SNC·LAVALIN

ENVIRONMENTAL MONITORING PLAN
(Water and Sediment Quality)

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ENVIRONMENT & WATER

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1.0 INTRODUCTION

At the request Executive Flight Centre Fuel Services Ltd. (EFC), the Environment & Water business unit of SNC-Lavalin Inc. (SNC-Lavalin) has prepared the following Environmental Monitoring Plan (EMP) of water and sediment for the Lemon Creek Jet-A1 fuel spill incident that occurred on July 26, 2013. The area covered in this EMP is Lemon Creek to the confluence of the Slocan River, along the Slocan River to Winlaw (the Site). The area south of Winlaw was not included as part of the Site because there were limited visual observations of jet fuel south of Winlaw, preliminary Shoreline Cleanup Assessment Technique (SCAT) results indicated no remediation was required south of Winlaw and other contributing sources of hydrocarbons may be present at Winlaw and southward due to increased population/activities. In addition, within approximately two weeks of the spill, the agencies indicated that the area south of Winlaw was not a concern. The Site location, including existing sample locations, registered water wells and points of diversion, is presented on Drawings 614668-005 to 614668-008.

The scope of work proposed for this EMP has been developed in consideration of the results of the draft Lemon Creek Spill Response Environmental Impact Assessment[1] (EIA), which has been completed by SNC-Lavalin, on behalf of EFC, and as required by the BC Ministry of Environment (MoE). The EIA assessed and evaluated the impact(s) of the spill on physical (water, sediment) and biological (trophic levels, fisheries, terrestrial wildlife) resources. The proposed water and sediment monitoring program herein has been identified and developed based on currently available information and SNC-Lavalin's current understanding of the conditions in the area (pre- and post-spill) as well as available research on the environmental fate of the Jet fuel/kerosene category, (e.g., API, 2010[2]).

The results of this water and sediment monitoring program (program initiated the week of August 23, 2013) will be utilized by the biological monitoring programs (where applicable) as well as human health and ecological risk assessment (HHERA) components, if appropriate. For example, a risk assessment will be conducted if contaminants measured in excess of the standards or guidelines outlined in this document are identified; the contaminants will be carried forward as chemicals of potential concern (COPCs) for evaluation in a human health and ecological risk assessment (HHERA).

This EMP may be updated, as needed, based on the outcome of each proposed field sampling event. SCAT records will be utilized to coordinate any potential new monitoring locations (e.g., monitoring locations may be established at downstream flushing locations and product collection sites if not covered by existing locations). The plan is proposed to be adaptive and continually improved/refined as results are received and reviewed.

[1] SNC-Lavalin Inc. 2013. Draft, Lemon Creek Spill Response Environmental Impact Assessment. Report prepared for Executive Flight Centre Fuel Services Ltd.

[2] American Petroleum Institute – Petroleum HPV Testing Group. 2010. Kerosene/Jet fuel category assessment document. Submitted to the United States Environmental Protection Agency (USEPA). Consortium Registration # 201-16846A. 47p.

2.0 CONCEPTUAL SITE MODEL

A preliminary desktop hydrogeological study was carried out within a few weeks of the spill which comprised the compilation and review of registered water wells logs, locating these water supply wells and estimating rough hydraulic gradients in order to develop a conceptual site model (CSM). The CSM of the hydrogeological conditions, as well as the fate and transport of the Jet A-1 fuel at the time of the spill to Lemon Creek, is provided below and was used as the basis for the development of the water and sediment EMP.

2.1 Hydrogeological Setting

Lemon Creek flows in a west-northwesterly direction to the Slocan River, which flows to the south-southwest. The spill release point to Lemon Creek (i.e., the accident site) was approximately 4 km from the confluence with the Slocan River. For approximately 1.5 km downgradient of the spill site, the creek flows within a relatively narrow incised channel which is characteristic of channels cut into bedrock. Bedrock outcrop was observed along the bank and creek bottom at the spill site. There was about 0 m to 0.3 m of surficial sands and gravels overlying the bedrock near the creek's edge. The final 1.5 km of Lemon Creek is underlain by sands and gravels that are tens of metres thick, defined as an alluvial fan deposit, which serves as an aquifer. Drawing 614668-005 illustrates the approximate limits of the alluvial fan and flood plain. The alluvial fan deposit slopes to the west at a topographic gradient of approximately 0.02 m/m. Further to the south of Lemon Creek, it appears to be underlain by finer soils (i.e., silts with sand and clay) that are possibly floodplain deposits associated with the Slocan River.

Groundwater levels measured in the existing registered water wells at the time of completion, according to water well logs obtained from the BC MoE Water Resources Atlas database, indicate the water table under static conditions was located at a depth of approximately 5.0 m bgs and suggests a flow direction to the west-southwest, similar to fan topography. This suggests that the alluvial fan aquifer may be recharged by Lemon Creek during varies times of the year, specifically at high stage levels such as, spring freshet and that Lemon Creek may be recharged by the aquifer during times of low stage levels. Similar hydraulic conditions are expected for the Slocan River and adjacent floodplain area throughout the year.

According to the MoE database, a number of domestic use groundwater wells are located along Lemon Creek (mainly within the alluvial fan/floodplain of the creek at its confluence with the Slocan River) and along the Slocan River. In addition, a number of points of diversion (POD) were registered in the database. Through recent site reconnaissance, these PODs and other unidentified PODs and shallow dug wells have been located along the bank and within 20 m of the shoreline of these water bodies.

2.2 Contaminant Distribution in Soil at the Spill Site

There were two areas that required soil remediation at the accident site; 1) in the creek along the south bank, where the major jet fuel spill occurred, and 2) approximately 130 m along the road above, where jet fuel leaked from the tanker when the truck was pulled from Lemon Creek. Field observations indicated that there was approximately 0 m to 0.3 m of overburden on bedrock on the south side of the creek. All overburden was removed in this area. The road was comprised of hardpan, underlain by large cobbles and gravels, and then bedrock. Hydrocarbons were limited to surficial impacts along the roadway and confirmatory results indicated that impacts did not reach bedrock.

2.3 Contaminant Characteristics

Approximately 35,000 L of Jet A1 fuel was released into Lemon Creek on July 26, 2013. This was a high volume, rapid release into a generally rapid or high velocity flowing water system. Jet A1 fuel is highly volatile and a light non-aqueous phase liquid (LNAPL); therefore, it dispersed on the surface of the water, and volatilized quickly. Combined with the fact that bedrock was observed and encountered on the south side (below the road down to the creek) and the bottom of Lemon Creek during the soil remediation excavation, there was no opportunity for a large mass of the fuel to migrate into the underlying bedrock and impact groundwater beneath the creek. Due to its volatility, it is predicted that 30% to 35% of the volume released volatilized in one day and 100% volatilized in 9 to 12 days[3].

As the liquid product migrated downstream, some LNAPL and related contaminants accumulated in slower moving reaches of the creek and/or river, and came into contact with river-bank sediments. Particular contaminants (e.g., polycyclic aromatic hydrocarbons [PAHs]) were bound to organic material (i.e., organic carbon - wood debris, leaves, peat etc.); if left in place, the sediment contamination would eventually biodegrade.

Jet A1 fuel is comprised of petroleum hydrocarbons such as, toluene, ethylbenzene, xylenes, PAHs and gross hydrocarbons (volatile petroleum hydrocarbons [VPH] and light and heavy extractable hydrocarbons [LEPH/HEPH]). Based on current analytical results of soil, sediment and surface water samples collected along Lemon Creek and the Slocan River, benzene was not detected. The following chemical compounds exceeded BC Contaminated Sites Regulation[4] (CSR) standards and/or BC Water Quality[5] (BCWQ) guidelines in various media comprised; toluene, ethylbenzene, xylenes (TEX); VPH; LEPH; naphthalene; 2-methylnaphthalene; acridine; phenanthrene; fluoranthene; benzo(a)pyrene and pyrene.

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3 SNC-Lavalin, Jet A1 Fuel Spill at Lemon Creek, BC – Air Quality Assessment (Draft in progress).

4 *Contaminated Sites Regulation* (CSR), B.C. Reg. 375/96, including amendments up to B.C. Reg. 6/2013.

5 *British Columbia Approved Water Quality Guidelines (Criteria), updated 2011, includes (A Compendium of Working Water Quality Guidelines for BC, 2006)* (BCWQG). British Columbia Ministry of Environment (MoE), September 2011.

2.4 Surface Water Results

Surface water quality has been monitored at a number of locations since July 28, 2013; at most locations, multiple samples have been collected. Locations were chosen based on visual evidence of hydrocarbons/fuel (i.e., worst case locations, defined as those locations that were considered to be areas of greatest concern) and from other locations that were accessible from the shoreline or other access points. On August 4, the results indicated that surface water met the provincial, numeric standards for all water uses with most parameters less than the laboratory detection limits, with one exception; the concentration of LEPH at SW13-WW exceeded the aquatic life guideline[6] for LEPH (concentration of 320 µg/L versus the guideline of 50 µg/L). At surface water location SW13-03, at the confluence of Lemon Creek and the Slocan River, ethylbenzene was measured above BCWQ drinking water (DW) guideline on one occasion (July 28, 2013); this guideline is an aesthetic objective derived to be protective of taste and odour concerns. A subsequent sample collected on August 3, did not contain detectable hydrocarbon parameters. No other exceedences of the CSR DW standards were measured during the spill response sampling program.

A shallow dug well located nearest the spill site and on the Lemon Creek alluvial fan, as well as six (6) other water supply wells, were sampled between July 28 and August 5, 2013. Analytical results were non-detect indicating that hydrocarbon impacts had not occurred. In addition, the Interior Health Authority (IHA) sampled eight (8) water supply wells and two (2) PODs, almost all within 30 m of Lemon Creek and the Slocan River between August 12 to August 14, 2013 and analytical results were also non-detect.

2.5 Sediment Quality Results

Up to 60 sediment samples were collected along the shoreline of the Slocan River where hydrocarbons were observed (i.e., worst case locations) and in other locations where the shoreline was accessible and submitted for analytical testing of chemicals associated with Jet A1 fuel. One exceedence (2-methylnaphthalene) was measured in one sediment sample collected north of Perry's Back Bridge. Approximately two thirds of the samples were non-detect and only a single sediment sample contained concentrations in excess of the CSR Schedule 9 Sediment Criteria, indicating that the Jet Fuel had minimal impacts to sediment.

[6] BCWQ guidelines do not exist for LEPH or VPH for the protection of aquatic life (AW); as such, 1/10th of the CSR AW standard is applied as suggested in MoE Technical Guidance 15 (TG15): Concentration Limits for the Protection of Aquatic Receiving Environments. However, the method detection limit (MDL) for LEPH was above the suggested criterion of 50 µg/L and therefore, there may be other AW exceedences that were not identified.

Sediment samples could not be collected from Lemon Creek due to the coarse nature of the material comprising the alluvial fan; as such, there are limited to no fine grained sediments to act as on-going sources of hydrocarbons (via sorption) in this area.

2.6 Current Potential Contaminants of Concern

Based on the analytical results to date, the following parameters are considered current potential contaminants since they have exceeded CSR standards or BCWQ guidelines at least once in either water or sediment. Even though some exceedences of potential contaminants were only measured in one medium, the potential contaminant was retained for both media if a standard or guideline exists for that parameter and particular medium. For instance, other than 2-methylnaphthalene, PAH exceedences were not measured in sediment, but select PAHs have been retained as potential contaminants.

Table A: Current Potential Contaminants for Water and Sediment

Potential Contaminants	Surface Water/Porewater	Sediment
TEX	X	-[a]
VPH	X	-[a]
LEPH	X	X[b]
PAHs		
naphthalene	X	X
2-methylnaphthalene	-[a]	X
acridine	X	-[a]
phenanthrene	X	X
fluoranthene	X	X
benzo(a)pyrene	X	X
pyrene	X	X

[a] A standard or guideline does not exist for this parameter.
[b] A standard or guideline does not exist for this parameter; however, it is retained as a general indicator for the presence of hydrocarbons.

It is noted that given the volatile nature of TEX/VPH and the conditions at the Site, these parameters are unlikely to be present but have been included as potential contaminant for water to be conservative. TEX are not considered a potential contaminants in sediment since they are unlikely to partition to sediments and furthermore, there are no standards/criteria for them.

Benzo(a)pyrene and pyrene are high molecular weight PAHs and were not present in the Jet Fuel-A1; the measurement of these PAHs is considered associated with other sources, however, they have been retained as potential contaminants to be conservative.

Trimethylbenzenes (TMBs) were initially identified as potential contaminants based on the MSDS for the fuel, and were measured in one water sample collected during the initial days of the spill response. TMBs have not been measured since, and based on their volatile nature, are unlikely to be present. On this basis, and given that they are not regulated, they are not considered to be potential contaminants.

These potential contaminants will be included in the analytical program going forward but may be removed if future analytical data does not indicate exceedences of provincial standards/guidelines.

2.7 Potential Human Health Exposure Pathways

Data collected to date indicates that current concentrations of parameters associated with the Jet-A1 fuel are less than the laboratory detection limit in surface water and groundwater (from select domestic and agricultural wells), and that concentrations of fuel associated parameters are less than the applicable provincial criteria in sediment, as well as in soil from the spill site. Based on the current data set, the residual contamination meets the applicable regulatory standards and thus, there is no potential for human exposure to residual contamination associated with the spill (i.e., the current data does not indicate the need for an HHERA). However, following the completion of the proposed water and sediment sampling events, the data will be reviewed to determine if concentrations in excess of the applicable standards/criteria are present, and therefore, whether or not an HHERA is required.

3.0 OBJECTIVES

The key objectives of the EMP are:

1) to monitor, assess and document the distribution and concentrations of residual contaminants associated with the spill in environmental media (water and sediment) following flushing/clean-up efforts completed as part of the spill response; and,
2) to ensure that potential effects to human and environmental health are effectively assessed, monitored and addressed, if appropriate.

The data collected will inform the EIA.

4.0 MONITORING PROGRAMS

Currently, there are only minor (if any) detectable concentrations of contaminants of concern, and no exceedences in surface water and sediment collected from Lemon Creek and the Slocan River which indicates that these media are no longer, or may not have been, impacted. However, seasonal monitoring is recommended to verify this finding; as such, the EMP was developed in accordance with the current conditions and based on observation and analytical data collected during the initial spill response phase.

Select existing sample locations which are representative of worst case locations (i.e., areas of greatest concern) will be included in the water/sediment EMP. Worst case conditions were identified based on:

- analytical exceedences;
- preliminary SCAT results;
- observations of hydrocarbons made at time of sampling; and/or,
- location in proximity to shallow water supply wells or points of diversion.

Sample locations which initially had exceedences in surface water and sediment are indicated in the table below with notes indicating if hydrocarbon concentrations were measured in the other media.

Table B: Sample Locations with Initial Exceedences in Surface Water and Sediment

Surface Water Location	Sediment Location	Media with Detectable Hydrocarbons
SW13-01	-	Non-detect in sediment
SW13-03	-	Detected in sediment
SW13-04	-	Detected in sediment
SW13-05	-	Non-detect in sediment
SW13-A	-	Non-detect in sediment
SW13-H	-	Non-detect in sediment
SW13-AA	-	Non-detect in sediment
SW13-GG	-	Detected in sediment
SW13-II	-	Detected in sediment
SW13-JJ	-	Detected in sediment
SW13-LL	-	Non-detect in sediment

Table B (Cont'd): Sample Locations with Initial Exceedences in Surface Water and Sediment

Surface Water Location	Sediment Location	Media with Detectable Hydrocarbons
SW13-WW	-	Detected in sediment
-	**SED13-06**	Non-detect in surface water
Total number of location exceedences = **12**	Total number of location exceedences = **1**	
Approximately 208 samples total analyzed at 60 locations	Approximately 60 samples total analyzed	

Bold – indicates proposed sample locations to be included in the EMP. Notes on the observations of hydrocarbons at each existing EMP sample location are indicated on Table C below.

4.1 Preliminary SCAT Results

A draft SCAT report has just been issued, results indicate that multiple segments of the creek and river that were classified as heavy or moderate were re-classified as no-trace of oil or no further treatment required after cleanup. When the final SCAT report is reviewed, this EMP will be reviewed and modified appropriately. However, to be conservative, the preliminary results of the SCAT work as of August 8th (indicated on Drawings 614668-005 through 008) were reviewed and used to identify areas of greatest concern (i.e., presence of hydrocarbons). These areas will be inspected in the field and new sample locations for surface water, sediment and porewater will be chosen in the worst case areas (i.e., areas with accumulation of hydrocarbons, such as back eddies/slow moving water). Worst case locations/areas of greatest concern will also be based on visual observations (such as sheens and stained rocks, sediment and/or vegetation) made during the first sampling event. A contingency of six (6) locations has been allocated for this.

4.2 Environmental Media Monitoring

There are two primary objectives to monitoring water and sediment quality: 1) to assess surface water, sediment and porewater quality and identify the presence or any trends of the effects of residual jet fuel compounds in Lemon Creek, the Slocan River and potentially groundwater; and 2) to evaluate whether further remediation/removal is required and whether flushing/clean-up efforts were effective.

4.2.1 Proposed Sampling Events

The EMP was developed to target various seasonal conditions to assess whether water and sediment quality at different water levels and environmental conditions remain the same. As a result, it is proposed that four (4) surface water/sediment sampling events be carried out;

1) Immediately after shoreline clean-up.
2) Following a major rainfall event prior to winter (October/November) when any residual hydrocarbons may be flushed through the system. In order to time that event, diligent monitoring of weather forecasts for potential rainfall events will be required. Precipitation data obtained from the Castlegar Airport indicates that November is the third highest month for rainfall (May and June were highest), so the second event has been tentatively planned for November. However, if the forecast information indicates a heavy rainfall event in October, field sampling will be carried out then.
3) During spring freshet (anticipated high water levels). Water stage level data will be obtained from Environment Canada[7] and monitored to determine when spring freshet is occurring.
4) If necessary, near the end of July 2014 when water levels are expected to be similar to those during the time of the spill. Depending on analytical results of the above three sampling events, it is anticipated that a fourth sampling event may not be warranted.

If any potential contaminants are detected during any of these various conditions, consideration will be given to interval sampling over a short period of time. Otherwise, it is considered unlikely that non-detect locations will have significant increases in concentrations to result in exceedences of standards/guidelines over an 8 hour or 24 hour time period.

4.2.2 Surface Water and Sediment Quality

4.2.2.1 Sample Locations

For the first post clean-up sampling event (September 2013), 22 surface water/sediment locations were targeted for sampling, including two background locations (i.e., one upgradient of the spill site on Lemon Creek and one upgradient of the confluence of the Slocan River/Lemon Creek on the Slocan River). The other sample locations comprised 14 existing locations (10 of which had historical exceedences recorded) and six (6) new locations. As indicated above and further detailed in the

[7] Daily stage levels are recorded at a monitoring gauge station located on Lemon Creek above South Lemon Creek (#08NJ160).

table below, the new locations were based on review of the preliminary SCAT information as well as visual observations of hydrocarbons at the time of the sampling event and/or locations proximate to water supplies. Some POD that were sampled during the emergency response activities were also included since several PODs are located along the creek/river, which are used as intakes for potable water, irrigation water and/or for livestock watering. Sediment sampling points also included those locations at product collection points where booms directed materials towards shoreline product recovery sites.

Existing sample locations that were sampled during the first post clean-up sampling event (September 2013) are listed below. It is proposed that only eleven existing sample locations (including two background) will be carried forward into subsequent sampling events (i.e., the 14 existing locations (plus two background) from the September event will be pared down to 11 locations based on analytical results and visual observations). Existing sample locations are shown on the attached Drawings. Any potential new locations will depend on proximity to PODs or shallow water supply wells and visual observation made in the field at the time of sampling.

Table C: Proposed Surface Water and Sediment Sample Locations

Location	Surface Water	Sediment	Location Description	Rationale
Background	SW13-300	SED13-300	♦ Located on Lemon Creek – upstream of accident/spill site.	♦ Background reference location.
	SW13-12	SED13-12	♦ Located on Slocan River – upstream of Lemon Creek.	♦ Background reference location. ♦ Assess for porewater sampling.
Lemon Creek	SW13-01	Remedial Excavation (Confirmatory Samples)	♦ Accident/Spill Site. ♦ Surface water collected along the south side of the creek slightly downstream of the accident/spill site excavation. ♦ Confirmatory soil/sediment samples collected from the south bank of the creek within the limits of the accident/spill area excavation.	♦ Accumulation of fuel and sheen observed on the surface of the water. ♦ South bank of the creek impacted by accident/spill. ♦ Surface water exceedence measured.

Location	Surface Water	Sediment	Location Description	Rationale
Lemon Creek (Cont'd)	Previously no sample collected	SED13-305 / -306	♦ Located approximately 1 km downstream of the spill site on Lemon Creek. ♦ Sample location in creek along the south side.	♦ Area identified as heavily impacted by the SCAT Team. ♦ Continuous rainbow sheen and fuel was found in droplet concentrations when sediment/cobble is disturbed.
	SW13-05	SED13-05	♦ Located approximately 3 km downstream of the accident / spill site on Lemon Creek adjacent to the property owned by Russell Hubert @ 7803 Lemon Creek Road (presence of shallow dug well). ♦ Sample location in creek along the south side.	♦ Area identified as light impacted, by the SCAT Team. ♦ Assess south bank of the creek for porewater sampling. ♦ Surface water exceedence measured. ♦ Continuous rainbow sheen was found when sediment/cobbles are disturbed. ♦ Location of shallow dug drinking water well approximately 40 m from the south side of the creek.
	SW13-23	To be collected	♦ Located approximately 3 km downstream of the accident/spill site along the south side of Lemon Creek at POD 27773 and 27774.	♦ Area identified as lightly impacted by the SCAT Team. ♦ Adjacent to POD 27774. ♦ Collect sediment sample if possible. ♦ Light rainbow sheen found along the south side of the creek when cobbles are disturbed. ♦ Assess area for porewater sampling.

Table C (Cont'd): Proposed Surface Water and Sediment Sample Locations

Location	Surface Water	Sediment	Location Description	Rationale
Lemon Creek (Cont'd)	SW13-03	SED13-03	♦ Located approximately 4 km downstream of the accident/spill site south side of Lemon Creek, up from the confluence of the Slocan River.	♦ Area identified as heavily impacted by the SCAT Team. ♦ Surface water exceedence measured. ♦ Heavy rainbow sheen found along the south side of the creek when cobbles are disturbed.
Slocan River	SW13-A	SED13-A	♦ Located downstream of the confluence of Lemon Creek on east bank of the Slocan River. Registered DW well 52681, possible unregistered POD in the area.	♦ Area identified as lightly impacted by the SCAT Team. ♦ Surface water exceedence measured. ♦ Light rainbow sheen found along the side of the creek, when cobbles are disturbed as well as a few dead fish. ♦ Assess area for porewater sampling.
	SW13-AA	BEACH6-01	♦ Located along the south side of the Slocan River approximately 8.5 km downstream of the confluence of Lemon Creek adjacent to a shallow dug well (POD 79652) near the river, drinking water sample DW13-A collected from the area.	♦ Potential area for accumulation of product along the side of the river where organic debris and water back eddies. ♦ Surface water exceedence measured. ♦ Assess area along the southwest bank of the river for porewater sampling. ♦ Possible beach area where the public gathers.

Table C (Cont'd): Proposed Surface Water and Sediment Sample Locations

Location	Surface Water	Sediment	Location Description	Rationale
Slocan River (Cont'd)	SW13-06	SED13-06	♦ Located approximately 9 km south of the accident/spill site on the east side of the Slocan River in section of slow moving water.	♦ Sediment exceedence measured. ♦ Potential for accumulation of product along the east bank of the river in areas of slow moving water and where organic debris has accumulated. ♦ Light rainbow sheen observed along the river side. ♦ Registered POD 26743 located in the area. ♦ Assess east bank of the river for porewater sampling.
	SW13-04	SED13-04	♦ Located on the west side of the Slocan River beneath Perry's Back Bridge	♦ Surface water exceedence measured. ♦ Accumulation of Jet fuel observed along the west side of the river at this sample location. ♦ Assess east bank of the river for porewater sampling.
	To be collected	SED13-113	♦ Located approximately 200 m south of Perry's Back Bridge along the south side of the Slocan River where the river turn west.	♦ Light rainbow sheen found along the south side of the river on the water surface as well as when sediment and organic debris are disturbed. ♦ Assess east bank of the river for porewater sampling.

Table C (Cont'd): Proposed Surface Water and Sediment Sample Locations

Location	Surface Water	Sediment	Location Description	Rationale
Slocan River (Cont'd)	SW13-LL / SW13-LL-01/02	SED13-104	♦ Located approximately 12 km downstream of the accident/spill site on the Slocan River in section of slow moving water.	♦ Surface water exceedence measured. ♦ Dead duck found in the area of the sample location. ♦ Light rainbow sheen along the sides of the river when sediment/organic debris disturbed. ♦ Potential area for accumulation of product along the west side of the river. ♦ Registered PODs 66714 & 82873 in the area. ♦ Assess west bank of the river for porewater sampling.
	SW13-II	SED13-101	♦ Located approximately 16 km downstream of the accident/spill site on the Slocan River in section of slow moving water.	♦ Surface water exceedence measured. ♦ Light rainbow sheen within a log jam along the side of the river. ♦ Assess river bank for porewater sampling.
	SW13-JJ	SED13-102	♦ Located approximately 14 km south of the accident/spill site along west bank of the river in section of slow moving water.	♦ Surface water exceedence measured. ♦ Back eddy with rainbow sheen and odour ♦ Registered POD 76800 located in the area ♦ Assess area for porewater sampling.
	SW13-504	SED13-504	♦ Located north of Winlaw on the west bank of the Slocan River in section of slow moving water.	♦ Numerous Point of Diversions along this section of the river. ♦ Light rainbow sheen previously observed along the banks ♦ Assess area for porewater sampling.

Following analytical processing of samples, the results will be reviewed by SNC-Lavalin. In keeping with the adaptive approach of this EMP, depending on the results, the number of sampling locations may be increased or decreased accordingly for the subsequent sampling events.

The field methodology for surface water and sediment sampling will be conducted in accordance with our preferred operating procedures and standard industry practice, as summarized in Appendix I. Sample locations will be photographed, with visual observations documented.

4.2.2.2 Data Collection and Regulatory Standards/Guidelines

As indicated in Table A, surface water/sediment samples will be submitted for analysis of current potential contaminants listed for each media; TEX (water only), select PAHs and gross hydrocarbons (VPH and LEPH/HEPH). Select sediment samples will also be analyzed for grain size and organic carbon content. A variety of representative sediment samples will be selected and analyzed for grain size and TOC. Depending on sample locations, all types of sediment except gravel and cobbles will be collected.

In addition to the analytical testing, field measurements such as, pH, conductivity, turbidity and dissolved oxygen will also be collected. All samples collected will be kept in ice-chilled coolers and delivered to a certified laboratory (i.e., ALS Environmental located in Burnaby, BC) for analyses, via courier, with appropriate chain-of-custody documentation.

For screening purposes, surface water chemistry results will be compared to the BCWQ guidelines for the applicable water uses (aquatic life, drinking water, recreational use, irrigation and/or livestock watering) and the BC CSR Schedule 6 Generic Numerical Groundwater standards for the point of exposure water uses (i.e., aquatic life, drinking water, irrigation and livestock watering). In addition, the CSR Schedule 6 volatile petroleum hydrocarbons in water (VPHw) and light extractable petroleum hydrocarbons in water (LEPHw) aquatic life standards divided by 10 will be referenced as suggested in MoE TG15. For future screening of contaminants for evaluation in an HHERA (if required), the federal guidelines may be considered.

Sediment chemistry results will be compared to the BC CSR Schedule 9 Sediment Criteria for sensitive contaminated sites ($SedQC_{SS}$). Results will also be compared to data previously collected during the emergency response phase and to data from upgradient (background) surface water/sediment samples.

Analytical data will be tabulated, compared to applicable provincial standards/guidelines and then reviewed to determine if exceedences have occurred. If analytical results vary between each event, then data sets will be compared and plotted against water levels to determine if there are seasonal variations.

4.2.3 Porewater Quality

In order to assess groundwater, it is proposed that porewater samples will be collected at an approximate 1 m depth along the creek and/or riverbank in identified worst case areas to assess interstitial groundwater quality and the potential for contaminated sediments to act as a source of groundwater contamination. The number of locations will be determined based on the results of the preliminary surface water/sediment sampling carried out during the emergency response phase; the SCAT activities; physical site conditions; and also observations made during the initial post clean-up sampling event.

In the spill area, remedial soil excavation was carried out; confirmatory base samples were obtained and impacted soil was removed. Since bedrock was encountered at the bottom of the creek and along the south bank and soil impacts were surficial along the roadway (i.e., did not reach bedrock), jet fuel is not expected to have migrated into the bedrock and underlying groundwater but rather volatized immediately and/or mixed with the rapid flowing creek. As such, groundwater investigation in the spill area is not required.

If possible, porewater samples will be collected at locations in which the highest concentrations of contaminants in sediment are measured. Therefore, it is intended that these porewater locations will coincide with the sediment sample locations targeted above and will be focused on areas where shallow groundwater wells are present; these wells have the potential to draw contaminants into the groundwater system through pumping. It is noted, however, that sampling of water supply systems to date, by both SNC-Lavalin and IHA, has not indicated any detectable hydrocarbon parameters. If porewater quality does not indicate impacts, it is assumed that groundwater is not at risk, and detailed groundwater investigation would not be required.

One up-gradient background sample location on the Slocan River will be established and will continue to be sampled in order to evaluate background conditions. As outlined in the above Table C, the proposed sediment sample locations carried forward into the EMP will be assessed and if suitable, porewater samples will be collected.

The porewater sample points (i.e., mini-drive/pushpoint piezometers) will be manually installed within 5 m of the creek/river's edge. Due to variable water levels in Lemon Creek and the Slocan River; potential ice flow conditions during the winter; and, various property access issues, these piezometers are expected to be destroyed; and therefore will be removed after each sampling event and re-installed prior to each future sampling event.

Installation of the porewater piezometers may not be possible along shorelines consisting mainly of gravel and cobbles. However, the drive/pushpoint sampler technology will be tested in these areas. If this approach is unsuccessful, then alternative approaches will be evaluated. It has also been observed that there is limited to no recharge in the piezometers installed in shoreline areas (during the September 2013 event) with compact, fine grained sediments. This finding would indicate that groundwater impacts would be negligible in these areas.

4.2.3.1 Data Collection and Regulatory Standards/Guidelines

Following purging, porewater samples will be collected and analyzed for the potential contaminants (toluene, ethylbenzene, xylenes, select PAHs, VPH, and LEPH/HEPH), as well as alkalinity, hardness and total suspended solids. In addition to the analytical testing, field measurements such as, pH, conductivity, turbidity and dissolved oxygen will also be collected.

Porewater chemistry results would be compared to the BCWQ guidelines for aquatic life and recreational use; the BC CSR Schedule 6 Generic Numerical Groundwater standards for the point of exposure water uses including Drinking Water, Irrigation and Livestock Watering; as well as the CSR Schedule 6 VPHw and LEPHw aquatic life standards divided by 10. For future screening of contaminants for evaluation in an HHERA (if required), the federal guidelines may be considered.

It is noted that of the potential contaminants associated with the Jet-A1 fuel, only a few of the parameters are regulated for the protection of drinking water. The predominant contaminant measured in surface water samples collected from the spill area is LEPH (C10-19); SNC-Lavalin has used Health Canada's litre-equivalent approach to derive a health-based guideline for LEPH; SNC-Lavalin (Tara Siemens Kennedy) spoke with Dr. Glyn Fox of the BC MoE regarding the proposed use of the Health Canada's litre-equivalent approach in the derivation of a health-based drinking water target for LEPH. Dr. Fox was open to the review of the approach/resulting target, and also suggested that SNC-Lavalin consider the Massachusetts Drinking Water Limits for Total Petroleum Hydrocarbons (TPH). SNC-Lavalin will further consult with Dr. Fox to ensure that a scientifically sound and health-protective target is applied. It is noted that the results to date indicate that concentrations of LEPH are less than the laboratory detection limit.

Results will also be compared to data from upgradient (background) samples.

4.2.4 Trigger Criteria and Follow-up Action

The objective of the EMP is indicated in Section 3. The following approach is recommended for evaluation of the data and follow-up action, if required for water and sediment:

Table D: Recommended Triggers for Water

Trigger 1	Exceedence of applicable standards and/or guidelines.
Action:	Resample during similar environmental conditions to confirm/refute exceedence.
Trigger 2	Exceedence is confirmed.
Action:	Determine if seasonal effects occur and duration and magnitude of elevated concentrations. (A detailed sampling plan will be developed when/if necessary).
Trigger 3	Concentration trend is increasing in water.
Action:	Delineate plume and determine local source. Develop and carry out a monitored natural attenuation (MNA) program and carry contaminants forward for evaluation in HHERA.
Trigger 4	Results of HHERA indicate unacceptable risk.
Action:	Evaluate mitigative/risk management options.

Table E: Recommended Triggers for Sediment

Trigger 1	Exceedence of applicable Schedule 9 Criteria.
Action:	Resample to confirm/refute exceedence.
Trigger 2	Exceedence is confirmed.
Action:	Delineate the extent of the sediment contamination and review along with the entire sediment data set to evaluate the overall sediment quality.
Trigger 3	Widespread sediment contamination is identified.
Action:	Conduct HHERA. Note: if sediment contamination is determined to be localized, impacted area will be reviewed to determine remedial approach – if sensitive habitat is present, RA may still be determined to be most appropriate approach.
Trigger 4	Results of HHERA indicate unacceptable risk.
Action:	Evaluate mitigative/risk management options.

4.2.5 Quality Assurance/Quality Control (QA/QC)

QA/QC measures will be undertaken to confirm representative sample collection. These measures include the following:

- using dedicated sampling equipment and where necessary decontamination of non-dedicated sampling equipment at each sample location;
- adequate development and purging of wells/piezometers prior to sampling;
- undertaking work in accordance with written field protocols;
- using laboratory prepared sample containers and chain-of-custody documentation when collecting and transporting samples; and
- utilizing experienced field personnel.

To assess the repeatability and accuracy of field sampling and laboratory analyses, the following measures will be undertaken:

- blind duplicate samples are to be collected and tested at a rate of one duplicate per ten samples collected;
- one trip blank and equipment blank will be collected and tested per sampling event; and
- method blanks, duplicate and spiked samples will be analyzed as part of the laboratory's internal QA/QC program.

The precision of the laboratory and field sampling is to be evaluated based on the relative percent difference (RPD) between duplicate results. The RPD is the absolute value of the difference between the two results, divided by the average of the two and reported as a percentage; i.e.,

$$RPD = abs[(C_{sample}-C_{dup})/(C_{sample}+C_{dup})*2]*100$$

For the purposes of evaluation, it is interpreted that RPD values that exceed the targets below will require an investigation into the cause of the discrepancy. In evaluating the RPD, only samples/parameters for which the measured concentration is greater than five times the analytical detection limit (i.e., greater than the practical quantitation limit) are considered.

Table F: Applicable RPD Values

Analyte	Soil/Sediment (RPD) BC MoE (1.5 x Lab RPD)	Water (RPD) BC MoE (1.5 x Lab RPD)
TEX/VPH/EPH	60%	45%
PAH	75%	45%
Metals	60%	30%
Inorganics	45 - 60%	30%

4.2.6 Database Management

Laboratory analytical results will be provided in an electronic format that is directly downloadable in our access database. This data will be formatted and electronically compared to the standards and/or guidelines indicated above. Laboratory hard copies of the analytical results will be manually compared to the results downloaded into the database at a rate of approximately 20%. A review of the data tables will also be performed to assess potential errors in units of concentration, parameters that exceed standards and guidelines, and duplicate samples.

4.3 Schedule

The proposed activities commenced early September 2013 (initial post-clean up sampling event), and future events will be scheduled upon approval from the MoE to transition the incident from the remediation phase to the monitoring phase. A factual update with tables and drawings will be prepared for the first two sampling events and provided to EFC in January 2014 in order to meet the BC MoE deadline of January 31, 2014. Depending on results of the three post clean-up sampling events, it is anticipated that the fourth sampling event (i.e., July 2014) may not be required. In any case, SNC-Lavalin will prepare a final factual report for EFC to review prior to submission to the BC MoE in September 15, 2014.

5.0 LIMITATIONS OF LIABILITY, SCOPE OF REPORT AND THIRD PARTY RELIANCE

This Environmental Management Plan (EMP) for water and sediment has been prepared by SNC-Lavalin Inc. (SNC-Lavalin) for Executive Flight Centre Fuel Services Ltd. (EFC). It is intended for the sole and exclusive use of EFC, its affiliated companies and partners and their respective insurers, agents, employees and advisors. Any use, reliance on or decision made by any person other than EFC based on this document is the sole responsibility of such other person. EFC and SNC-Lavalin make no representation or warranty to any other person with regard to this document and the work referred to in this document and they accept no duty of care to any other person or any liability or responsibility whatsoever for any losses, expenses, damages, fines, penalties or other harm that may be suffered or incurred by any other person as a result of the use of, reliance on, any decision made or any action taken based on this document or the work referred to in this document.

This EMP prepared by SNC-Lavalin reflects SNC-Lavalin's judgment based on information available at the time of preparation of this document. This document has been prepared for specific application to this Site.

Other than by EFC, copying or distribution of this document or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of SNC-Lavalin. Nothing in this report is intended to constitute or provide a legal opinion.

Regulatory authorities are authorized to rely on the information contained in this document for the purpose of determining whether EFC is fulfilling or has fulfilled its obligations with respect to the applicable environmental statutory or regulatory requirements. Any use or reliance upon this document by any other third party is not authorized (without EFC's and SNC-Lavalin's consent) and is at the sole risk of such third party.

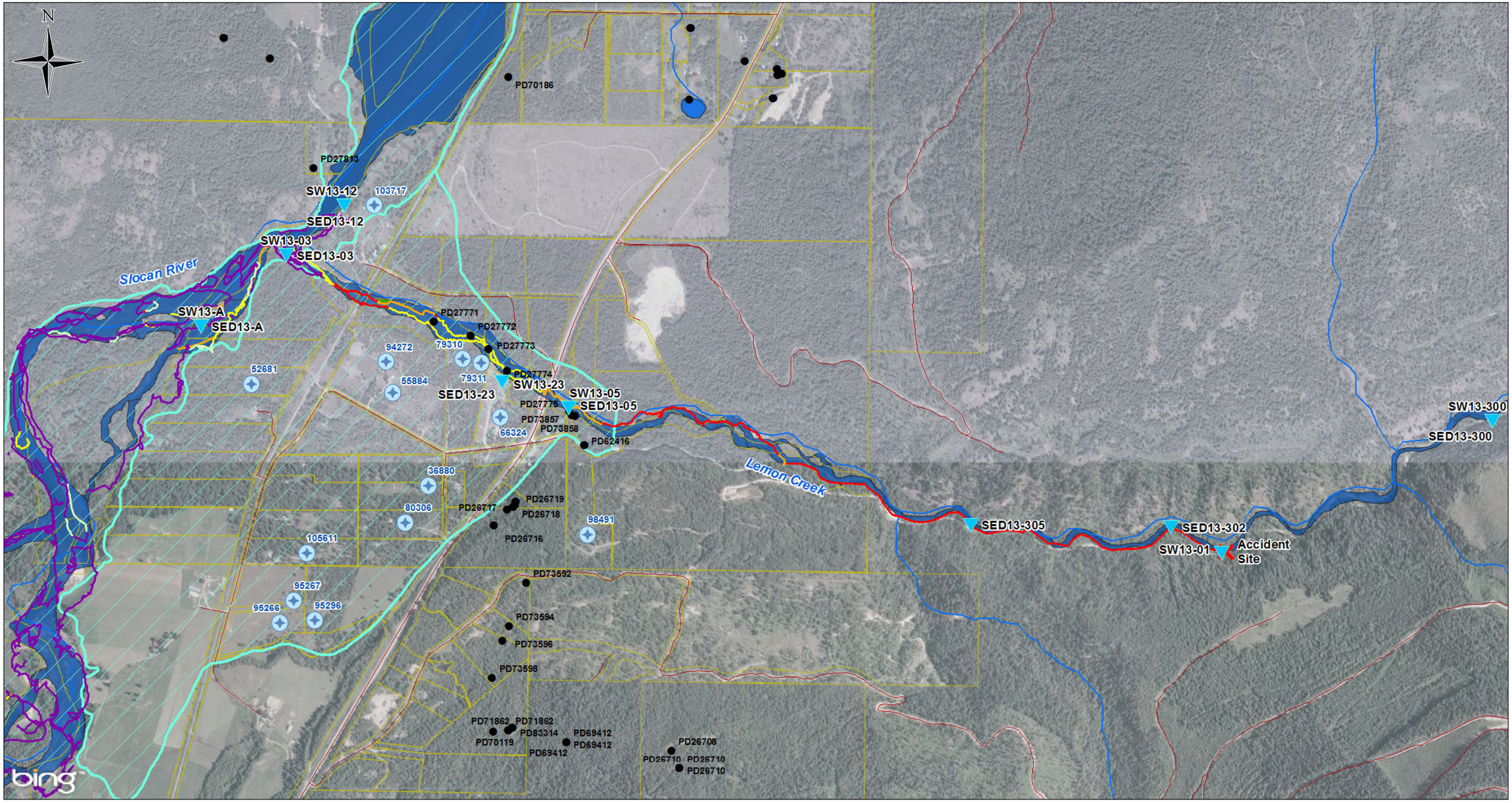
6.0 REFERENCES

American Petroleum Institute – Petroleum HPV Testing Group. 2010. Kerosene/Jet fuel category assessment document. Submitted to the United States Environmental Protection Agency (USEPA). Consortium Registration # 201-16846A. 47p.

Guiney, PD, JL Sykora and G. Keleti. 1987. Environmental impact of an aviation kerosene spill on stream water quality in Cambria County, Pennsylvania. 1987. Environmental Toxicology and Chemistry: Vol.6. pp. 977-988.

DRAWINGS

- 614668-005 – EMP Water & Sediment Sample Locations – Lemon Creek/Confluence with Slocan River
- 614668-006 – EMP Water & Sediment Sample Locations – Slocan North/Perry's Back Bridge
- 614668-007 – EMP Water & Sediment Sample Locations – Slocan Middle/Appledale
- 614668-008 – EMP Water & Sediment Sample Locations – Slocan South/Winlaw



LEGEND

- Accident Site
- Sediment and/or Surface Water Sample Location
- Point of Diversion Licence
- Groundwater Wells
- Floodplains
- Roads
- Cadastral Boundaries

SCAT Observations

- HEAVY
- MODERATE
- LIGHT
- TRACE
- VERY LIGHT
- NO OBSERVED JET FUEL

NOTES

1. Original in colour.
2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.
3. Intended for illustration purposes, accuracy has not been verified for construction or navigation purposes.
4. Surface soil and excavation sample locations were taken in the vicinity of the accident site, however specific locations are not shown on figure.

REFERENCES

0 105 210 420 630 Meters

1. BCGOV ILMB Crown Registry and Geographic Base Branch (CRGB) (data accessed through www.GeoBC.gov.bc.ca)

2. GPS Data Collected using an eTrex. Accuracy expected to be approximately +/- 3.5m.

Service Layer Credits: © 2012 DigitalGlobe Image courtesy of USGS © 2012 GeoEye © 2012 Blom State of Michigan

SNC·LAVALIN

CLIENT NAME:	PROJECT LOCATION:
Executive Flight Centre	Lemon Creek, BC Spill Site

EMP Water & Sediment Sample Locations - Lemon Creek/Confluence with Slocan River

BY: DMB	SCALE: 1:14,000	DATE: 2013/09/30	REF No: 614668-005-EMP	REV: 0
CHK'D: RRW	PROJ COORD SYS: NAD 1983 UTM Zone 11N			

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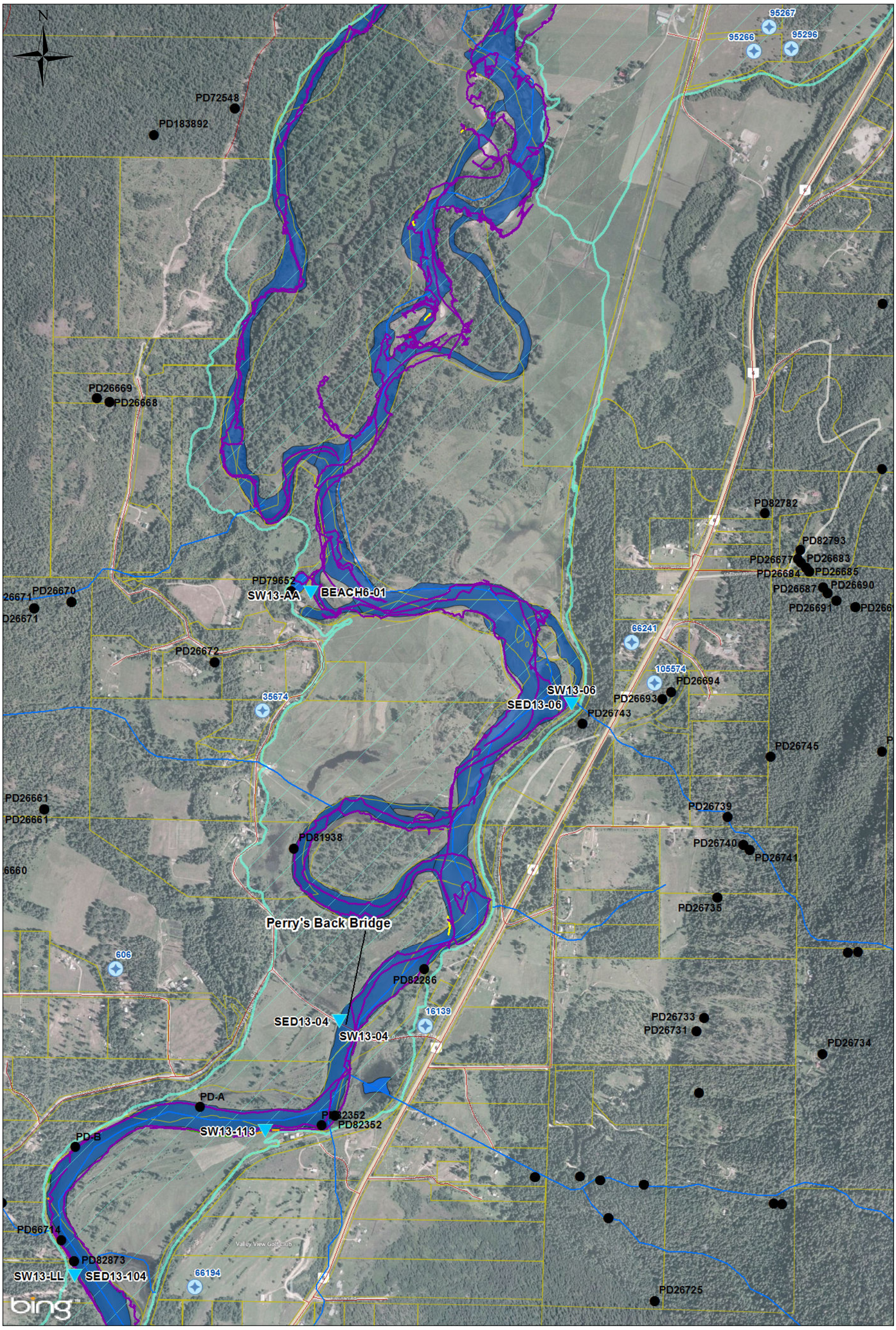

LEGEND

- Sediment and/or Surface Water Sample Location
- Groundwater Wells
- Point of Diversion Licence
- Floodplains
- Roads
- Cadastral Boundaries

SCAT Observations

- HEAVY
- MODERATE
- LIGHT
- TRACE
- VERY LIGHT
- NO OBSERVED JET FUEL

NOTES

1. Original in colour.
2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.
3. Intended for illustration purposes, accuracy has not been verified for construction or navigation purposes.

REFERENCES

1. BCGOV ILMB Crown Registry and Geographic Base Branch (CRGB) (data accessed through www.GeoBC.gov.bc.ca)
2. GPS Data Collected using an eTrex. Accuracy expected to be approximately +/- 3.5m.

0 100 200 400 600 800 Meters

SNC·LAVALIN

CLIENT NAME:	PROJECT LOCATION:
Executive Flight Centre	Slocan River North of Winlaw, BC

EMP Water & Sediment Sample Locations - Slocan North/Perry's Back Bridge

BY:	DMB	DATE:	2013/09/30	REF No:	REV: 0
CHK'D:	RRW	SCALE:	1:12,500	614668-006-EMP	

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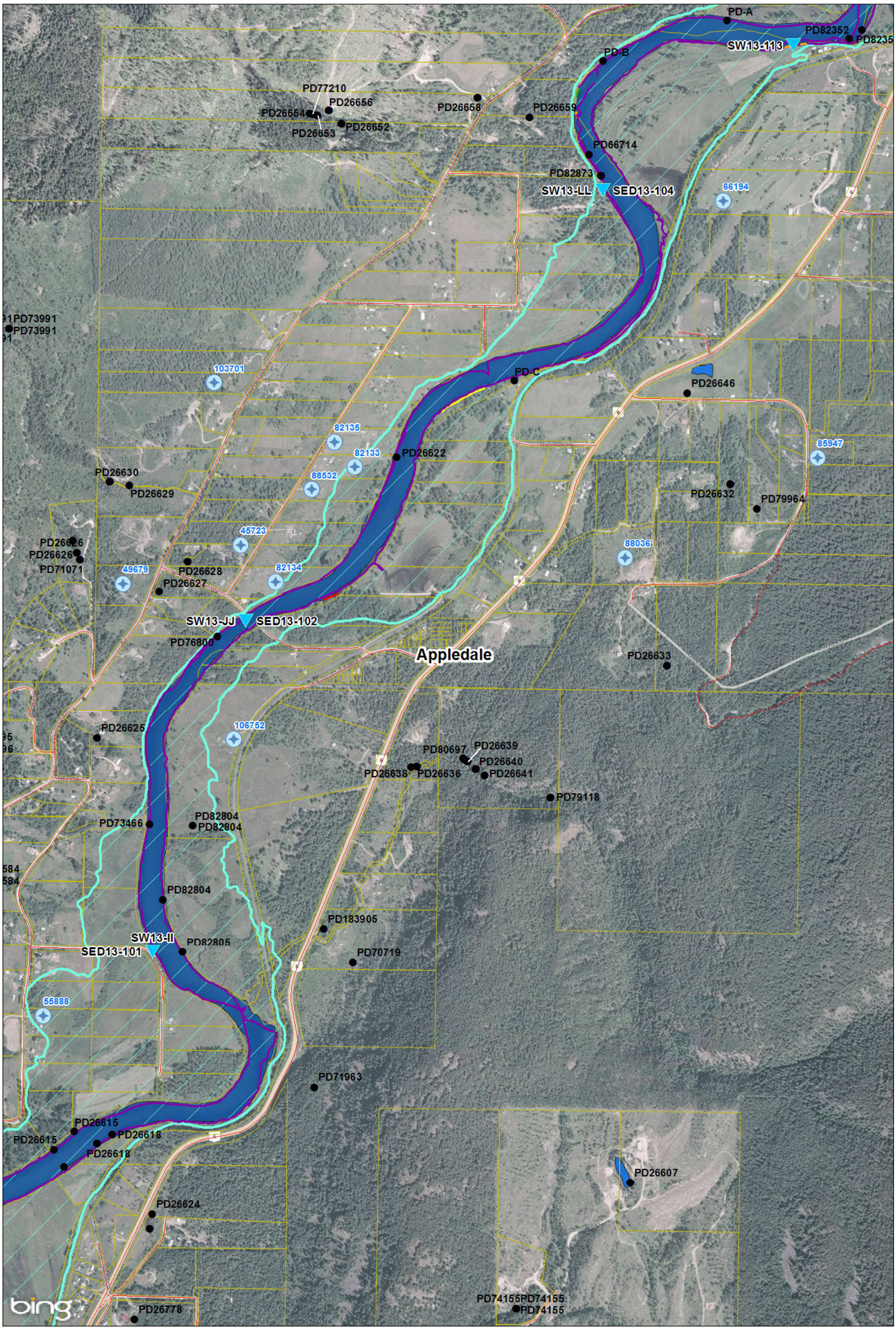

LEGEND

- Sediment and/or Surface Water Sample Location
- Groundwater Wells
- Point of Diversion Licence
- Floodplains
- Roads
- Cadastral Boundaries

SCAT Observations

- HEAVY
- MODERATE
- LIGHT
- TRACE
- VERY LIGHT
- NO OBSERVED JET FUEL

NOTES

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2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.
3. Intended for illustration purposes, accuracy has not been verified for construction or navigation purposes.

REFERENCES

1. BCGOV ILMB Crown Registry and Geographic Base Branch (CRGB) (data accessed through www.GeoBC.gov.bc.ca)
2. GPS Data Collected using an eTrex. Accuracy expected to be approximately +/- 3.5m.

0 100 200 400 600 800 Meters

SNC·LAVALIN

CLIENT NAME: Executive Flight Centre

PROJECT LOCATION: Slocan River North of Winlaw, BC

EMP Water & Sediment Sample Locations - Slocan Middle/Appledale

BY:	DMB	DATE:	2013/09/30	REF No:	REV: 0
CHK'D:	RRW	SCALE:	1:12,500	614668-007-EMP	

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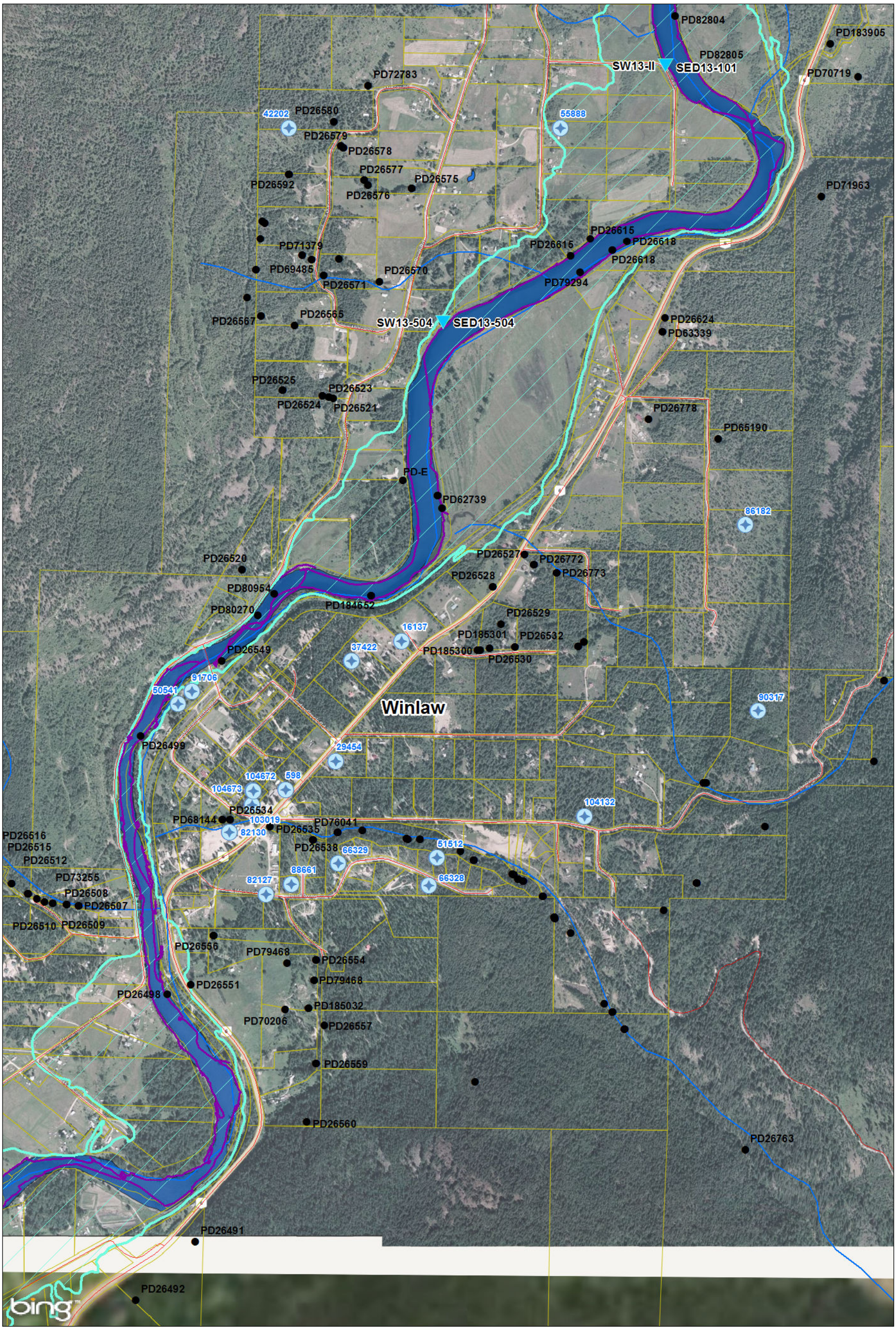

LEGEND

- Sediment and/or Surface Water Sample Location
- Groundwater Wells
- Point of Diversion Licence
- Floodplains
- Cadastral Boundaries
- Roads

SCAT Observations

- HEAVY
- MODERATE
- LIGHT
- TRACE
- VERY LIGHT
- NO OBSERVED JET FUEL

NOTES

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2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.
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REFERENCES

1. BCGOV ILMB Crown Registry and Geographic Base Branch (CRGB) (data accessed through www.GeoBC.gov.bc.ca)
2. GPS Data Collected using an eTrex. Accuracy expected to be approximately +/- 3.5m.

0 100 200 400 600 800 Meters

SNC·LAVALIN Environment

CLIENT NAME:	PROJECT LOCATION:
Executive Flight Centre	Slocan River North of Winlaw, BC

EMP Water & Sediment Sample Locations - Slocan South/Winlaw

BY:	DMB	DATE:	2013/09/30	REF No:	REV: 0
CHK'D:	RRW	SCALE:	1:13,000	614668-008-EMP	

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APPENDIX I

Field Sampling Methodology

FIELD SAMPLING METHODOLOGY

The field methods to be followed during the water and sediment Environmental Monitoring Program (EMP) are described below. These field methods will be carried out according to SNC-Lavalin's in house Preferred Operating Procedures (POPs) and Quality Assurance/Quality Control (QA/QC) protocols, accepted industry practice.

Surface Water Sampling

Surface water samples will be collected from close to the bank of Lemon Creek and the Slocan River in areas considered high risk or known to be worst case based on analytical data, preliminary Shoreline Cleanup Assessment Technique (SCAT) results, initial observations following the spill and/or observations made during the sampling event.

Surface water sampling will be carried out using laboratory supplied sampling containers that are rinsed with surface water in the general area of the sample location. Care will be taken to avoid disturbing the sediment. With the field person positioned downstream of the sampling point, each sampling container will be gently immersed with the opening facing upstream to the water surface to ensure that potential floating hydrocarbons are captured. When filled, each sampling container will be lifted out of the surface water and the caps tightly secured.

During sample collection, pH, conductivity, turbidity, temperature and dissolved oxygen will be measured in the field using appropriate calibrated meters placed downstream of each sampling location.

Surface water samples will be stored in ice-chilled coolers and submitted for analysis to ALS Environmental (ALS) in Burnaby, BC under SNC-Lavalin chain-of-custody procedures and within specified holding times.

Sediment Sampling

SNC-Lavalin will collect sediment samples at a depth of 0 m to 0.2 m at the interface between the water surface and the river/creek bank at targeted sample locations. Sediment sampling will be completed following the collection of surface water samples such that sediment disturbances will not influence surface water analytical results.

In shallow waters close to shore, sediment sampling will be carried out by hand using a trowel or shovel. Care will be taken to minimize movement of sediment samples through the water column (i.e., avoid removing fines from the sample).

If sediment sampling in deeper waters is required (i.e., in log boom areas and/or product collection areas etc.), a petite Ponar grab sampler (or similar sampling device) will be used which has a steel jaws that are held open using a tension triggered, spring-loaded pin. The sampler will be slowly lowered by hand into the creek/river at each sampling station using an attached rope. By maintaining tension on the rope, the sampling jaws remain open. Once the sampler reaches the creek/river bottom, the tension on the rope is released, activating the spring-loaded pin and closing the jaws of the sampler. The sampler is then slowly lifted to the surface and the jaws of the sampler remain closed as long as tension remains on the attached rope. Sediment samples will then be collected directly from the sampler.

Sediment will then be transferred into three (3) laboratory supplied 125 mL glass jars sealed with Teflon© lined lids. Samples will be stored in ice-filled coolers and submitted for analysis to ALS in Burnaby, BC under SNC-Lavalin chain-of-custody procedures and within specified holding times.

The sampler (i.e., Ponar, trowel or shovel) will be decontaminated between each sampling station.

Porewater Sampling

If field conditions are amenable (i.e., no gravels and/or cobbles or tight, very fine sediments), porewater samples will be collected from the piezometers located adjacent to Lemon Creek and the Slocan River. The drive-point piezometers will be used for collecting porewater approximately 1 m below ground surface along the river/creek shoreline. However, depending on field conditions, drive-point piezometers may not be successful; as such, other porewater sampling methods will be attempted if deemed favourable. The proposed methods include;

1) Solinst Model 615 Shielded Drive-Points[8] comprised of 20 mm diameter and 0.30 m long stainless steel, 50 mesh cylindrical filter screens threaded onto steel extension pipes. The screens have a barbed fitting at the top for attachment of Waterra® tubing which extends inside the extension pipes.
2) A mini-drive/pushpoint sampler technology consisting of a very thin, stainless steel pushpoint sampling rod with a screen at one end. It can be pushed/forced in by hand and then attached directly to peristaltic pump for collection of a porewater sample.
3) Hand–auger to approximately 1 m depth and install a 1” polyvinyl chloride (PVC) screened casing.

[8] http://www.solinst.com/Prod/615/Drive-Point-Piezometers.html

Each porewater piezometer will be purged using a low flow peristaltic pump with dedicated tubing prior to sampling to ensure collection of representative porewater samples. Selected field parameters (pH, conductivity, temperature, turbidity, and dissolved oxygen) will be measured during purging, and allowed to stabilize before sampling. Samples will also be collected using a peristaltic pump with dedicated tubing at each location. Porewater samples will be immediately transferred to laboratory-supplied containers and stored in an ice-chilled cooler and shipped by ground for delivery to ALS in Burnaby, BC under SNC-Lavalin chain-of-custody procedures.