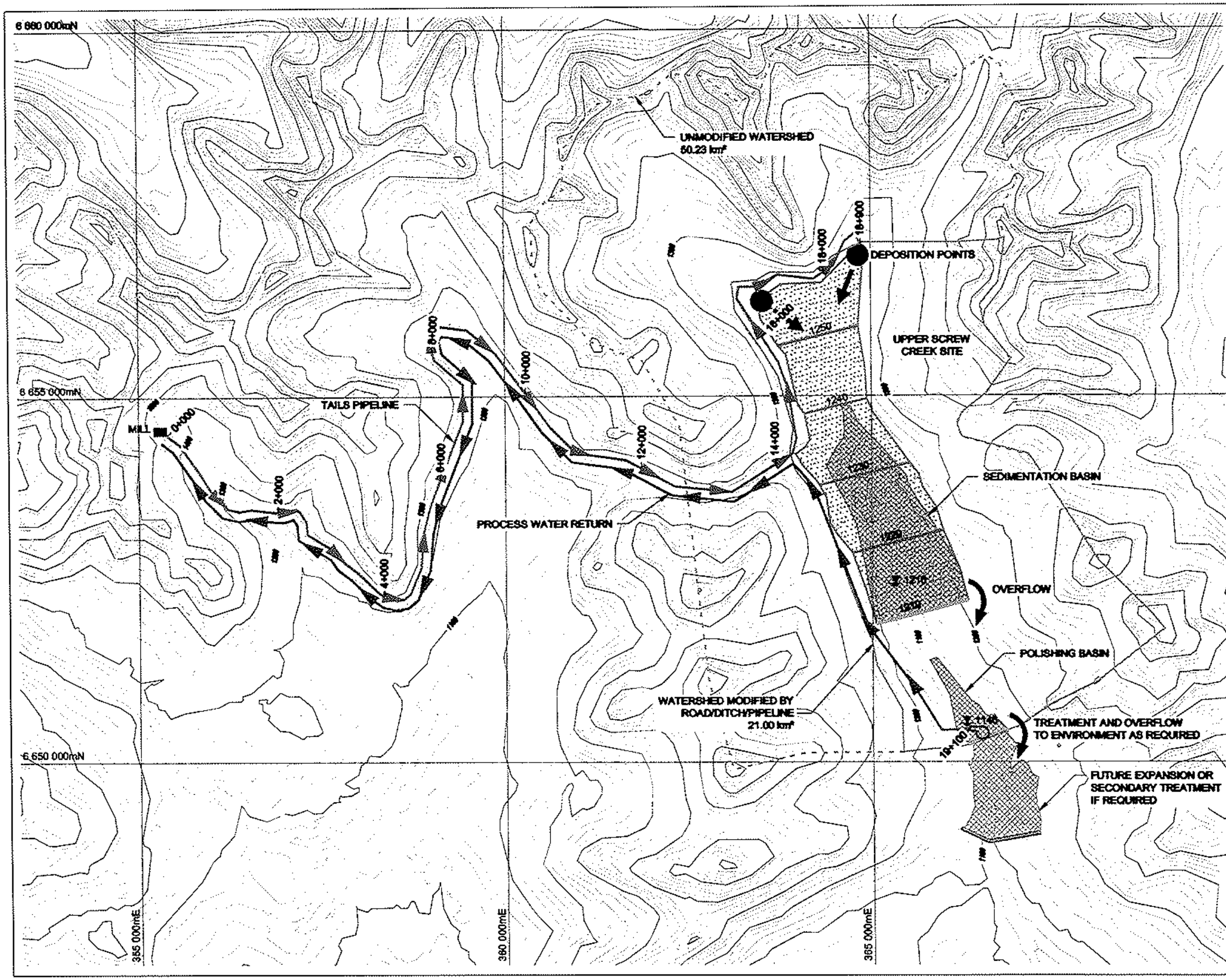
---- Piezometric line




Static analysis
Height = 51 meters
Safety Factor = 1.461
Slip surface number = 1827
Dike (sand and gravel)
Estimated unit weight = 20 kN/m3
Ø = 33°
Cohesion = 0 kPa
Foundation (sand)
Estimated unit weight = 21 kN/m3
Ø = 35°
Cohesion = 0 kPa
Water
Unit weight = 9.807 kn/m3
---- Piezometric line
1.461
Water
Dike
Slip surface
Foundation



Dynamic analysis
Height = 51 meters
Safety Factor = 1.166
Slip surface number = 1827
Dike (sand and gravel)
Estimated unit weight = 20 kN/m3
Ø = 33°
Cohesion = 0 kPa
Foundation (sand)
Estimated unit weight = 21 kN/m3
Ø = 35°
Cohesion = 0 kPa
Water
Unit weight = 9.807 kn/m3
---- Piezometric line
1.166
Water
Dike
Slip surface
Foundation



NOTE:

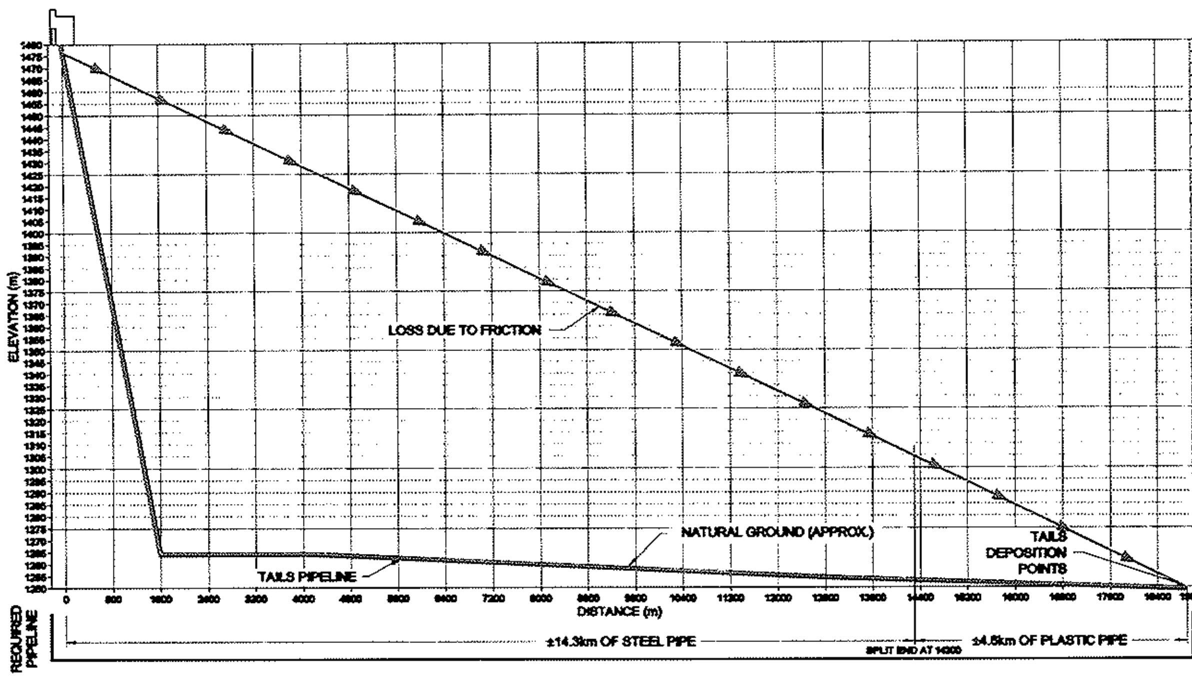
TOPO BASE MAP PROVIDED BY LARGO RESOURCES.

JOURNEAUX, BÉDARD

CLIENT : LARGO RESOURCES

PROJECT :
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PLAN VIEW OF SITE
UPPER SCREW CREEK
USING 1% SLOPE, VOLUME: 130 Mm3
NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-09	SCALE : 1:50 000
DRAWN BY : C. LAPLANTE, tech.	
PROJECTED BY : J. LEMIEUX, eng.	
APPROVED BY : J. LEMIEUX, eng.	
PROJECT No. : S-08-2133	DRAWING No. : S2133-101 / REV. : A



LEGEND:

PROCESS WATER RETURN:

LOSS DUE TO FRICTION:

LOSS DUE TO FRICTION:

Q = 1916 m³/h
V = 2.7m/s
Ø = 20" ID

ASSUMED FRICTION GRADIENT: 0.012

JOURNEAUX, BÉDARD & assoc. inc.

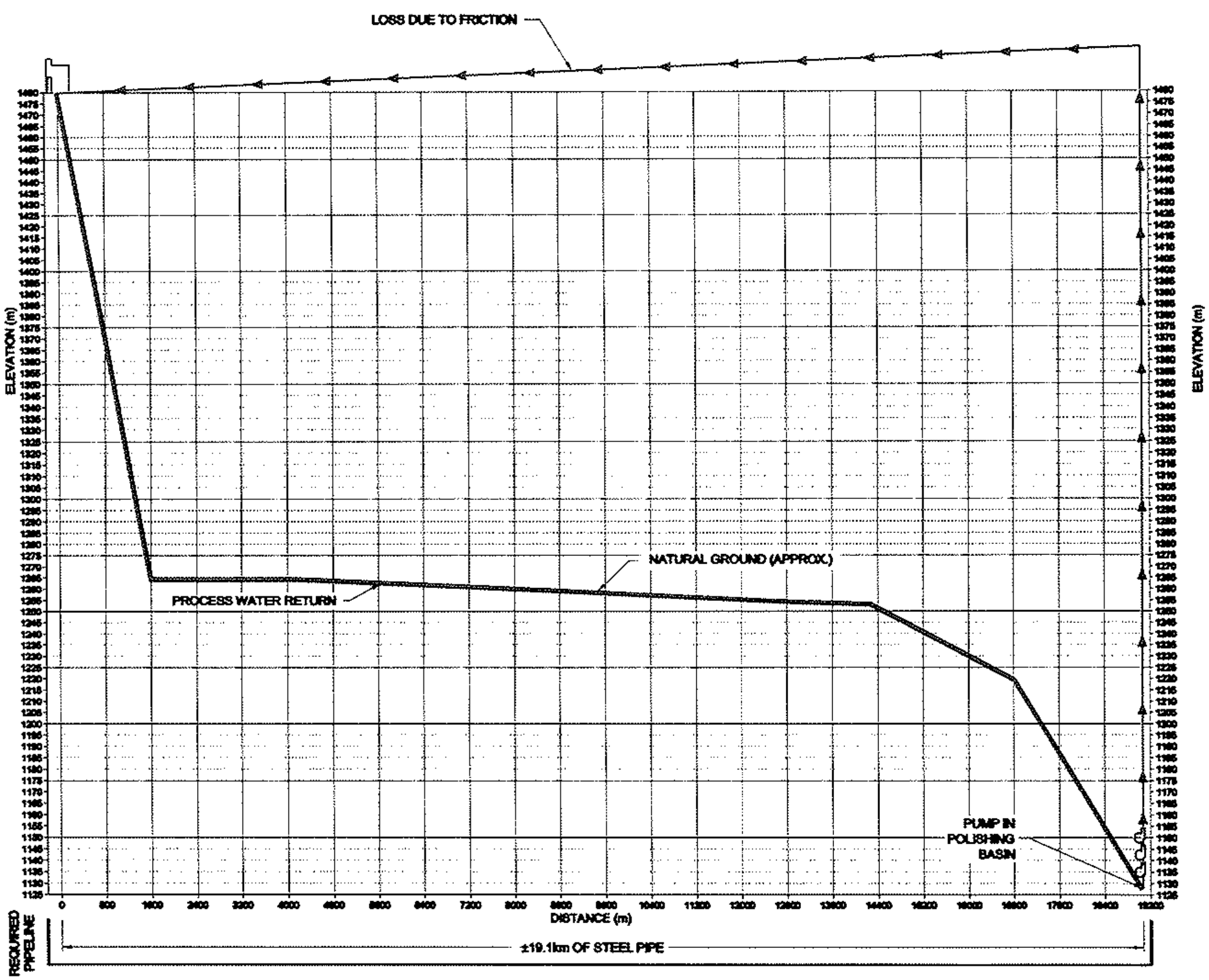
CLIENT: LARGO RESOURCES

PROJECT:
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PROFILE OF TAILS PIPELINE
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE: 08-09-09	SCALE: HORIZ. 1:80 000, VERT. 1:2000
DRAWN BY: C. LAPLANTE, tech.	
PROJECTED BY: J. LEMIEUX, eng.	
APPROVED BY: J. LEMIEUX, eng.	

PROJECT No.:	DRAWING No.:	REV.:
S-08-2133	S2133-102	A



LEGEND:

PROCESS WATER RETURN:

LOSS DUE TO FRICTION:

LOSS DUE TO FRICTION:

Q = 1292 m^3/h
V = 1.0m/s
Ø = 28" ID

ASSUMED FRICTION GRADIENT: 0.001

S:\Data-SOA\Dates2100\2133\dessins\S2133-103.dwg

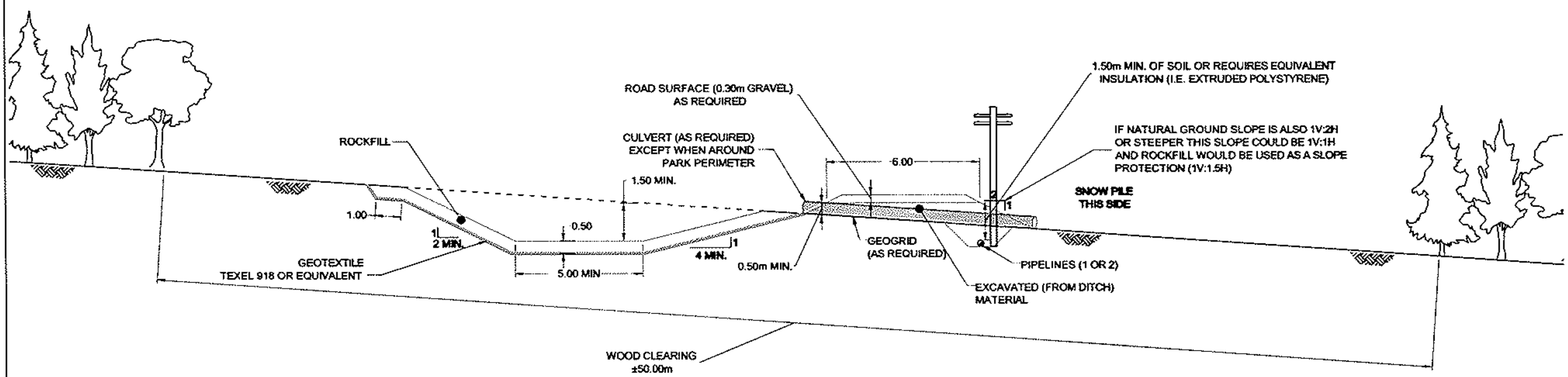
JOURNEAUX, BÉDARD & assoc. inc.

CLIENT : LARGO RESOURCES

PROJECT :
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PROFILE OF PROCESS WATER RETURN
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-09	SCALE : HORIZ. 1:80 000, VERT. 1:2000
DRAWN BY : C. LAPLANTE, tech.	
PROJECTED BY : J. LEMIEUX, eng.	
APPROVED BY : J. LEMIEUX, eng.	
PROJECT No. : S-08-2133	DRAWING No. : S2133-103
REV. : A	



TYPICAL SECTION - ROAD / DITCH / PIPELINE
SCALE 1:150

JOURNEAUX, BÉDARD & assoc. inc.

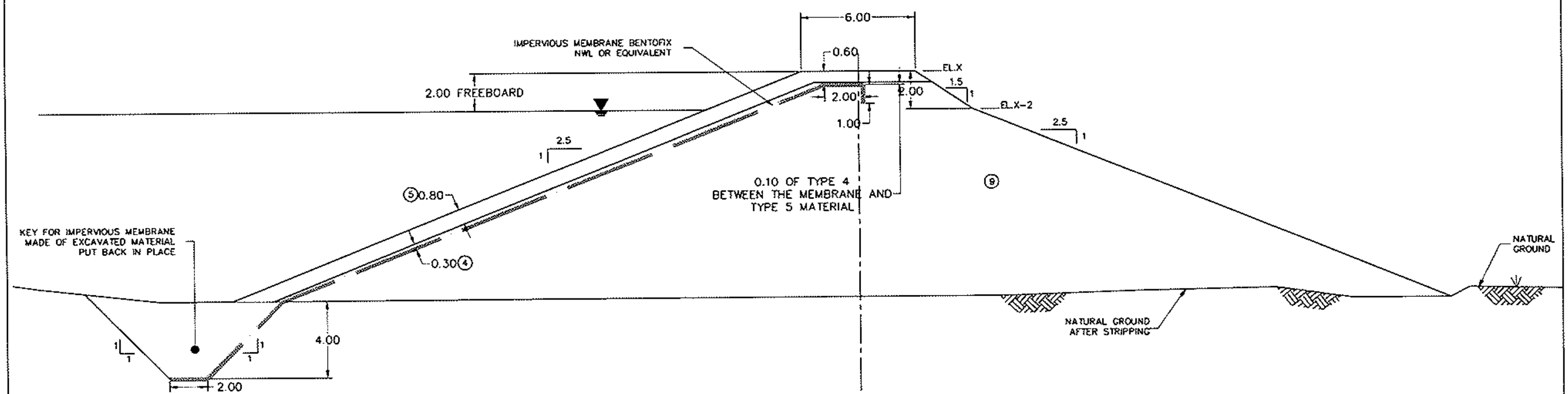
CLIENT : LARGO RESOURCES

PROJECT :
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
TYPICAL ROAD / DITCH SECTION
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-08	SCALE : 1:100
DRAWN BY : C. LAPLANTE, tech.	
PROJECTED BY : J. LEMIEUX, eng.	
APPROVED BY : J. LEMIEUX, eng.	

PROJECT No.	DRAWING No.	REV.
S-08-2133	S2133-104	A



JOURNEAUX, BÉDARD & assoc. inc.

CLIENT : LARGO RESOURCES

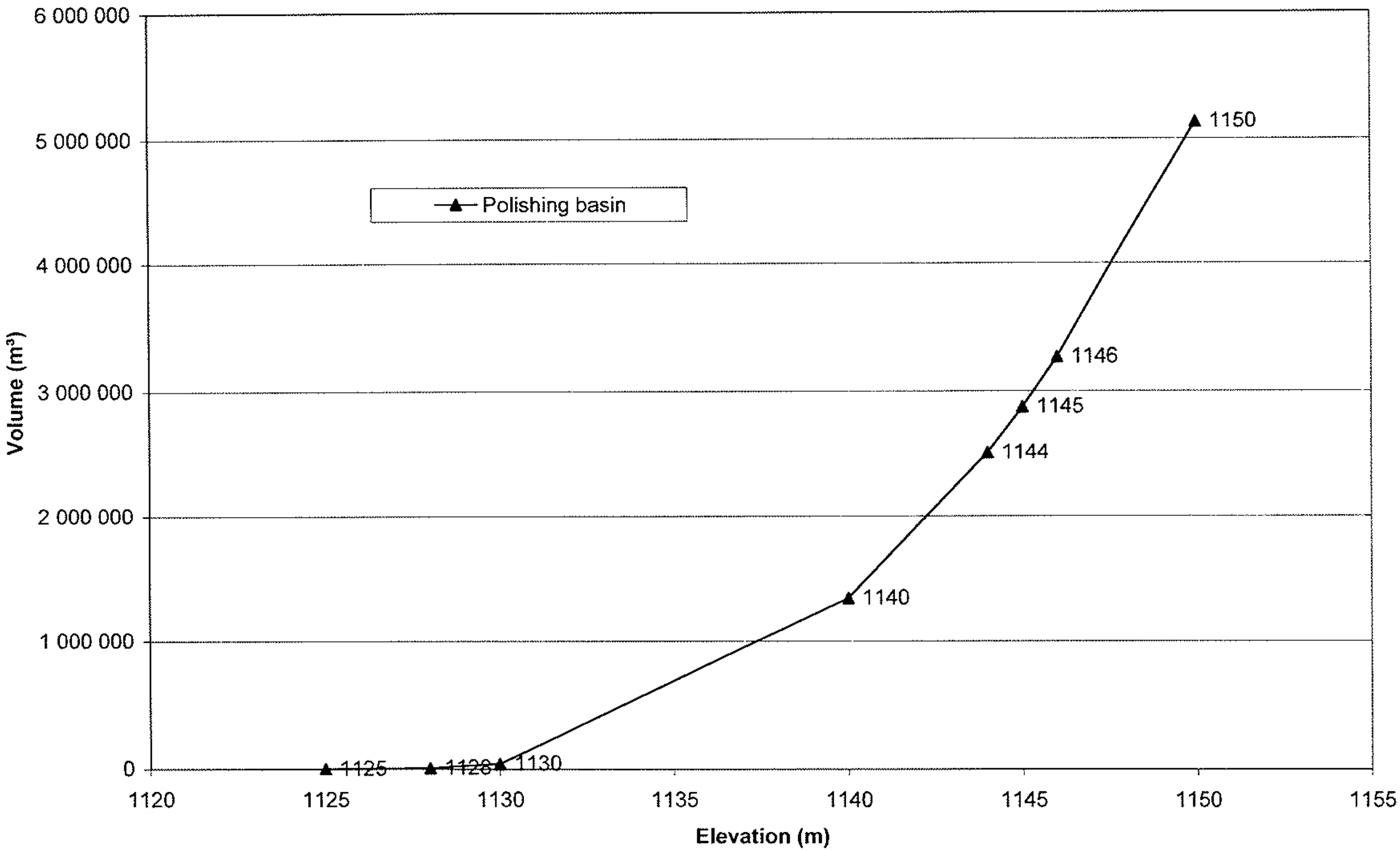
PROJECT :
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
IMPERVIOS DYKE TYPICAL SECTION
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-09	SCALE : 1:200
DRAWN BY :	C. LAPLANTE, tech.
PROJECTED BY :	J. LEMIEUX, eng.
APPROVED BY :	J. LEMIEUX, eng.

PROJECT No. :	DRAWING No. :	REV. :
S-08-2133	S2133-105	A

Volume-elevation curve



S:\Data-SOIL\Datas2100\2133\dessins\volume bassin de polissage.xls 2008-09-09

TABLE 1: DETAILED CAPITAL COST ESTIMATE
TAILINGS IMPOUNDMENT DAMS & PIPELINES
UPPER SCREW CREEK

			130 Mm³		
DESCRIPTION	UNIT	UNIT PRICE	QTY	COST	INFORMATION SOURCE
Wood clearing (park)	ha.	$ 6 000.00	625	$ 3 750 000	Northern Quebec project
Sedimentation basin dam					Northern Quebec project
Type 4, screened granular	m^3	$ 16.00	37 716	$ 603 456	
Type 5, crushed stone	m^3	$ 16.00	102 716	$ 1 643 456	
Type 9, run of pit sand & gravel	m^3	$ 9.00	4 754 309	$ 42 788 781	
Impermeable membrane (incl. overlap)	m^2	$ 37.50	138 722	$ 5 202 075	
Stripping	m^2	$ 7.50	238 419	$ 1 788 143	
Key excavation	m^3	$ 5.00	36 462	$ 182 310	
Polishing basin dam					Northern Quebec project
Type 4, screened granular	m^3	$ 16.00	8 207	$ 131 312	
Type 5, crushed stone	m^3	$ 16.00	23 141	$ 370 256	
Type 9, run of pit sand & gravel	m^3	$ 9.00	459 183	$ 4 132 647	
Impermeable membrane (incl. overlap)	m^2	$ 37.50	31 952	$ 1 198 200	
Stripping	m^2	$ 7.50	53 677	$ 402 578	
Key excavation	m^3	$ 5.00	17 503	$ 87 515	
Pipelines					Abitibi (Quebec) project
see drawing S2133-104, including roads, ditch excavation, power lines and installation of all material					
Process pump & pipeline					
Process station	unit	$ 7 500 000.00	1	$ 7 500 000	
Process water pipeline	m.	$ 1 403.30	19 100	$ 26 803 030	
Tails pump & pipeline					
Tails station	unit	$ 1 000 000.00	1	$ 1 000 000	
Tails pipeline (from 0+000 tio 14+300)	m.	$ 1 090.90	14 300	$ 15 599 870	
Tails pipeline (from 14+300 tio 18+900)	m.	$ 390.00	4 600	$ 1 794 000	
Emergency/operation spillway	Unit	$ 75 000.00	2	$ 150 000	Northern Quebec project
Drainage trench	m.	$ 200.00	2 200	$ 440 000	Northern Quebec project
TOTAL INVESTMENT				**$ 115 567 628**	
INVESTMENT / m^3 TAILINGS				**$ 0.88**	

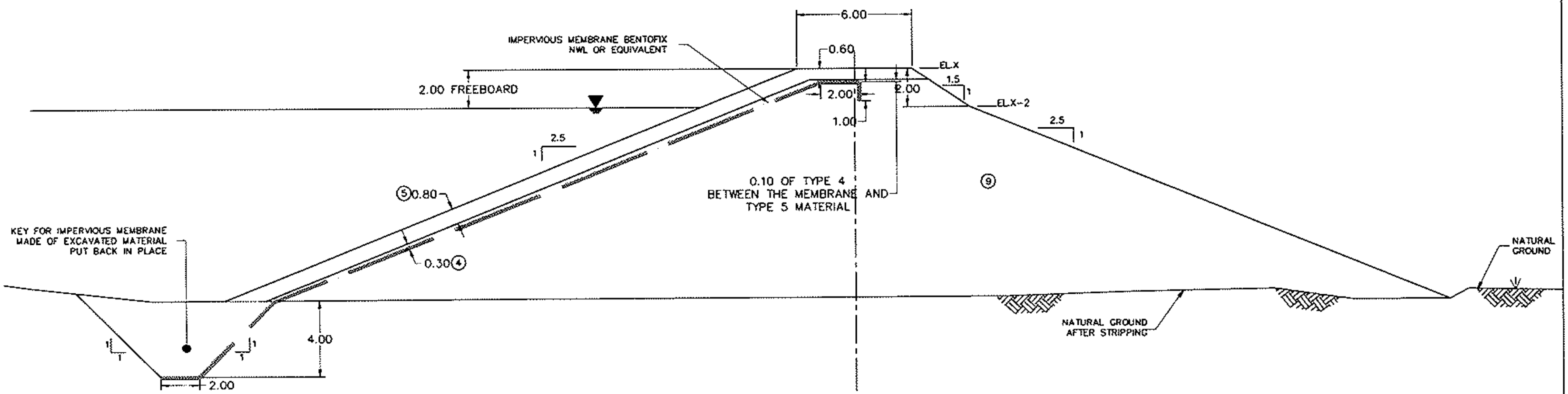
TAILINGS IMPOUNDMENT INVESTMENT SCHEDULE

DESCRIPTION	Pre-production	Post-production		
	Year 0	Year 7	Year 14	Year 21
Wood clearing (park)	$ 3,750,000			
Sedimentation basin dam	$ 6,400,000	$ 7,900,000	$ 13,100,000	$ 24,600,000
Polishing basin dam	$ 6,322,508			
Process pump & pipeline				
Process station	$ 7,500,000			
Process water pipeline	$ 26,803,030			
Tails pump & pipeline				
Tails station	$ 1,000,000			
Tails pipeline (from 0+000 tio 14+300)	$ 15,599,870			
Tails pipeline (from 14+300 tio 18+900)	$ 1,794,000			
Emergency/operation spillway	$ 150,000	$ 150,000	$ 150,000	$ 150,000
Drainage trench		$ 440,000		
INVESTMENT SCHEDULE	$ 69,319,408	$ 8,490,000	$ 13,250,000	$ 24,750,000

TAILINGS IMPOUNDMENT OPEX

DESCRIPTION	$/year
Tailings deposition crew	$ 740,000
(truck, loader, 3 man 24/7)	
Process pump & pipeline	
Electricity (13 * 600kw pumps at 0.05$/kwh	$ 3,416,400
Maintenance, from experience roughly = elec.	$ 3,416,400
Tails pump & pipeline	
Electricity (1 * 600kw pump)	$ 262,800
Maintenance	$ 262,800
	$ 8,098,400

Does not include operator at mill
Purchase and replacement of pipe, as required, not included
Maintenance to dams, as required, is not included



JOURNEAUX, BÉDARD & assoc. inc.

CLIENT : LARGO RESOURCES

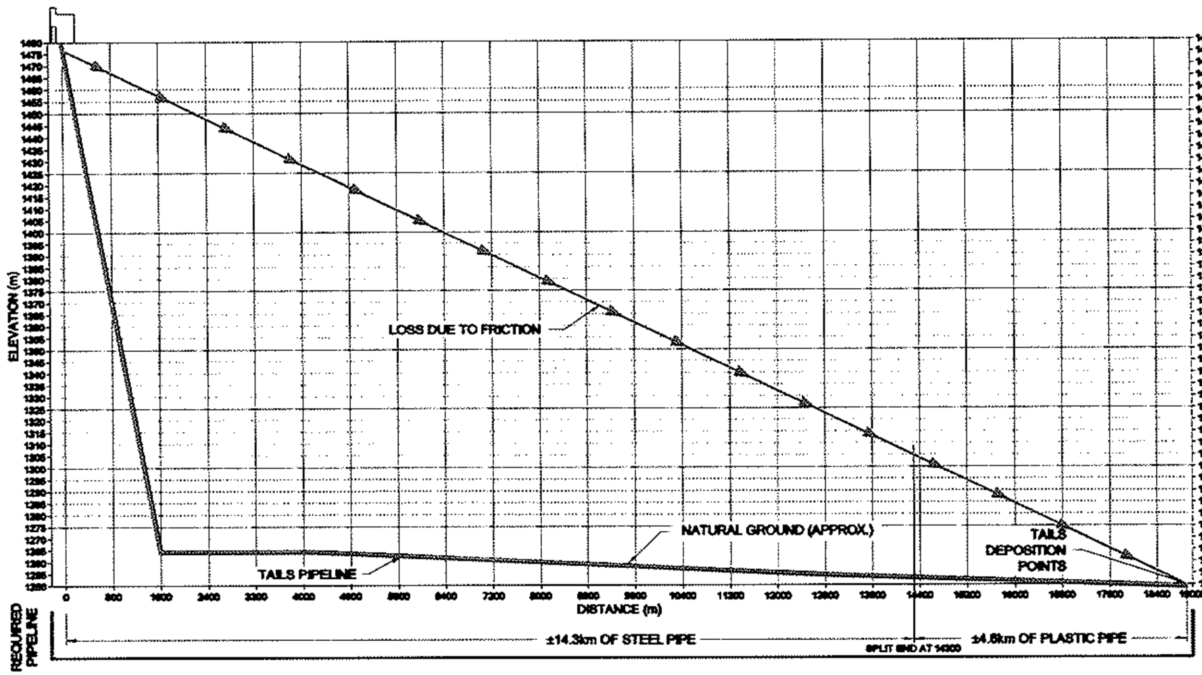
PROJECT :

NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
IMPERVIOS DYKE TYPICAL SECTION
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-09	SCALE : 1:200
DRAWN BY : C. LAPLANTE, tech.	
PROJECTED BY : J. LEMIEUX, eng.	
APPROVED BY : J. LEMIEUX, eng.	

PROJECT No. :	DRAWING No. :	REV. :
S-08-2133	S2133-105	A



LEGEND:

PROCESS WATER RETURN:

LOSS DUE TO FRICTION:

LOSS DUE TO FRICTION:

Q = 1915 m³/h
V = 2.7m/s
Ø = 20" ID

ASSUMED FRICTION GRADIENT: 0.012

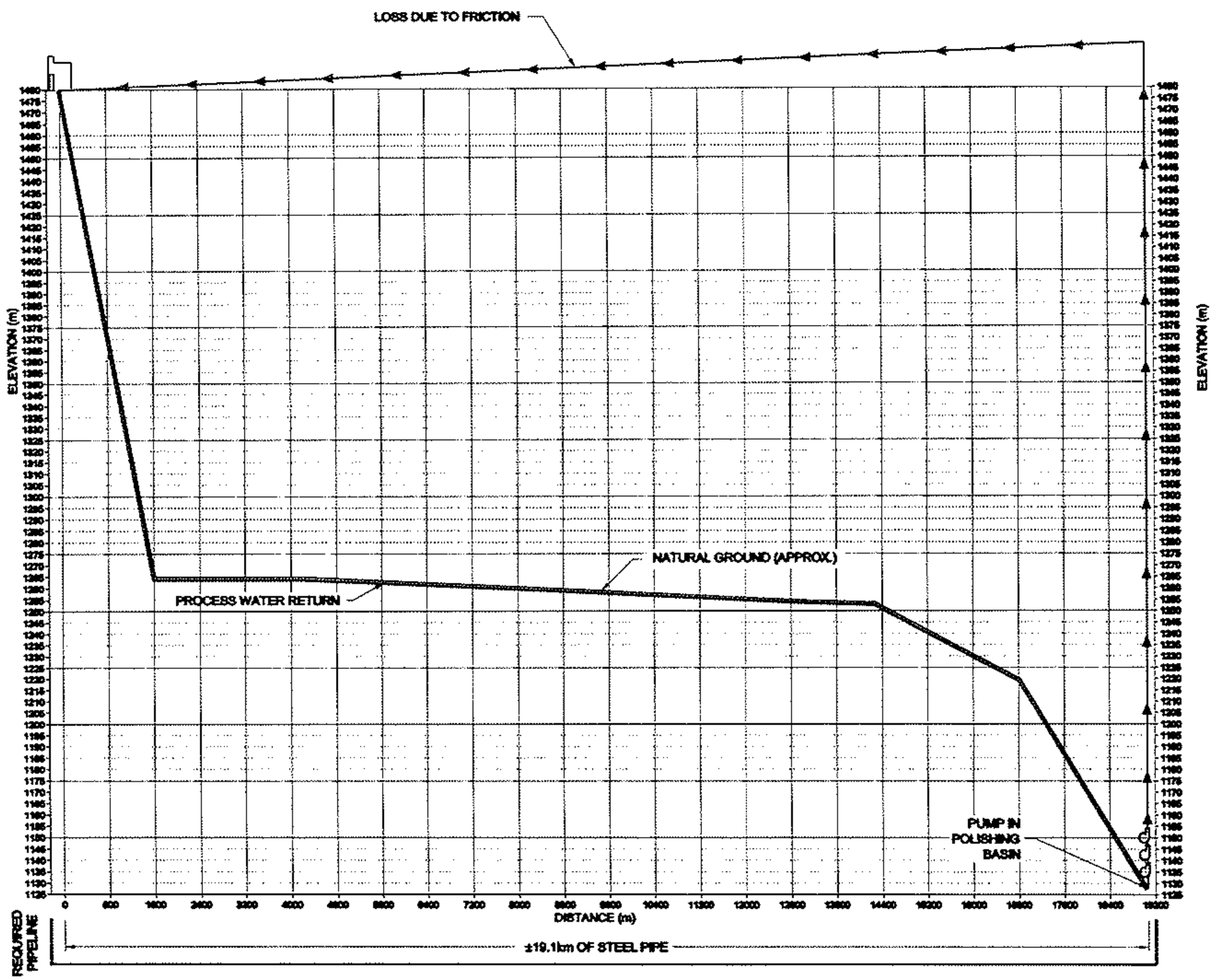
JOURNEAUX, BÉDARD & assoc. inc.

CLIENT : LARGO RESOURCES

PROJECT :
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PROFILE OF TAILS PIPELINE
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-09	SCALE : HORIZ. 1:80 000, VERT. 1:2000	
DRAWN BY : C. LAPLANTE, tech.		
PROJECTED BY : J. LEMIEUX, eng.		
APPROVED BY : J. LEMIEUX, eng.		
PROJECT No. : S-08-2133	DRAWING No. : S2133-102	REV. : A



LEGEND:

PROCESS WATER RETURN:

LOSS DUE TO FRICTION:

LOSS DUE TO FRICTION:

Q = 1292 m³/h
V = 1.0m/s
Ø = 26" ID

ASSUMED FRICTION GRADIENT: 0.001

JOURNEAUX, BÉDARD & assoc. inc.

CLIENT : LARGO RESOURCES

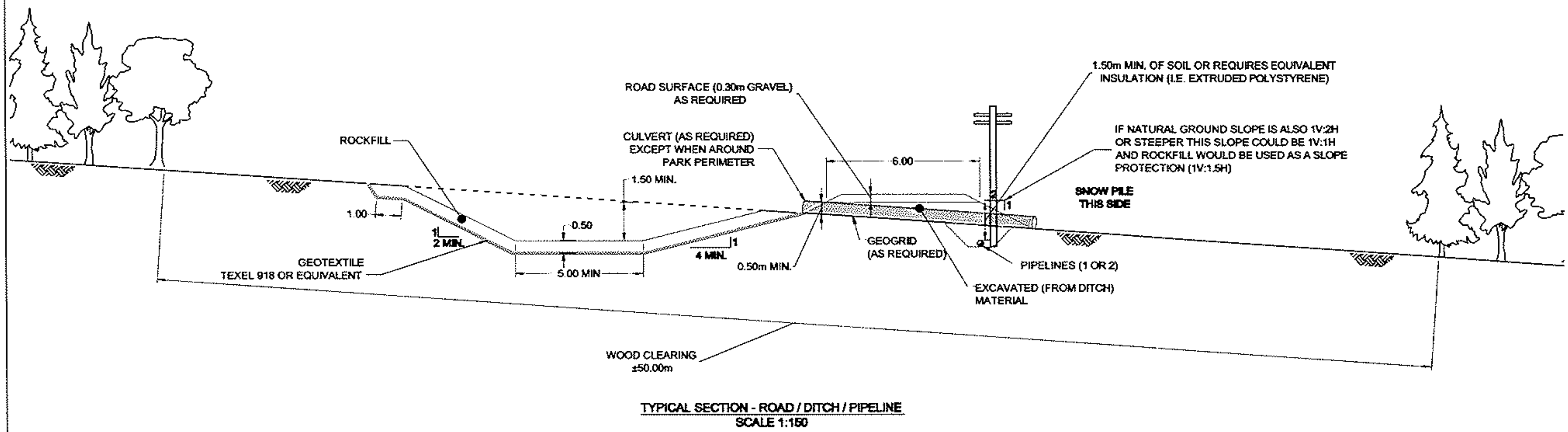
PROJECT :

NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PROFILE OF PROCESS WATER RETURN
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-09	SCALE : HORIZ. 1:80 000, VERT. 1:2000
DRAWN BY : C. LAPLANTE, tech.	
PROJECTED BY : J. LEMIEUX, eng.	
APPROVED BY : J. LEMIEUX, eng.	

PROJECT No. :	DRAWING No. :	REV. :
S-08-2133	S2133-103	A



TYPICAL SECTION - ROAD / DITCH / PIPELINE
SCALE 1:150

S:\Data-SDc\Data2100\2133\dessins\S2133-104.dwg

JOURNEAUX, BÉDARD & assoc. inc.

CLIENT : LARGO RESOURCES

PROJECT :
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
TYPICAL ROAD / DITCH SECTION
UPPER SCREW CREEK

NORTHERN DANCER, YUKON TERRITORY

DATE : 08-09-08	SCALE : 1:100
DRAWN BY : C. LAPLANTE, tech.	
PROJECTED BY : J. LEMIEUX, eng.	
APPROVED BY : J. LEMIEUX, eng.	
PROJECT No. : S-08-2133	DRAWING No. : S2133-104 · REV. : A

TABLE 1: DETAILED CAPITAL COST ESTIMATE
TAILINGS IMPOUNDMENT DAMS & PIPELINES
UPPER SCREW CREEK

DESCRIPTION	UNIT	UNIT PRICE	130 Mm³ QTY	130 Mm³ COST	INFORMATION SOURCE
Wood clearing (park)	ha.	$ 6 000.00	625	$ 3 750 000	Northern Quebec project
Sedimentation basin dam					Northern Quebec project
Type 4, screened granular	m^3	$ 16.00	37 716	$ 603 456	
Type 5, crushed stone	m^3	$ 16.00	102 716	$ 1 643 456	
Type 9, run of pit sand & gravel	m^3	$ 9.00	4 754 309	$ 42 788 781	
Impermeable membrane (incl. overlap)	m^2	$ 37.50	138 722	$ 5 202 075	
Stripping	m^2	$ 7.50	238 419	$ 1 788 143	
Key excavation	m^3	$ 5.00	36 462	$ 182 310	
Polishing basin dam					Northern Quebec project
Type 4, screened granular	m^3	$ 16.00	8 207	$ 131 312	
Type 5, crushed stone	m^3	$ 16.00	23 141	$ 370 256	
Type 9, run of pit sand & gravel	m^3	$ 9.00	459 183	$ 4 132 647	
Impermeable membrane (incl. overlap)	m^2	$ 37.50	31 952	$ 1 198 200	
Stripping	m^2	$ 7.50	53 677	$ 402 578	
Key excavation	m^3	$ 5.00	17 503	$ 87 515	
Pipelines					Abitibi (Quebec) project
see drawing S2133-104, including roads, ditch excavation, power lines and installation of all material					
Process pump & pipeline					
Process station	unit	$ 7 500 000.00	1	$ 7 500 000	
Process water pipeline	m.	$ 1 403.30	19 100	$ 26 803 030	
Tails pump & pipeline					
Tails station	unit	$ 1 000 000.00	1	$ 1 000 000	
Tails pipeline (from 0+000 tio 14+300)	m.	$ 1 090.90	14 300	$ 15 599 870	
Tails pipeline (from 14+300 tio 18+900)	m.	$ 390.00	4 600	$ 1 794 000	
Emergency/operation spillway	Unit	$ 75 000.00	2	$ 150 000	Northern Quebec project
Drainage trench	m	$ 200.00	2 200	$ 440 000	Northern Quebec project
TOTAL INVESTMENT				**$ 115 567 628**	
INVESTMENT / m^3 TAILINGS				**$ 0.88**	

Largo Resources – Preliminary Stability analysis

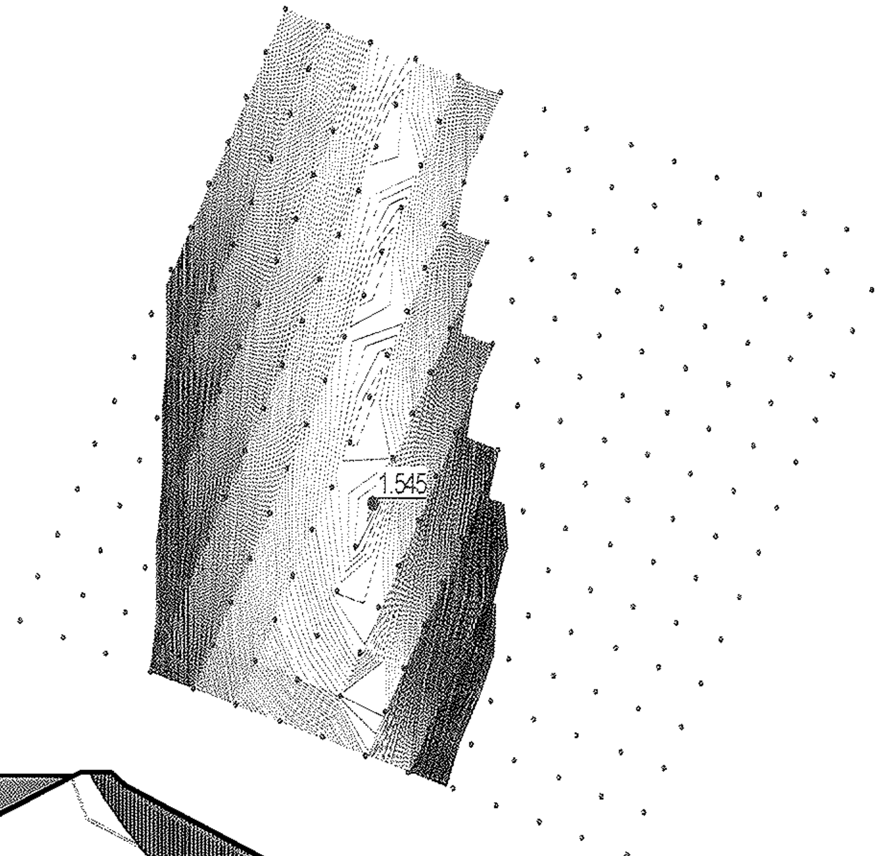
Static analysis
Height = **26 meters**
Safety Factor = **1.545**
Slip surface number = 729

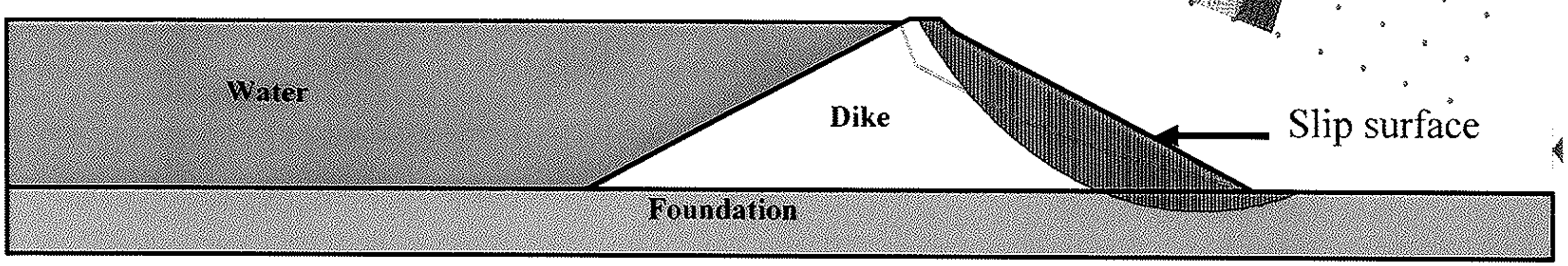
Dike (sand and gravel)
Estimated unit weight = 20 kN/m3
Ø = 33°
Cohesion = 0 kPa

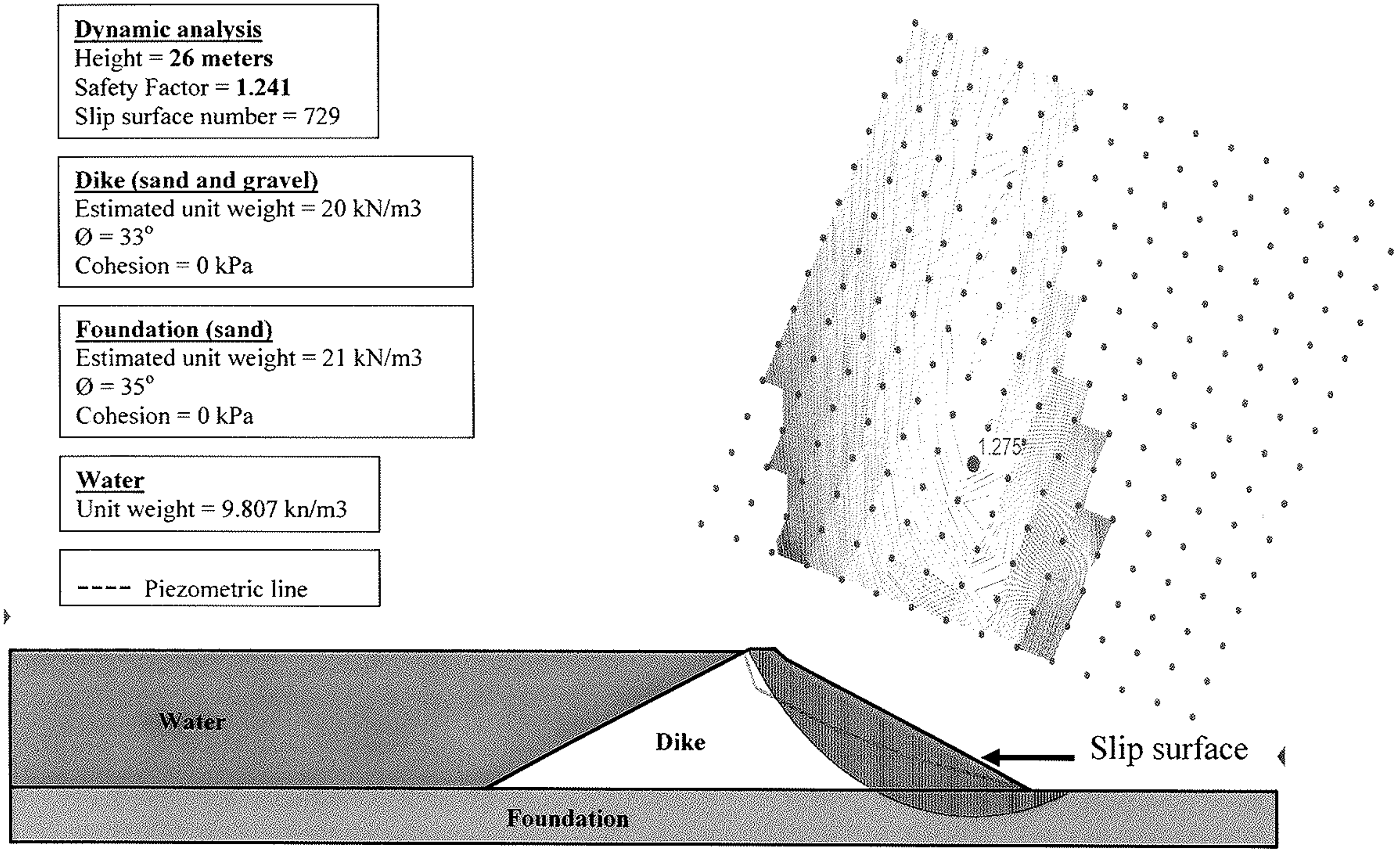
Foundation (sand)
Estimated unit weight = 21 kN/m3
Ø = 35°
Cohesion = 0 kPa

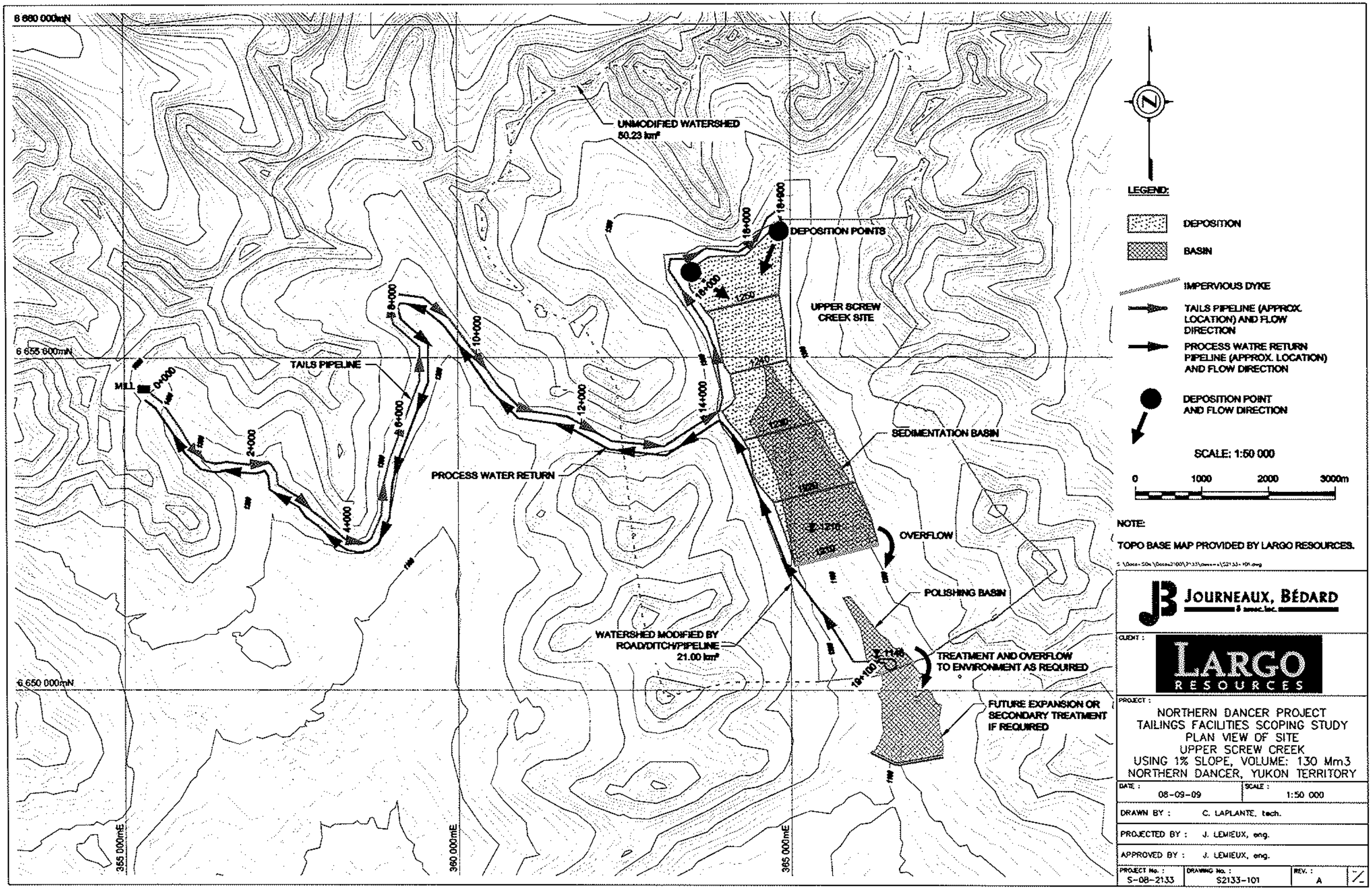
Water
Unit weight = 9.807 kn/m3

---- Piezometric line

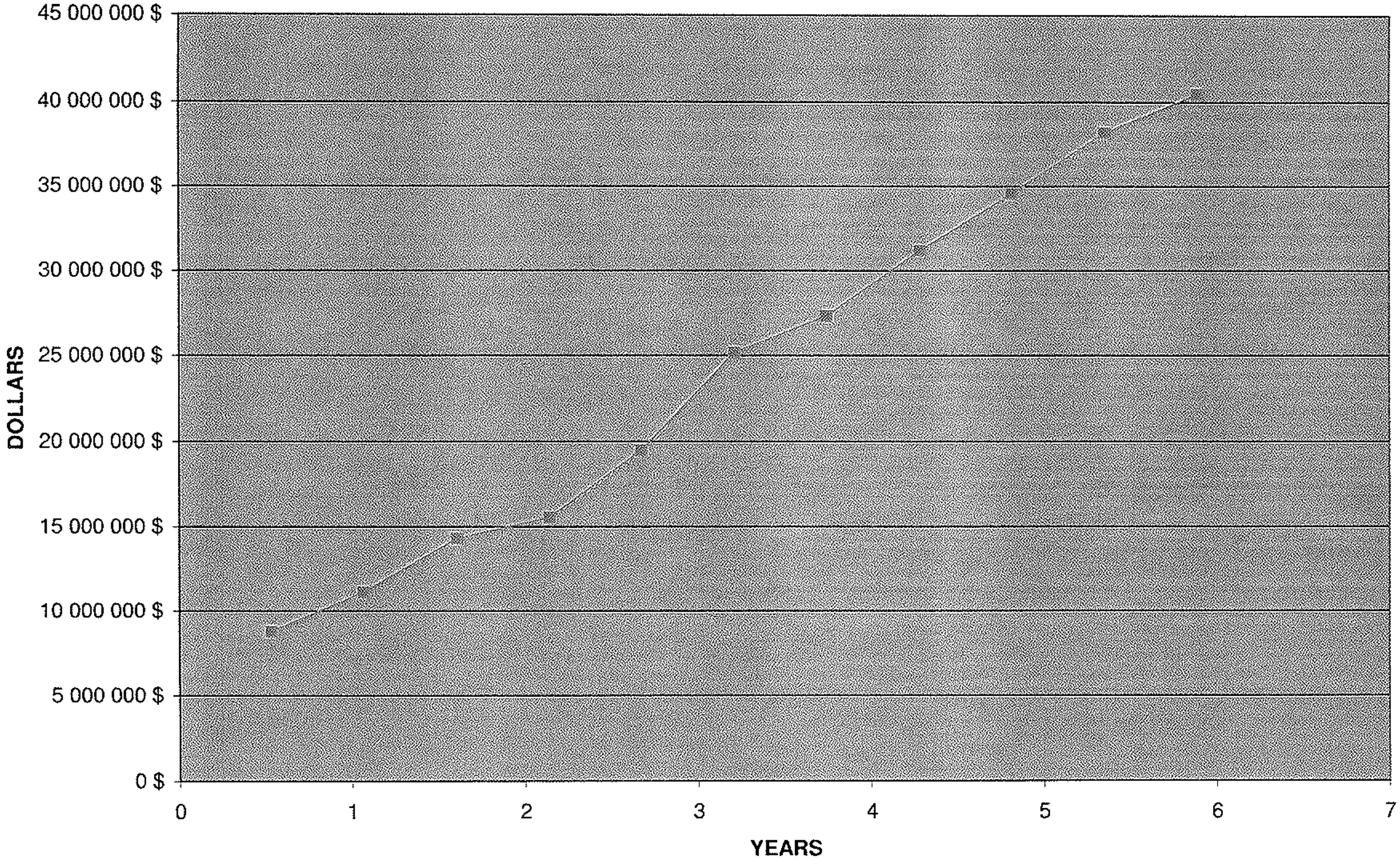





Dynamic analysis
Height = 26 meters
Safety Factor = 1.241
Slip surface number = 729
Dike (sand and gravel)
Estimated unit weight = 20 kN/m3
Ø = 33°
Cohesion = 0 kPa
Foundation (sand)
Estimated unit weight = 21 kN/m3
Ø = 35°
Cohesion = 0 kPa
Water
Unit weight = 9.807 kn/m3
---- Piezometric line
1.275
Water
Dike
Slip surface
Foundation


6 660 000mN
6 655 000mN
6 650 000mN
355 000mE
360 000mE
365 000mE
UNMODIFIED WATERSHED
50.23 km²
DEPOSITION POINTS
UPPER SCREW
CREEK SITE
MILL
0+000
2+000
4+000
6+000
8+000
10+000
12+000
14+000
16+000
18+000
18+900
19+100
TAILS PIPELINE
PROCESS WATER RETURN
SEDIMENTATION BASIN
OVERFLOW
POLISHING BASIN
WATERSHED MODIFIED BY
ROAD/DITCH/PIPELINE
21.00 km²
TREATMENT AND OVERFLOW
TO ENVIRONMENT AS REQUIRED
FUTURE EXPANSION OR
SECONDARY TREATMENT
IF REQUIRED
LEGEND:
DEPOSITION
BASIN
IMPERVIOUS DYKE
TAILS PIPELINE (APPROX. LOCATION) AND FLOW DIRECTION
PROCESS WATRE RETURN PIPELINE (APPROX. LOCATION) AND FLOW DIRECTION
DEPOSITION POINT AND FLOW DIRECTION
SCALE: 1:50 000
0
1000
2000
3000m
NOTE:
TOPO BASE MAP PROVIDED BY LARGO RESOURCES.
JOURNEAUX, BÉDARD
& assoc. inc.
CLIENT :
LARGO
RESOURCES
PROJECT :
NORTHERN DANCER PROJECT
TAILINGS FACILITIES SCOPING STUDY
PLAN VIEW OF SITE
UPPER SCREW CREEK
USING 1% SLOPE, VOLUME: 130 Mm3
NORTHERN DANCER, YUKON TERRITORY
DATE :
08-09-09
SCALE :
1:50 000
DRAWN BY :
C. LAPLANTE, tech.
PROJECTED BY :
J. LEMIEUX, eng.
APPROVED BY :
J. LEMIEUX, eng.
PROJECT No. :
S-08-2133
DRAWING No. :
S2133-101
REV. :
A

COST SOUTH-WEST OPTION 2



Appendix 4: Northern Dancer All Weather Access Road Report

Northern Dancer Project
All Weather Access Road

Prepared By:
Erik Nyland, P.Eng.

September 2008

Introduction

Largo Resources has retained Erik Nyland, P.Eng. to provide route assessment and preliminary cost estimating services for the construction of an all weather access road from approximately km 1168 of the Alaska Highway to the proposed mine site; a distance of approximately 13 km. An access road currently exists that is sufficient for the exploration stage of mine development, however it is substandard for heavier use during mine construction. A second part of the assessment is to provide route assessment and preliminary cost estimate to construct a roadway for pipeline construction from the proposed mine site to the proposed tailings facility at upper Screw Creek, a distance of approximately 12.5 km. There is no existing route for this part of the project.

A visit of the site by helicopter took place on September 9, 2008 by Project Manager Kevin Brewer, P.Geo., and Erik Nyland, P.Eng. The existing road was viewed from the air as well as several stops on the road to assess ground conditions. A proposed route for the pipeline was viewed from the air as well.

Information used to produce this report has been derived from 1:50,000 scale NTDB map sheets, satellite imagery, one site visit and through discussions with Mr. Kevin Brewer P.Geo, Project Manager for Largo Resources. Further investigations must be conducted prior to detailed design being undertaken. These investigations will include, but not be limited to geotechnical, hydrological, terrain analysis, environmental including biophysical and archaeological, and surveys. The reader is cautioned that this report is intended to provide cost estimates to plus or minus 50%

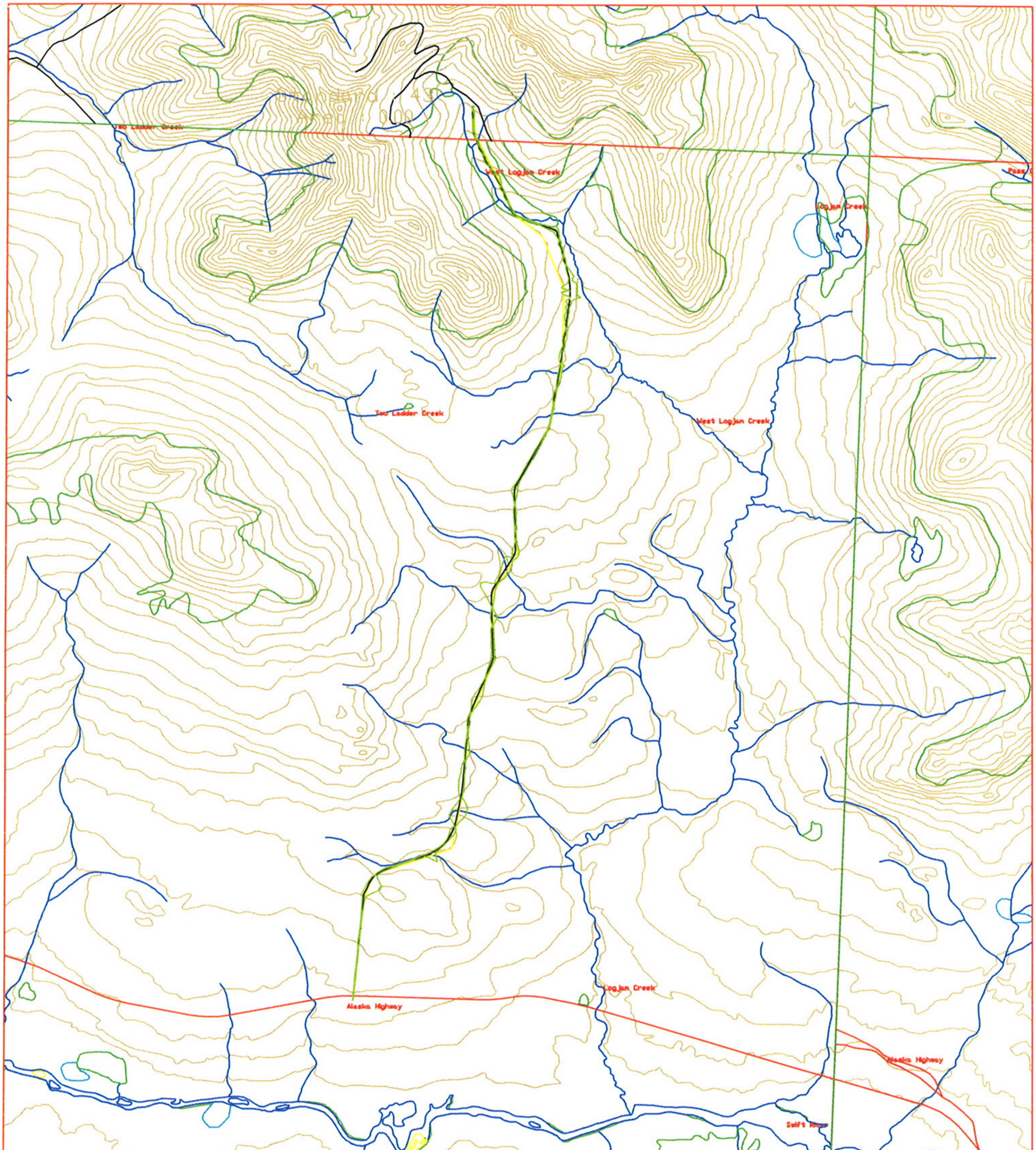
All Weather Access Road

The project requires construction of an approximately 13 km long all weather access road from km 1168 of the Alaska Highway to the proposed mine site. Access off the Alaska Highway appears to have sufficient sight lines which will require field verification, and the existence of the access simplifies permitting. The road leaves the Alaska Highway at a previously used borrow source and travels generally northeast through gently south sloping terrain. Approximately 3 km from the highway the road turns directly north and follows an east facing slope with drainage into Logjam Creek.

The road crosses several small creeks which drain into Logjam Creek, before transitioning into the steeper West Logjam Creek valley at approximately km 9. This creek is crossed as the road crosses to the west facing slope approximately 1.5 km from the existing exploration camp. New construction will follow the existing road route but will provide a straighter alignment and improved grades throughout.

Picture 1 - Access off Alaska Hwy

Picture 2 - Typical Road Section



Largo Resources
Northern Dancer Project

Northern Dancer Access Road
Preliminary Routing

SCALE: 1:75 000	DRAWN: EWN	PROJECT:
DRAWING: 104O13 Largo Rd.dwg	CHECKED:	DATE: 23/09/08

Road Design

The suggested standard of the proposed road design meets or exceeds Transportation Association of Canada (TAC) RLU 60 Single Lane Resource Road with intervisible two lane sections. The suggested standards are summarized below:

Desirable Minimum Curve Radii	170m
Minimum Curve Radii	150m
Minimum Switch-back Radii2	65m
Desirable Maximum Gradient3	8%
Minimum "k" Factor Crest	15
Minimum "k" Factor Sag Single Lane Width	10
Two Lane Width	6m crowned @ 3%
	8.5 m crowned @ 3%
Super-elevation	Emax 8%
Minimum Culvert Diameter Culvert Installations	600mm or Q^{100} whichever is greater
Clearing	as per *YG 06010-1, -2, -3, -4, -5, -6, -7 (Appendix A)* Machine and Hand Clearing as per: YG Sections 03010, 03011 (Appendix A) to 15m either side minimum, or 3m beyond cuts (tree root protection),
	6m beyond fills (access to reclaim stripping), whichever is greater.
Surfacing Aggregate	300mm
Sideslopes (fill)	2H:1V ratio (except as geotechnically modified)
	1.5H:1V ratio, where safety berms are employed
Backslopes (earth cut) Backslopes (rock cut) Ditch Depth	1.5H:1V ratio (except as geotechnically modified) 0H:1V ratio (except as geotechnically modified)
Ditch Type	1m
Safety Berms	"V" Ditch, with widenings for side-borrow.
	0.75m Ht. where Fills > 10m, or where downhill side hazard requires. Roadbed widened 1.5m to accommodate.
	95% Standard Proctor (Embankment)
	98% Standard Proctor Density (Surfacing Aggregate and culvert bedding/backfill

This standard of road construction has been suggested with economy of construction, environmental impact and suitability for the final purpose of the road in mind. The existing route appears to have been constructed in practical location which will likely serve well for the upgraded road. For the purposes of this very preliminary route assessment and cost estimate the standards outlined above have been applied to the route of the existing trail, with various realignments due to straightening, to provide necessary information.

Drainage crossings appear to be minor with the exception of West Logjam Creek at km 11.5. A temporary bridge has been placed over this creek which does not appear to be sufficient for sustained heavy traffic. Hydrological and geotechnical assessments will allow determination of the type of crossing at this point, but for the purpose of this report it has been assumed that the current structure will be replaced by a similar more permanent crossing. The majority of the stream crossings will consist of culverts, for which an item has been included in the cost assessment table.

Picture 3 - West Logjam Ck Bridge

Geotechnical conditions on site appear to be suitable for subgrade construction, and a suitable borrow source for surfacing material may be found along the route of the existing road. If so this will result in significant cost savings during construction. Further geotechnical investigation will determine subgrade material suitability and borrow source location.

Picture 4 - Typical Sandy Gravel conditions

Access will be from the Alaska Highway at the existing location. During construction a camp and lay down area will be required to provide facilities for the construction contractor. The existing and apparently abandoned borrow pit will suit. A Land Use Permit will be required to utilise this area for the purpose.

Cost Estimate

Construction cost estimate for the project has been developed using historical unit costs from previous similar projects. Materials quantities have been derived using estimates from projects of similar terrain and magnitude. A very conceptual alignment has been created along with a conceptual profile. However, accurate quantities estimates cannot be achieved using this data because significant refinement is required and quantity take off at this stage would be inflated.

Item	Description	Unit	Quantity	Price	Cost	Notation
1	Mobilization, Demobilization	LS	LS	$100,000.00	$ 100,000.00	Local Contractor Assumed
2	Engineer's Office and Camp	Mo.	3	$ 10,000.00	$ 30,000.00	Staff of 3
3	Clearing and Grubbing	Ha.	65	$ 7,500.00	$ 487,500.00	Includes R/W, Borrow Pits
4	Stripping	m^3	30,000	$ 4.50	$ 135,000.00	Estimated from conceptual
5	Excavation Common	m^3	240,000	$ 9.00	$2,160,000.00	Estimated from conceptual
6	Excavation Rock	m^3	20,000	$ 60.00	$1,200,000.00	Estimated from conceptual
7	Overhaul (beyond 100m)	m^3*km	50,000	$ 2.00	$ 100,000.00	Estimated from conceptual
8	Granular Surfacing	m^3	14,000	$ 26.00	$ 364,000.00	11,700 + 2,400 for widenings
9	Construct Safety Berms	m^3	2,000	$ 16.00	$ 32,000.00	Estimated from conceptual
10	Supply and Install Geotextile	m^2	2,000	$ 7.50	$ 15,000.00	
11	<u>Supply and Install Drainage and Crossing Structures</u>					
11.a	600mm CSP	m	390	$ 500.00	$ 195,000.00	Est one every 500 m
11.b	1000mm CSP	m	80	$ 750.00	$ 60,000.00	4 majour pipes, subject to hydrological study
11.c	15 m Single Lane Bridge 80T Capacity	ea.	1	$200,000.00	$ 200,000.00	West Logjam Creek
11.d	Ditch Lining	m^3	2000	$ 30.00	$ 60,000.00	Erosion Protection
11.e	Ditch Blocks	ea.	10	$ 500.00	$ 5,000.00	
	Total Running Estimate				$5,143,500.00	
	Project Mgt & Quality Control	Day	90	$ 3,000.00	$ 270,000.00	Dayshift and night shift inspectors, geotech technician
	Engineering Design	%	10		$ 541,350.00	Typical
	Contingency	%	10		$ 595,485.00	
	GST	%	5		$ 327,516.75	
	<u>**Total**</u>				<u>**$6,877,851.75**</u>	No PST Included

Next Steps

Further investigation of the site will be required before detailed design is possible. This will include:

- Detailed topographical mapping of the site through the acquisition of air photography or satellite imagery. This will allow 3d analysis of the imagery to produce a Digital Earth Model (DEM) of the site. The DEM could include all areas of the project including road, water source, minesite, tailings pipeline and tailings pond.
- Hydrological assessment to predict water flows across the road and other areas of the project. This will permit accurate sizing of drainage crossing structures and prediction of scour.
- Hazard assessment to predict the possibility of land slides, avalanches, floods etc. This is especially important close to the mine site, camp locations and tailings facilities.
- Geotechnical assessment at location of all structures and facilities. This is especially important along the road route to ensure a long term stable road structure. The geotechnical assessment will also identify borrow sources along the route.
- ARD assessment of the abandoned borrow source at the junction of the Alaska Highway, as well as other areas along the route, to determine suitability for further borrow as well as whether the location will be suitable for a camp / laydown area. These typically consist of Shake Flak Tests and Acid Base Accounting Tests.
- Various Environmental studies as required by the permitting bodies.
- Assessments of required traffic control as requested by the permitting bodies.
- Sediment and Erosion Control mitigation measures.

Summary

This report has been provided with the best available data available at this time. As such the author assumes no responsibility for the accuracy of the information included. Upon the completion of the above mentioned studies a detailed design and a more accurate cost estimate could be completed.

Erik Nyland, P.Eng.

Sept 23/08

Date

PROFESSIONAL
YUKON
ERIK NYLAND
TERRITORY
ENGINEER

PROFESSIONAL
PROVINCE OF
E. W. NYLAND
31380
BRITISH
COLUMBIA
ENGINEER

Appendix 5: Water Sampling and Testing Procedures

A MEMBER OF ALEXCO RESOURCE GROUP
3 Calcite Business Centre, 151 Industrial Road, Whitehorse, Yukon Y1A 2V3
PHONE (867) 668-6463 **FAX** (867) 667-6680
WWW.ACCESSCONSULTING.CA
mail@accessconsulting.ca

February 11, 2010

Mr. Kevin Brewer
General Manager, Northern Dancer Project
3151B 3rd Ave
Whitehorse, YT
Y1A 1G1

Dear Mr. Brewer:

This is to confirm that our firm was engaged to conduct preliminary environmental baseline investigations along the current access road to the Northern Dancer property that is located within British Columbia. Our investigations comprised of water quality data, fisheries investigations on small creeks, and an aerial wildlife survey conducted by Grant Lortie. This work was completed in the summer of 2008.

The results of the work were presented in brief reports to your office. We have reviewed the assessment report filed with the British Columbia Energy, Mines and Resources office and confirm that all results noted to you are included within this report. We do note that our firm and its subcontractors did complete some preliminary investigations on other areas outside of the claim block to provide additional baseline data that were expected to contribute to Largo Resources Ltd understandings of potential environmental impacts that could arise from the Northern Dancer project. We are of the understanding that these results were not incorporated into the assessment report as they were not completed within the claims tenures in British Columbia.

Our firm continues to look forward to working with Largo to complete further environmental baseline studies for the Northern Dancer Project.

Regards,

David Petkovich, B.Sc.
Senior Environmental Manager
ACCESS CONSULTING GROUP
A Registered Tradename for Access Mining Consultants Ltd.

LARGO RESOURCES LTD.
Whitehorse Branch
3151B 3rd Ave
Whitehorse, YT, Y1A 1G1
Tel: (867) 633-4260

February 11, 2010

Mr. Allan F. Wilcox, P.Geo.
Sr. Assessment Report Geologist
Via: mailto:allan.wilcox@gov.bc.ca

Dear Mr. Wilcox:

As per our conversation on February 9, 2010 regarding the 2008 Assessment Report filed on the Northern Dancer Property, I have attached a letter from Access Consulting Ltd. ("Access") who completed the preliminary environmental baseline studies on the BC tenures associated with that property. The reporting on these matters was quite brief to us as the examination of baseline issues on water quality, fisheries and wildlife investigations was very early stage and conducted primarily to identify any issues which could impact future permitting or environmental assessment of the project.

You will note that the results are presented in the following sections of the report:

- 7.1.2 General Description of Site Water
- 7.1.3 Sampling Station ND-LJ 2.5
- 7.1.4 Water Quality Results
- 7.2.2.1. Fish Habitat – Access Road
- 7.2.2.2 In-Situ Water Quality – Access Road
- 7.3 Wildlife Investigations

These sections incorporated all of the results we were presented from Access.

Largo completed some regional level baseline investigations in the area to also gain insight into potential future issues. These were not included in the assessment report as they were activities completed outside of the tenures and claims within British Columbia and Yukon.

If you have any further questions please feel free to contact me at the above address and phone number.

Regards,

Kevin Brewer, P. Geo.
General Manager, Northern Dancer Project

cc. R. Campbell, VP Exploration - Largo Resources
Archer Cathro & Associates, Vancouver

The following field gear is required for each sampling site located at the Property:

1) pH and EC meter
2) DO meter
3) Wading rod and flow meter
4) Measuring tape
5) Stop watch
6) Field note book
7) Pencil
8) Wading boots
9) Bottles (see next section for bottle requirements at each station)
10) Sampling gloves
11)

Each sampling site requires the sampler to collect specific information for the baseline environmental study. To assist sampling personnel, a sampling checklist is provided.
All sites require the following activities and data collection:

1) Collect the following water samples at each station. Sampling personnel should follow the Water Sampling Protocol provided in Appendix B. The following sampling parameters will be collected at each station on the property.

Sampling Parameter	Bottle Type	Minimum Volume	Preservative
Solids - TSS	plastic	1 L	cold
Routine	plastic	250 ml	cold
Anions	plastic	125 mL	cold
Cyanide	plastic	125 mL	H2SO4 ~ cold
Total Metals	plastic	125 mL	HN03
Dissolved Metals	plastic	125 mL	field filtered ~ HN03
DOC	plastic	125 mL	field filtered ~ HN03
TOC	plastic	125 mL	cold

2) Write down staff gauge measurements (if a hydrology station is installed).
3) Collect stream discharge measurement using a flow meter and wading rod for stream discharge measurements protocol. Collect in-situ measurements. See Appendix A for in-situ measurement protocol.

2) In the field notebook, for each sample site the following information is documented, including but not limited to:

- start and end time of sampling activities at each station,
- date,
- weather and ambient air temperature,
- samples collected,
- in-situ parameters (pH, electrical conductivity, dissolved oxygen, water temperature),
- staff gauge measurements,
- flow readings,
- general site conditions,
- any variances from regular sampling, and
- notable changes from previous sampling events observed by the sampler (i.e. installation or removal of data loggers, increase or decrease in water levels, etc.).

For pH measurements the following procedures were followed:

Direct measurement of pH can be done in the field. Prior to any use, the meter must be calibrated using a minimum of two pH calibration standards. Operators will follow manufacturer's instructions for proper calibration, use, storage and maintenance of the specific meter. Calibration of the pH meter should be verified at least daily. The meter must be re-calibrated or replaced if the meter readings do not meet project objectives for minimum detectable differences, precision, and accuracy.

The two standards chosen for calibration should bracket the pH of the water being monitored. The exact calibration procedure for each pH meter may vary slightly from the procedure outlined here and is outlined in the meter-specific operation manual. To calibrate, press the <CAL> "calibration" key and place the standards in plastic or glass bottles. Set the temperature of the pH standards (if required) and immerse the probe into the standard, stir gently and press the <RUN/ENTER> key. When in calibration mode, most new meters will recognize the pH of the buffer solution and automatically calibrate. The reading must be allowed to stabilize. Many newer meters have an icon indicating that a stable reading has been reached. Once the reading has stabilized the probe is then removed and rinsed with distilled water. The probe is then pat-dried with a paper towel and immersed into the second standard.

The calibration process is then recorded in the meter calibration log book, including the % slope.

To record pH in the field, the probe is then placed in the water or in a water sample and the meter is then turned on. The sample is stirred and then one must allow the reading to reach equilibrium. In soft waters this may take a long time (>2 minutes). The pH is then recorded on the appropriate data sheet. Corresponding depth is also recorded for all pH measurements according to the calibrated probe line when producing a profile. If the water is deeper than the probe line, the pH can be read directly from the water samples collected at depth (e.g., with beta bottle or Kemerer).

When the pH probe is not in use, the end should be immersed in potassium chloride (KCl, generally 4 M).

For conductivity measurements, the following procedures were followed:

A variety of conductivity meters and multimeters with conductivity probes are currently in use. The units in which conductivity is expressed may vary among meters and may be expressed as -1μS/cm, μmhos/cm, or simply as cm. Refer to the operations manual of your meter for detailed operating instructions.

Conductivity measurements were taken by direct measurement in the field. Prior to use, the meter is calibrated and/or verified using a calibration standard. Operators follow manufacturer's instructions for proper calibration, use, storage and maintenance of the specific meter. When sampling is conducted over many days, the conductivity meter was calibrated or verified at least daily. The exact calibration procedure for each conductivity meter is outlined in the meter-specific operation manual and may vary slightly from the procedure outlined here.

Typically to calibrate, press the <CAL> ("calibration") key and place enough standard in a small container to allow for a reading. Immerse the conductivity measuring cell (probe) in the control standard solution and press <RUN/ENTER>. Most new meters have an icon indicating that a stable reading has been reached. Once the reading has stabilized the probe is removed, rinsed with distilled water and patted dry with a paper towel. The calibration results are then recorded in the meter calibration log book, including the determined cell constants relative to the accepted range.

Following calibration, conductivity measurements were then taken in the field. To record conductivity in the field, the probe was placed in the water or in a water sample and the meter is turned on. The sample is stirred and the reading is allowed to reach equilibrium. The temperature is then recorded (switch MODE to TEMPERATURE and the meter read when the reading stabilizes) and the conductivity (switch MODE to appropriate conductivity scale for on-scale meter readings) is then noted on the appropriate data field sheet. Corresponding depth are then recorded for all conductivity measurements according to the calibrated probe line when producing a depth profile. If the water is deeper than the probe line, conductivity was read directly from water samples collected at depth (e.g., with beta bottle or Kemerer). Some conductivity probes may require wet storage. If this is the case, store in a dilute solution of potassium chloride (KCl). Each conductivity cell constant is recorded in the meters log book. Should, at any point, the cell reach conductivity values more than ±5.0% of the original cell constant, cleaning may be necessary. Cleaning should be conducted by submersing the cell in HCl foam cleaning solution. If the % error in conductivity is still greater than ±5% then the probe should be sent in for evaluation or replacement. Any cleaning or replacement of the probe is to be noted in the meter log book.

If properly calibrated, interferences are minimal. This method is applicable to surface water, groundwater and wastewater with specific conductance values greater than 0.5 μS. The minimum detectable conductivity obtainable with this method is generally 0.2 μS

For dissolved oxygen measurement the following procedure was followed:

A variety of DO meters and multimeters with DO electrodes are currently in use. The units in which dissolved oxygen is usually expressed are mg/L and % saturations. Refer to the operations manual of your meter for detailed operating instructions. Dissolved oxygen measurements were taken by direct measurement in the field. Prior to any use, the meter was calibrated with saturated water or a standard. Operators follow manufacturer's instruction for proper calibration, use, storage and maintenance of the specific meter. Calibration of the DO meter was conducted at least daily. Each time the meter is turned off, it may be necessary to re-calibrate before taking measurements. The meter was re-calibrated or the membrane replaced if the meter readings do not meet project objectives for minimum detectable differences, precision, and accuracy. The exact calibration procedure for each DO meter may vary slightly from the procedure outlined below and is outlined in the meter-specific operation manual. Typical procedures for calibrating a digital (e.g., YSI Model 85, WTW Oxi) DO meter are outlined here. The calibration is performed in water vapour-saturated air usually within a supplied calibration vessel. Turn the meter on and set the measuring mode to read mg/L or % saturation. Wait for the dissolved oxygen and temperature readings to stabilize (usually 15 minutes is required). Press the <CAL> "calibration" key until the oxygen calibration mode appears and then press <RUN/ENTER>. Certain DO meters will require the operator to know and enter the approximate altitude of the region in which the meter is being used. When the measured value is stable, the instrument displays the value of the relative slope and the sensor evaluation. The calibration process was then recorded in the meter calibration log book, including the determined slope and sensor evaluation.

Following calibration, DO measurements were taken in the field. Stream DO measurements were taken just below the surface of the water. In order to take the measurements within the water column, an extended cable was attached to the DO probe. It was important to ensure that the probe was not inserted into the mud when obtaining the DO measurement.

- Place the probe into the water column and gently move it in a circular motion, while remaining at the same depth;
- Adjust salinity control if necessary;
- Read dissolved oxygen, while continuing to gently move the probe;
- The instrument should be left on between measurements to avoid the necessity of re-calibrating the probe.;

Repeat above steps for subsequent measurements.

The probe is then stored in calibration solution and kept moist at all times. The DO was then recorded on the appropriate data field sheet. Corresponding depth and temperature were also recorded for all DO measurements according to the calibrated probe line when producing a profile. If the water is deeper than the probe line, the DO was read directly from water samples collected at depth (e.g., with beta bottle or Kemerer).

For temperature measurements, since the field meters used (and all conductivity and dissolved oxygen meters) were equipped with a thermistor, temperature measurements simply involved recording the temperature while taking the conductivity and/or dissolved oxygen readings.

WATER SAMPLING PROCEDURE

PREPARATION AND MATERIALS

Prior to departure for sampling, all field equipment should be checked for functionality and cleanliness. All equipment, calibration standards, sampling gear and sample bottles should be assembled in clean, dry containers. The analytical laboratory chosen to analyze the samples will supply the appropriate sample containers for the collection of water. The laboratory should ensure that sample bottles are clean prior to delivery, although it should be noted that some laboratory practices such as adding a concentrated charge of acid (e.g., ≥ 8M HNO3) may result in contamination (Hall 1998). High density polyethylene (HDPE) bottles are recommended as they require minimal pre-cleaning (e.g., distilled water or weak HNO3 solution; Hall 1998). Interestingly, the purchase of pre-cleaned (by the manufacturer/supplier) HDPE bottles was discouraged based on the potential for increased contaminantion, particularly of zinc (Hall 1998). Polypropylene (PP) bottles generally require cleaning if aluminum concentrations are of interest (Hall 1998).

The use of teflon (FEP) bottles is not recommended.

Sample bottles should be ordered from the laboratory one week before the field trip or earlier if bottles need to be shipped ahead of time to the site.

Sample bottles will be labeled using a permanent marker, with labels appearing on the jars (not the lids). All sample bottles should be transported in large sealed coolers to prevent damage and reduce the risk of contamination. Several extra bottles should be included as a reserve in case of sample contamination, loss or breakage.

Preparation and materials must also include provision for quality control samples (e.g., blanks, field replicates). The number of field quality control samples taken must correspond to a minimum of 10% of the total number of samples taken during the sampling program.

The field crew must be experienced in the operation and safety requirements for all sampling gear, meters, equipment (e.g., boats) and reagents used in the water quality assessment. This should include having reviewed the study design and applicable standard operating procedures.

SAMPLE COLLECTION

Water sampling in different aquatic environments involves different sampling techniques. Whenever sediment or benthic samples are also taken at a site, water samples should always be taken first to avoid contamination. Samples should only be collected if it can be done safely.

The same protocol for rinsing of sample bottles must be followed in all sampling environments. If sample bottles have not been pre-cleaned and pre-preserved by the laboratory, then they must be rinsed three times with either de-ionized water or sample water prior to collecting the sample. The exceptions to this are when a sample is to be analyzed for suspended sediments, for contaminants likely associated with the suspended solids, or for oil and grease. In these cases, the bottles should not be rinsed with sample water as suspended particles or grease-like materials are retained on the interior surface of each bottle with each rinsing.

Wherever practical, samples should be collected away from rather than near shore. If the water body has no or slow flow such that the collector can wade in, then the sample can be collected at a depth that does not pose a threat to the safety of the sample collector. When conditions, such as a strong flow or thin ice, dictate that the sample be taken from shore (e.g., stream bank), deviations from the standard protocol should be accurately documented in a field notebook.

Wading to Sample Collection Point

Obtain labelled bottles and wade to the sampling point. In creeks/rivers, wade in downstream from the point at which the samples will be collected, and then wade upstream to the sample site. Continue to stand perpendicular to the flow and face upstream to collect the sample. This minimizes sediment disturbance in the vicinity of the sample point.

- If rinsing is required as described above, then proceed;
- Grasp the bottle well below the neck. Plunge it beneath the surface in front of you to a depth of 20 cm (if possible) with the opening facing directly up, then remove the lid underwater and let the bottle fill with water. This avoids collection of surface materials in the container;
- Once the bottle is full, replace the lid underwater, remove the bottle from the water and shake it vigorously;
- Remove the lid and reach back towards shore to pour the water out;
- Repeat previous steps twice more before collecting the sample;
- Grasp the bottle well below the neck. Plunge it beneath the surface in front of you to a depth of 20 cm (if possible) with the opening facing directly up, then remove the lid underwater and let the bottle fill with water; and,
- Once the bottle is full, replace the cap underwater and remove the bottle from the water. Samples should be filled to the very top to minimize air space.

Sampling from a Stream Bank

Be careful not to disturb sediments or debris along the shoreline and avoid sampling any disturbed areas by sampling upstream of where you are. As a safety precaution, the second person must remain nearby while the first is collecting the samples;
If sample containers do not contain preservatives and the samples are not being collected for analysis of suspended solids or oil/grease, rinse three times as described:

- Hold the bottle well below the neck;
- Reach out upstream (arm length only) and plunge the bottle beneath the surface in front of you to a depth of 20 cm (if possible) with the opening facing directly up, then remove the lid underwater and let the bottle fill with water; and,
- When the bottle is full, replace the cap underwater and remove the bottle from the water.

Sample Collection from a Boat

Surface Grab Samples

Once the sampling station is reached, anchor the boat and wait until it settles with the bow facing into the current, if applicable, before collecting the sample. Collect the samples as follows:

- The person at the bow should always collect the samples because the bow is the anchor point and the boat will drift so that the bow is facing the current or wind direction. This precaution reduces the potential for contamination from the boat and/or motor;

- Obtain a labeled sample bottle. If sample containers do not contain preservatives and the samples are not being collected for analysis of suspended solids or oil/grease, rinse three times as described in Section B1 .2.1 a) to d);
- Ensure that the person in the stern is providing counterbalance. Reach out an arm length from the boat to take the sample;
- Plunge the bottle under the surface to a depth of approximately 20 cm and move it slowly towards the direction the boat is facing; and,
- Once full, recap the bottle underwater and remove it from the water. Repeat procedure for the next sample.

Deep Grab Samples

Water samples may be collected from a specific depth using a Van Dorn or similar sampler (e.g. Beta Bottle) using the following protocol.

- Ensure the sample bottle is clean;
- Open the sampler by raising the end seals;
- Set the trip mechanism;
- Lower the sampler to the desired depth;
- Send the messenger down to "trip" the mechanism that closes the end seals;
- Raise the sampler to the surface;
- Transfer the water from the bottle to a labelled sample container via the drain valve if collecting water samples for analyses. If sample containers do not contain preservatives and the samples are not being collected for analysis of suspended solids or oil/grease, rinse three times as described in Section B1.2.1 a) to d) before retaining the sample for laboratory analysis; and,
- If only field measurements (e.g., pH, temperature, DO, conductivity) are being taken, then the probe of the water quality meter can be inserted directly into the sampler after removing one of the end seals.

FIELD FILTRATION

If it is necessary to collect samples for analysis of dissolved metals, samples should be filtered and preserved in the field, rather than later at the analytical laboratory. This will minimize chemical reactions potentially affecting chemical speciation that can occur in the sample prior to filtration.

An assessment of field filtration units concluded that a Millipore Sterivex syringe with a Durapore membrane was superior to 11 other filtration systems in terms of overall performance and ease of use (Hall 1998). A Gelman (now Pall) Acrodisc syringe filter with Supor membrane Gelman system also resulted in good performance but showed higher retention (filtration) of colloidal forms of some metals. The Millex LS 5 um syringe prefilter was recommended for samples high in particulate matter (Hall 1998). It was noted that nylon membranes should be avoided as they are slow and may show inferior performance.

SUPPORTING INFORMATION

Field measurements to be taken at all water sampling stations include pH, conductivity, dissolved oxygen (mg/L and % saturation) and temperature. These parametres should be measured in the field using appropriate metres and methods (See Appendix A). Given the wide variety of metres currently available (including single and multipurpose metres), operators should follow manufacturer's instructions for proper calibration, use, storage and maintenance.

All field measurements must be recorded, along with relevant site observations, on field sheets. Information recorded should include: station location and number, time and date of collection, sampler's name, general conditions (baseflow, freshet, during or following significant rain event or drought, etc.), water depth, type of sampler used (if applicable), any modifications to standard sampling methods required during sampling, and details pertaining to any unusual events which occurred during sampling (e.g., possible sample contamination, equipment failure, etc.). If meter failure occurs and no back-up metres are available, water samples should be collected and subjected as quickly as possible to laboratory analysis of pH and conductivity. A back-up measurement for dissolved oxygen can be obtained in the field using a Winkler Kit, which provides a rough measurement of dissolved oxygen concentration (± 1 mg/L). Litmus paper should also be available as back-up for pH measurements, as well as a hand-held thermometer, in the event of meter failure.

SAMPLE HANDLING AND SUBMISSION

From the time of collection to chemical analysis, all water samples should be maintained at or near 4°C in coolers or in a refrigerator. Samples should not be allowed to freeze. All samples should be submitted to the analytical laboratory (or laboratories) for chemical analysis within the required holding times for parameters to be analyzed.
All samples must be submitted to the appropriate laboratory for analysis according to the following schedules:

- On the next business day following return from the field program; or
- From the site before returning from the field program, if necessary, based on the maximum allowable holding times for samples.
-

The project manager should confirm the holding times for all sample analyses prior to going into the field and inform the field crew of sample submission schedules. A Chain of Custody Record must accompany all samples being submitted in order to ensure that the laboratory receives all samples, that the required analyses are completed, and to facilitate efficient sample tracking. Most analytical laboratories will provide a Chain of Custody Record for samples submitted to their laboratory for chemical analyses. After completing the Chain of Custody Record, a copy should be retained and the original form should be submitted to the lab with the samples. A copy of the data quality objectives and any other necessary laboratory quality control procedures should also be provided to the lab with the samples.

Appendix 6: Benthic Sample Collection Procedure

BENTHIC SAMPLE COLLECTION PROCEDURE

NATURAL SUBSTRATES (EROSIONAL HABITATS)

Benthic invertebrates residing in erosional (coarse-substrate) habitats are usually sampled using a Hess or Surber sampler. A Hess sampler is highly efficient because it totally encloses the area to be sampled and therefore does not allow any invertebrates to escape by swimming or crawling away. However, in very low water depths, the water may not pass through the sampling net of a Hess and it may be necessary to use a Surber sampler. A five-minute sampling time for each sample should be sufficient to make sure all invertebrates from the area have been collected.

Samples should be taken by placing the sampler in a representative location at the sampling station and inserting it into the substrate to a depth of approximately 5-10 cm or as deep as substrate density permits. Using your hand or a small implement (garden claw), stir the enclosed area, lifting the disturbed substrate into the flowing water. This will allow benthos to be swept into the mesh bag, and washed free of substrate. Continue agitating the substrate until all the debris and invertebrates to a depth of 10 cm below the bed have been suspended and washed into the mesh. Larger rocks should be rigorously rubbed to remove invertebrates and then removed from the sampler so the finer material can be accessed. Repeat the procedure to obtain the desired number of samples for compositing at each station.

Once the entire sample has been collected, the sampler mesh will contain the (potentially composited) benthic sample. Transfer the sample to the labelled sample jars while holding the mesh and sample jars over a tub or bucket. Be careful to ensure that all invertebrates clinging to the mesh are removed before collecting the next sample.

ARTIFICIAL SUBSTRATES

An artificial substrate survey can be an effective alternative to a natural substrate survey due to the elimination of natural variability in substrate type. Several types of artificial substrate are available, including rock-filled baskets, Beak trays, rock-filled trays, and multiplate samplers such as the Hester-Dendy sampler (Golder 1995). Rock-filled baskets are the sampler of choice for most applications because they: 1) closely mimic natural substrata yet 2) permit standardization of sampler area, 3) provide abundant microhabitat for colonization, 4) produce low replicate variability, 5) are reasonably stable in currents, and 6) are easy and inexpensive to build (Golder 1995).

Deployment

Artificial substrates can be deployed by wading, from a boat, or by SCUBA diving. Artificial substrates should be deployed such that replicates will be located at a consistent depth and a consistent distance above the substrate. This is achieved by tying the substrate to an anchor using a length of rope appropriate for the habitat. A small marker float is then used to mark the location of the sampler. To maintain data comparability, samplers should be placed at similar depths and current velocities in habitats with comparable substrate type. The date and time of sampler deployment should be recorded along with field measures of temperature, dissolved oxygen, conductivity, and pH.

The recommended time for substrate colonization is usually six weeks (USEPA 1990, Golder 1995). The low flow period from late summer to early fall is the best time for deployment (Golder 1995). Samplers should be replicated in each area to allow for robust statistical analysis of data and potential sampler loss (e.g., minimum six samplers per area; Golder 1995).

Collection

Collection of artificial samplers is more difficult than deployment due to the possibility of losing invertebrates. In cases where the water is flowing, approach must be from downstream. Upon reaching the sampler, a fine-mesh net (e.g., 500 μm sieve bag) should be placed around the sampler, and closed tight before retrieving the sample to the surface for washing, sieving and storage. Once in the boat or on shore, the sieve bag containing the substrate should be placed in a tub to catch any organisms that could potentially fall out during the process of sample transfer to bottles. The substrate can be placed in a labeled sample bottle of sufficient size to accommodate it, can be dismantled and placed in a sample bottle or can be fully scrubbed and only sample placed in a sample bottle. Regardless of the procedure used, all manipulation must be undertaken in the sieve bag and over a tub whose contents could be poured back into a sieve bag. Small scrub-brushes work best for removing colonized organisms from the substrates. Once the entire sample has been successfully transferred to a sample bottle (including a final rinse and examination of both the sieve bag and tub), place an internal label in the sample bottle, seal it, and place it in a safe place for storage. Repeat the entire sampling procedure for all subsequent samples.

SAMPLE PRESERVATION, HANDLING AND SUBMISSION

Samples must be preserved within eight hours of collection with buffered formalin solution (saturated with Borax or baking soda). The samples are preserved to a minimum dilution of 10% formalin. Samples should remain in an upright position during transport to the lab to avoid leakage of formalin. Sample shipping should be done by ground transport. A Chain of Custody Record must accompany all samples being submitted in order to ensure that the laboratory receives all samples and understands the analyses to be performed. After completing the Chain of Custody Record, a copy should be retained and the original form should be submitted to the lab with the samples. A copy of the data quality objectives and any other necessary laboratory quality control procedures should also be provided to the lab with the samples.

SUPPORTING INFORMATION

The careful recording and reporting of field observations will be critical for the proper interpretation of the benthic community data. Field observations must be reported on field sheets. Supporting information should include station location, date and time of sampling, field crew members, sampling method and sieve mesh size(s), wetted channel width and depth, sample depth, substrate texture observations, relative abundance of algae or other vegetation, water temperature, pH, dissolved oxygen, conductivity, general conditions (baseflow, freshet, during or following significant rain event or drought, etc.), any modifications to standard sampling methods required during sampling, and details pertaining to any unusual events which occurred during sampling (e.g., equipment failure, sample site inaccessible, etc.).

Appendix 7: Fish Sampling Procedure

FISH SAMPLING PROCEDURE

PREPARATION AND MATERIALS

The first step in conducting the fish survey will be to obtain a license to collect fish for scientific purposes. This license must be obtained from the local provincial or federal department office that is responsible for such licences. A licence request must generally include: target species, size and quantity of fish, waterbody(s) to be sampled, type of gear to be employed, the purpose of the survey, the names of persons doing the fishing, their training, any notable precautions and the proposed timing of the collection. A number of conditions are usually applied at the discretion of department staff.

All equipment, calibration weights, sampling gear and sample bags should be assembled in clean, dry containers. Fish collected at each station should be recorded on field sheets. Each fish should be uniquely identified and all data on that fish will be entered onto the record. Fish or tissue samples that will be transported to the laboratory for analyses should be placed in a container (e.g. Ziploc or whirl-pak bag for most tissues, small bottle/jar for ripe eggs) that has been labeled with a permanent marker.

QUANTIFYING SPECIES ABUNDANCE IN RIVERINE/STREAM HABITAT

Monitoring areas should be enclosed using nylon mesh barrier nets, located a set distance apart (e.g. 50 m), and spanning the entire width of the creek/river to define the sampling area. Stream morphology, substrate size, and total area should be similar and documented among sampling areas. Locations with relatively low gradient and/or small to moderate (cobble) substrate size are preferable for placement of upper and lower boundaries to ensure adequate closure of each area.

Fish communities within each enclosed area should be sampled using a battery-powered backpack electrofishing unit operated by a certified technician. An electrofishing team, consisting of the electrofisher operator and a netter should employ a multiple pass (i.e., K-pass) removal method whereby one upstream and downstream pass (i.e., a 'sweep') of the enclosed reach is repeated to yield population estimates for dominant species (e.g.,slimy sculpin and grayling) using Moran-Zippin methods (Ricker 1975).

At the conclusion of each sweep, total shocking effort (i.e., electrofishing seconds), and electrofisher settings should be recorded and captured fish temporarily placed in an aerated bucket of water dedicated to that sweep. After electrofishing has been completed (i.e., after a consistent decrease in catches through three or more sweeps), captured fish should be identified, enumerated, examined for external condition and measured for total length and fresh body weight, with separate data records for each sweep. Length should be taken using a standard measuring board (to the nearest 0.5 mm) and body weights recorded to the nearest 0.001 gram using an appropriate field balance (± 1% precision). After processing, all fish should be released to the waters from which they were captured.

At the conclusion of fish processing, the dimensions (length and width) of each enclosed station should be measured with a measuring tape and depth should be measured across several transects using a meter stick. The locations of the upstream and downstream boundaries of each sampling area should be geo-referenced using a global positioning system (GPS). As noted above, fish population (abundance) and biomass estimates (abundance) should be determined using Moran-Zippin methods (Ricker 1975).

SENTINEL SPECIES (SCULPIN) POPULATION HEALTH EVALUATION

Slimy sculpin will be sampled for a population health assessment using the approach and methods described by Environment Canada (2002). UTMs will be recorded at the upstream and downstream boundary of each fish sampling reach.

Sampling Methods

Sampling will be conducted using a battery-powered backpack electrofishing unit, seine nets, or minnow traps depending on the type of survey conducted and habitat conditions.
Two field crew members are necessary to conduct electroshocking. The field crew should review the safety procedures and safety options on the electrofisher prior to its use. One person operates the shocker and the second person works downstream of the operator with a dip net and a holding bucket. The crew should work from downstream to upstream so that disturbed debris and sediment does not interfere with catching fish as the material drifts downstream. Polarized glasses and a brimmed hat should be worn by both crew members to increase the ability to see fish in the water and to view underwater obstacles. During fish collection, the operator walks slowly through the water with the unit on their back, making sure both the cathode and anode are in the water. With current applied, the operator should slowly sweep the anode from side to side. Current should be applied intermittently since continued application of electrical current to the water will cause herding or avoidance behaviour by fish and reduce catch efficiency. All fish captured during each pass will be placed in aerated buckets of water.
At the conclusion of each pass, total shocking effort (*i.e.,* electrofishing seconds) will be recorded.

Seines can be used to sample lakes along the shorelines, and streams and rivers with slow moving currents. They are useful in capturing small slow-moving, or schooling fish; or spawning fish that are concentrated in shallow water. Seine nets are most effective when used over a smooth bottom, free from snags and dense aquatic vegetation. Two people are needed to effectively fish with a seine net, one on each end of the net. Small seines are usually operated from shore by manpower or wading. The net is pulled along from one or both ends, encircling an area, then pulled into shallow water. To prevent the escape of fish, care must be taken to ensure that the lead line remains in contact with the bottom, and does not ride up over obstructions. Information to be recorded on field sheets for each seine net set includes: a diagram of the set location; a description of the net; time of haul; number of hauls and approximate area (m) sampled.

Minnow trapping is a passive fish capture technique that requires minimal effort.

Minnowtraps are portable traps that capture fish that swim through the small openings at each end. The openings are funnel shaped and directed inwards. Once the fish enters the trap it has a difficult time finding the small hole that it used to enter. The traps can be set tied to shore and/or anchored to the bottom and marked with a float. Bait can be used to attract fish, but is not necessary. If bait is used, the type should be recorded on the field sheet. Traps work best to catch cyprinids and other small fish. Weedbeds or other fish holding structures and culverts are good locations to set minnow traps. Because of the variability in catch between traps and sets, minnow traps are not as efficient as other methods for measuring relative abundance. Minnow traps allow the fish to remain alive and in good condition for a few days. The exact set and lift time must be recorded for all traps set.

All captured fish will then be identified and enumerated, with all non-target fish species subsequently released to the waters from which they were captured and all sentinel species retained in the aerated buckets of water for further processing.

Non-Lethal Survey Design

Methods for non-lethal sampling, analysis and interpretation will follow recent guidance developed by Environment Canada (2005). A total of approximately 100 sculpin will be targeted in each area, including young-of-the-year, if available. Total length and total body weight will be measured on each specimen in the field and external condition will be noted. Length measurements will be taken using electronic calipers (to the nearest 0.1 mm) and weight will be taken using Pesola™ spring balances (60 g capacity ± 0.5 g, 30 g capacity ± 0.25 g and 10 g capacity ± 0.1 g) or a lab balance (±0.001 g), depending on the size of the fish. Any abnormalities will be recorded. A sub-sample of approximately 10% of fish captured (e.g., 10 per area) will be frozen whole for subsequent laboratory analysis of age using otoliths.

Weight and length will be summarized by separately reporting mean, median, minimum, maximum, standard deviation, standard error and sample size for each sampling area (Environment Canada 2000). Each data set will be assessed for normality and equality of variance before applying any parametric statistical procedures. Size-frequency distributions will also be developed as described by Bonar (2002) and Gray et al. (2002). An effect on the fish population will be evaluated for each of these measures and is defined as a statistically significant difference between exposure area and reference area (Environment Canada 2002). Statistically significant differences in mean weights and lengths between fish from reference and exposure areas will be assessed using Analysis

Appendix 7: Fish Sampling Procedure

FISH SAMPLING PROCEDURE

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At the conclusion of each sweep, total shocking effort (i.e., electrofishing seconds), and electrofisher settings should be recorded and captured fish temporarily placed in an aerated bucket of water dedicated to that sweep. After electrofishing has been completed (i.e., after a consistent decrease in catches through three or more sweeps), captured fish should be identified, enumerated, examined for external condition and measured for total length and fresh body weight, with separate data records for each sweep. Length should be taken using a standard measuring board (to the nearest 0.5 mm) and body weights recorded to the nearest 0.001 gram using an appropriate field balance (± 1% precision). After processing, all fish should be released to the waters from which they were captured.

At the conclusion of fish processing, the dimensions (length and width) of each enclosed station should be measured with a measuring tape and depth should be measured across several transects using a meter stick. The locations of the upstream and downstream boundaries of each sampling area should be geo-referenced using a global positioning system (GPS). As noted above, fish population (abundance) and biomass estimates (abundance) should be determined using Moran-Zippin methods (Ricker 1975).

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All captured fish will then be identified and enumerated, with all non-target fish species subsequently released to the waters from which they were captured and all sentinel species retained in the aerated buckets of water for further processing.

Non-Lethal Survey Design

Methods for non-lethal sampling, analysis and interpretation will follow recent guidance developed by Environment Canada (2005). A total of approximately 100 sculpin will be targeted in each area, including young-of-the-year, if available. Total length and total body weight will be measured on each specimen in the field and external condition will be noted. Length measurements will be taken using electronic calipers (to the nearest 0.1 mm) and weight will be taken using Pesola™ spring balances (60 g capacity ± 0.5 g, 30 g capacity ± 0.25 g and 10 g capacity ± 0.1 g) or a lab balance (±0.001 g), depending on the size of the fish. Any abnormalities will be recorded. A sub-sample of approximately 10% of fish captured (e.g., 10 per area) will be frozen whole for subsequent laboratory analysis of age using otoliths.

Weight and length will be summarized by separately reporting mean, median, minimum, maximum, standard deviation, standard error and sample size for each sampling area (Environment Canada 2000). Each data set will be assessed for normality and equality of variance before applying any parametric statistical procedures. Size-frequency distributions will also be developed as described by Bonar (2002) and Gray et al. (2002). An effect on the fish population will be evaluated for each of these measures and is defined as a statistically significant difference between exposure area and reference area (Environment Canada 2002). Statistically significant differences in mean weights and lengths between fish from reference and exposure areas will be assessed using Analysis of Variance (ANOVA). Statistically significant differences in length-weight relationships will be assessed using Analysis of Covariance (ANCOVA). Lastly, statistically significant differences between size frequency distributions (weight and length) will be assessed using a two-sample Kolmogorov-Smirnov goodness of fit test (per Gray et al. 2002).

Lethal Survey Design

Fishing will be conducted until 20 mature male and 20 mature female sculpin are collected. Physiological measurements collected from each fish will include all those recommended for the EEM program (Environment Canada 2002a). Specifically, body length, fresh body weight, external condition, age, gender, fresh gonad and liver weight, fecundity (females only) and egg-size (females only) will be measured/assessed from freshly sacrificed, sexually mature individuals of each sentinel species (20 males and 20 females from each area). Total length will be measured to the nearest hundredth of a millimeter using digital calipers. Fresh body-weight will be measured using an analytical balance with an accuracy of 0.001 g. Heads will be removed and frozen for subsequent age determination using otoliths. The visceral cavity of each sacrificed fish will be opened. The gender and/or sexual maturity level of each sacrificed fish will then be determined and recorded. Whole gonads and livers will subsequently be excised and weighed to the nearest milligram (0.001 g) using an analytical balance with a surrounding draft shield. Following removal and weighing, whole ovaries from each female will be placed in individually labeled sampling jars, preserved with 10% buffered formalin, and subsequently submitted to a qualified laboratory for determination of fecundity and egg size. During processing, any external or internal abnormalities will be recorded on data sheets. Following processing, fish carcasses will be disposed of in a manner consistent with collection permit specifications and live fish (i.e., those that were only measured) will be returned to locations near their point of collection.

All ageing structures will be processed by a qualified fish age determination laboratory. Primary ageing structures will be embedded and hardened in epoxy resin, sectioned using a low-speed isomet diamond saw, mounted on a glass slide and aged under a compound microscope using transmitted light. For each structure, the age and edge condition will be recorded along with a confidence rating for the age determination. For quality control purposes, 10% of the processed samples will be sent to a second fish ageing expert for independent age confirmation.

All fish ovary samples will be processed by a qualified biological laboratory. Methods utilized for fecundity estimation will be fully consistent with the technical guidance

(Environment Canada 2002), with the number of eggs in each sample enumerated using stereo-microscopes and ten percent of egg samples re-counted to verify the precision of fecundity estimates. For quality control purposes, fecundity re-counts will be conducted on 10% of the processed fecundity samples.

Consistent with EEM technical guidance (Environment Canada 2002), summary statistics including mean, median, minimum, maximum, standard deviation, standard error and sample size will be calculated by species, area and gender for "lethal" endpoints related to age, growth, condition and reproductive health. Each data set will be assessed for normality and equality of variance in order to determine the suitability of parametric statistical procedures. Statistical differences in each test endpoint between reference and exposure areas (by species and sex) will be made using either ANOVA or Analysis of Covariance (ANCOVA) in a manner consistent with Environment Canada (2002) guidance.

FISH PROCESSING

The appropriate procedures outlined in the following subsections must be followed in the field in order to ensure accurate measurements of physiological variables. During fish collection or immediately after fish collection is completed, the species of every fish caught should be identified and if possible, the sex of the every specimen of sentinel species (for population evaluation) should also be identified. Sexing of each specimen will provide a count of females and males caught relative to the goals of the program, such that live fish that are not needed can be released. All fish that are being collected for further processing should be placed in a cooler with sufficient ice for return to the field laboratory where additional measurements will be taken as described below.

Length

Length will be taken using a standard measuring board or electronic calipers. Total length is measured from the tip of the snout to the dorso-ventrally compressed lobes of the caudal fin. Fork length is the distance between the tip of the snout and the middle of the caudal fin, if applicable. When taking a measurement, ensure that the snout of the fish is at the end of the board and that it is lying flat. Rulers, meter sticks or tape measures can be used if a measuring board is not available. Length measurements should be reported to the nearest millimeter. A precision of ± 0.2 cm or better must be met.

Body Weight

Fresh weights can be taken on scales or electronic balances. When using weigh scales, insert the hook behind the gill cover below the lower jaw. Always use a scale or balance that is most accurate for the size of the fish being weighed. A precision of ± 5.0% is stipulated. Make sure that the scale or balance is calibrated with hand weights and zeroed prior to taking the measurement.

Age

Two appropriate ageing structures should be collected from each fish (e.g., listed in Environment Canada 2002). Typically, fish scales are collected as one of the ageing structures, if present. Scales are removed by using the sharp point of the filet knife and scrapping in the direction of the tail. Scales will loosen and can be collected on the edge of the knife. The scales (approximately 10) should be placed on wax paper, which is folded and inserted into the scale envelope. Scales must be relatively clean. Ensure that at least ten scales are collected that are relatively clean and undamaged. Bony structures such as spines or fin rays should be stipped of as much tissue as possible and removed cleanly (being sure to include the base - "knuckle") from the fish. If the fish is being sacrificed for other purposes, take more than just the first one or two spines or rays, to give the laboratory a choice of structures and thus provide the best age estimate.

Liver Weight

Fish livers are located in the anterior end of the visceral cavity behind the heart and ahead of the stomach. They typically have a brownish pink colour with several lobes. **Livers will deteriorate quickly if the fish is not stored with lots of ice.** When removing the liver, ensure that you collect all of it, but be careful to remove obvious fat deposits and the gall bladder before weighing the liver to the nearest 0.001 g on the electronic balance. Livers must be weighed to a precision of ± 1.0%. Balance accuracy should be assessed each day using standardized weights and calibrated if necessary.

Gonad Weight

Gonads should be removed from the surrounding tissue using forceps and scissors if necessary. Note the sex of the fish prior to measuring the gonad weight. The weight of the whole gonads should be measured to the nearest 0.001 g on the electronic balance. Gonads must be weighed to a precision of ± 1.0%.

If the fish is a female, ovarian subsamples should be removed after the total weight of the ovaries has been measured. A subsample should be taken from the ovary consisting of a portion from each end and a portion from the middle. Weigh the subsample to the nearest 0.001 g of the electronic balance and record the weight. Subsamples should then

Fecundity and Egg Weight Procedures

Large-Bodied Fish

Field Procedures

1 Remove whole gonads and weigh on an electronic balance to the nearest 0.00 1g.
2 Remove subsamples from ovaries. Take a portion from each end and midsection of one ovary and weigh to the nearest 0.001g.
3 Place subsample in a vial and preserve in 10% buffered formalin.

Lab Procedures

1 Rinse field subsample into an 18 μm sieve to remove the preservative.
2 Weigh preserved field subsample to the nearest 0.00 1g.
3 Remove three sub-subsamples each consisting of a minimum of 100 eggs from each ovarian subsample and weigh each sub-subsample to the nearest 0.00 1g.
4 Count the number of eggs in each sub-subsample.
5 Represerve eggs and archive.
6 Calculate the number of eggs in the original preserved subsample based on each of the three sub-subsamples as follows:

$$\text{preserved subsample fecundity} = \frac{\text{weight of preserved subsample}}{\text{weight of sub} - \text{subsample}} \times \text{number of eggs in sub} - \text{subsample}$$

7 Calculate average preserved field subsample fecundity from three subsubsample estimates.
8 Calculate total fecundity for each female as follows:

$$\text{total fecundity} = \frac{\text{weight of whole gonad}}{\text{weight of unpreserved subsample}} \times \text{average preserved subsample fecundity}$$

9 Calculate individual egg weight for each female as follows:

$$\text{individual egg weight} = \frac{\text{weight of whole gonad}}{\text{total fecundity}}$$

Small-Bodied Fish

Field Procedures

1 Remove whole gonads and weigh on electronic balance to nearest 0.00 1g.
2 Place entire gonads in vial and preserve in 10% buffered formalin.

Lab Procedures

1 Rinse preserved gonads into an 18 μm sieve to remove the preservative.
2 Weigh preserved gonads to nearest 0.001g.
3 Remove three subsamples each consisting of a minimum of 100 eggs from the whole gonad and weigh each subsample.
4 Represerve eggs and archive.
5 Calculate the number of eggs in the whole gonad as follows:

$$\text{total gonad fecundity} = \frac{\text{total weight of preserved gonads}}{\text{weight of subsample}} \times \text{number of eggs in subsample}$$

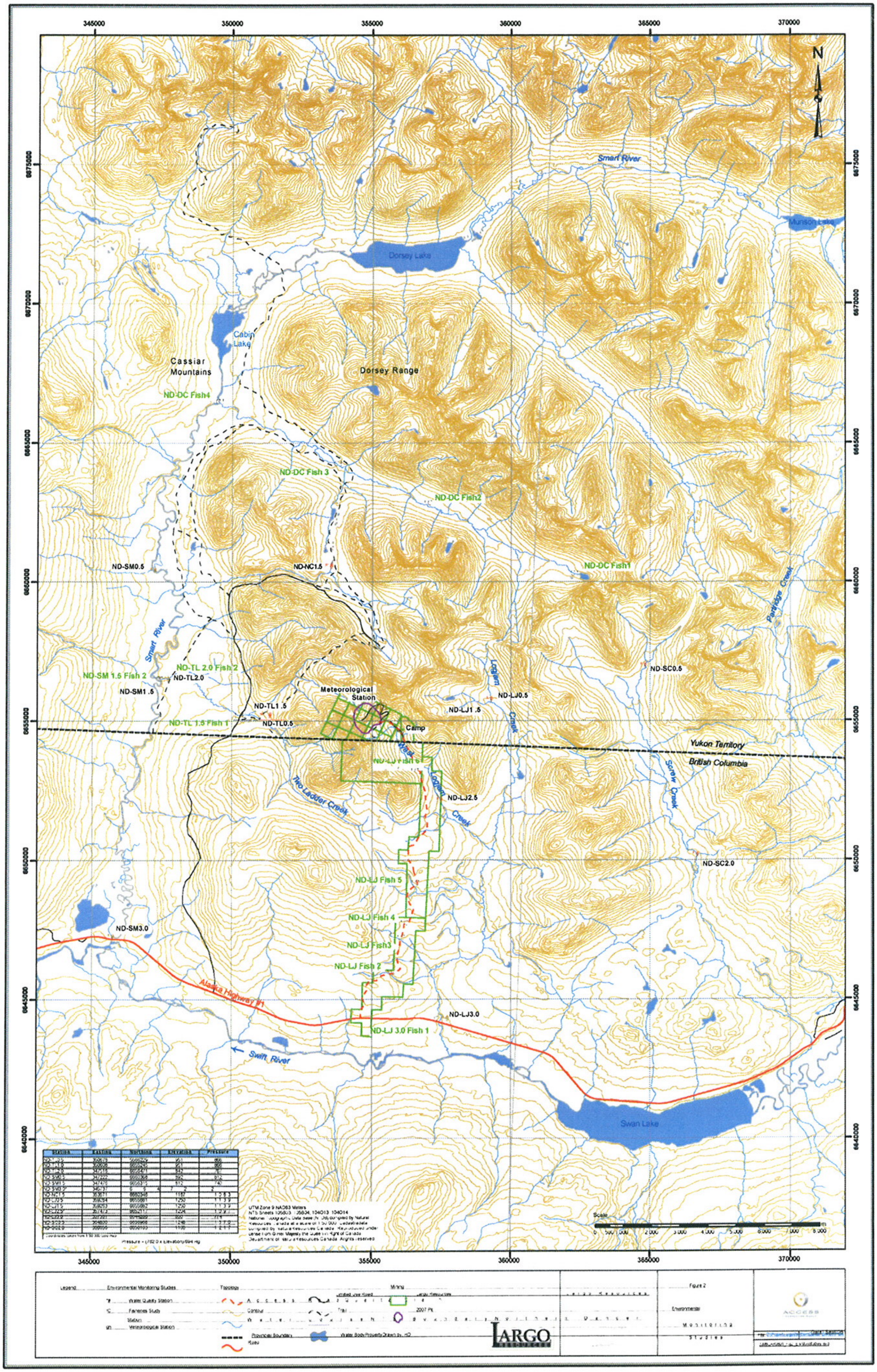
6 Calculate average total gonad fecundity from three subsample estimates.
7 Calculate individual egg weight for each female as follows:

$$\text{individual egg weight} = \frac{\text{weight of unpreserved gonad}}{\text{total fecundity}}$$

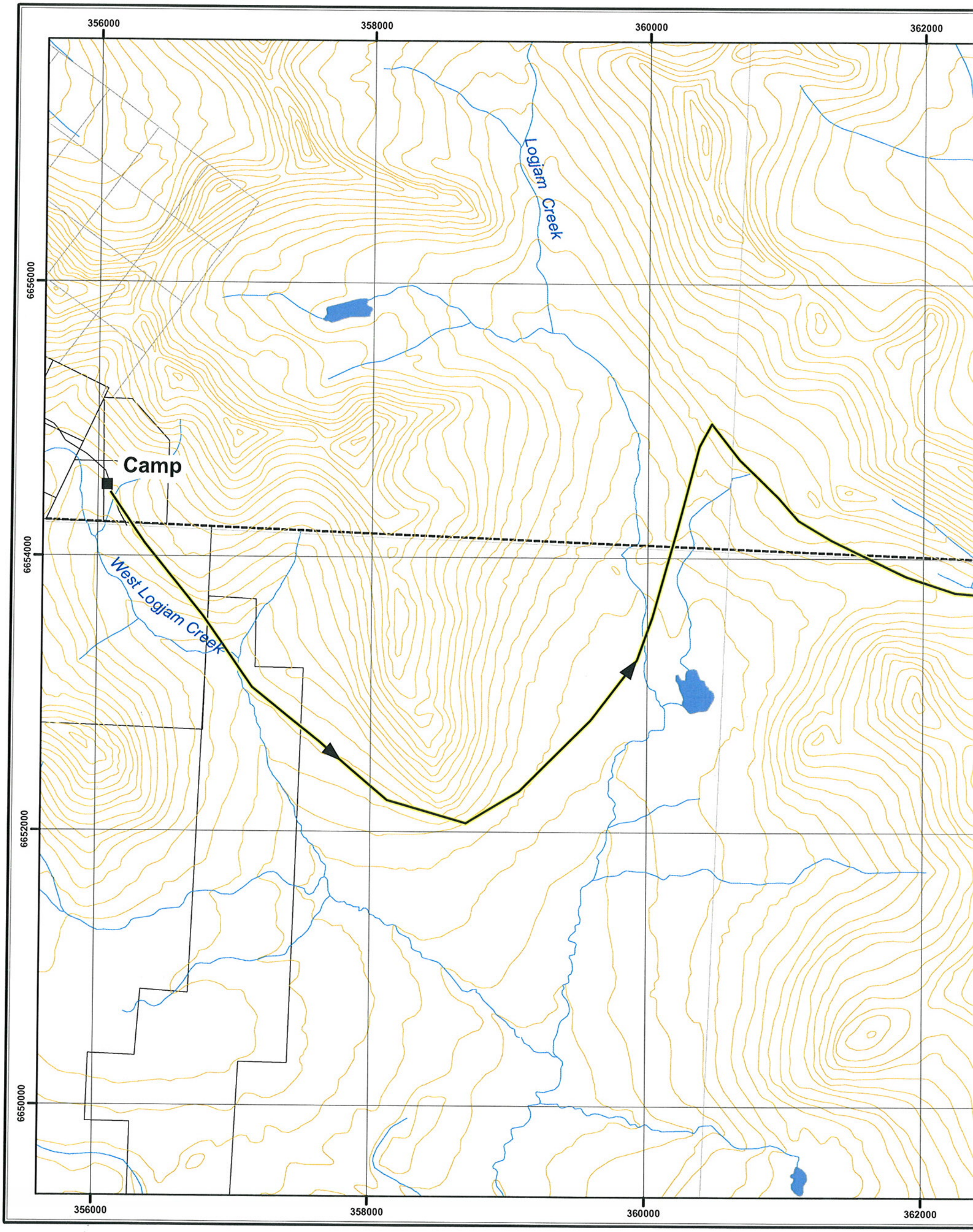
SUPPORTING ENVIRONMENTAL VARIABLES

Water temperature, dissolved oxygen, pH and conductivity, will be measured at each fish sampling area. Habitat characteristics, including wetted channel width and depth, extent of canopy coverage, surrounding land use, and general stream morphology, will also be recorded at each study area.

Appendix 8: Maps



Smart River
Munson Lake
Dorsey Lake
Cabin Lake
Cassiar Mountains
Dorsey Range
ND-DC Fish4
ND-DC Fish 3
ND-DC Fish2
ND-DC Fish1
ND-SM0.5
ND-NC1.5
Partridge Creek
ND-TL 2.0 Fish 2
ND-SM 1.5 Fish 2
ND-TL2.0
ND-SM1.5
ND-SC0.5
Meteorological Station
ND-TL1.5
ND-LJ0.5
ND-TL 1.5 Fish 1
ND-TL0.5
ND-LJ1.5
Camp
Logjam Creek
Yukon Territory
British Columbia
West Logjam Creek
ND-LJ Fish 6
Screw Creek
Two Ladder Creek
ND-LJ2.5
ND-SC2.0
ND-LJ Fish 5
ND-LJ Fish 4
ND-SM3.0
ND-LJ Fish3
ND-LJ Fish 2
Alaska Highway #1
ND-LJ3.0
ND-LJ 3.0 Fish 1
Swift River
Swan Lake
Station
Easting
Northing
Elevation
Pressure
Pressure = (762.0 x Elevation)/694 Hg
UTM Zone 9 NAD83 Meters
Scale
Legend
Environmental Monitoring Studies
Water Quality Station
Fisheries Study Station
Meteorological Station
Topology
Access
Contour
Provincial Boundary
Road
Limited Use Road
Trail
Mining
2007 Pit
Water Body Property Drawn by HD
LARGO
Figure 2
Environmental
Monitoring
Studies
ACCESS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Logjam Creek
Camp
West Logjam Creek
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