Cenovus Energy Inc.
500 Centre Street S.E.
P.O. Box 766
Calgary, AB T2P 0M5
(403)766-2000
www.cenovus.com

December 18 , 2013

Steve Thomas, P.Eng.
Section Leader, In Situ Oil Sands Applications
Oil Sands and Coal Branch
Alberta Energy Regulator (AER)
Suite 1000, 250 – 5th Street SW
Calgary, AB T2P 0R4

Margot Trembath
EIA Coordinator
Environment and Sustainable Resource Development (ESRD)
#111, Twin Atria Building
4999-98th Avenue
Edmonton, AB T6B 2X3

RE: Supplemental Information Responses (3)
Pelican Lake Grand Rapids Project
ERCB Application No. 1712169
EPEA Application No.001-293251
Water Act File No.00303376

Dear Sir and Madam:

Cenovus Energy Inc., (Cenovus) is submitting the enclosed responses to the supplemental information requests (SIR3) dated December 10, 2013 regarding the Environmental Impact Assessment (EIA) joint application for the Pelican Lake Grand Rapids Project.

Should you have any concerns or questions regarding this submittal, please contact the undersigned at (403) 766-6368.

Sincerely,
Cenovus Energy Inc.

Greg Demchuk

Regulatory Coordinator

cc: Salim Jagirdhar, AER
Albert Liu, ESRD
Kendall Dilling, Cenovus

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AER COMMERCIAL SCHEME APPLICATION

GENERAL

1. **Provide an update on the status of stakeholder (public and industry) consultation including a list of all stakeholders with an outstanding statement of concern regarding the proposed project, a summary of the key issues identified in each statement of concern, and the efforts taken to address and resolve the concerns.**

Response:

As per the response to Round 2 SIR 1a, the only outstanding statement of concern remaining for the Project was the submission from Canadian Natural Resources Limited (CNRL). Please see Appendix 1-1 for the non-objection letters received from CNRL on December 11, 2013 removing this statement of concern.

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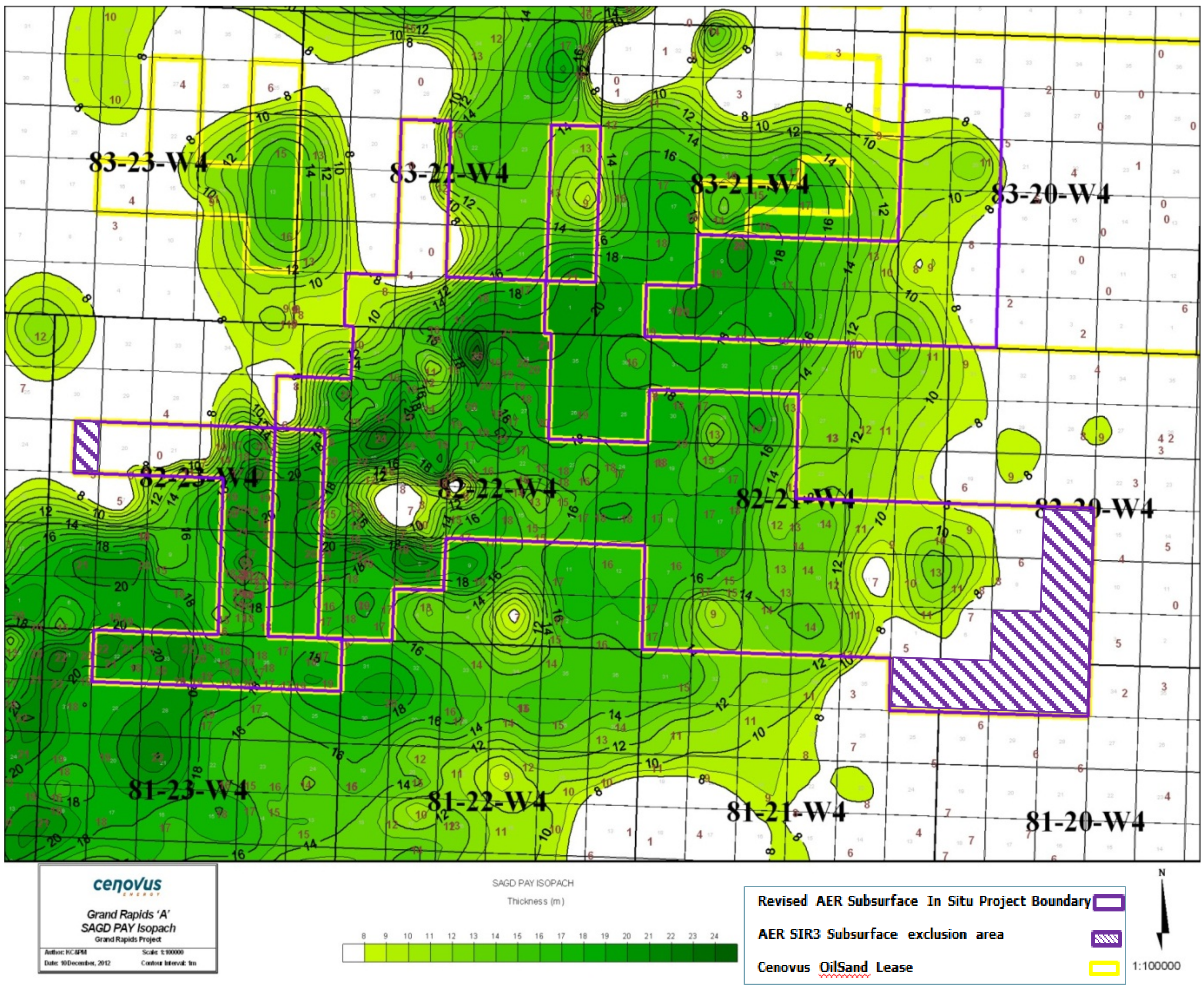
2. **SIR 2 Response, Fig 2-1 Grand Rapids 'A' SAGD Pay Isopach: Cenovus has proposed to include Sections 31, 32, 33-081-20W4M, Section 36-081-21W4M, Sections 4, 5, 9, 16-082-20W4M, and the east half of Section 19-082-23W4M in the project area; however, these areas do not appear to have thermally developable bitumen based on the provided bitumen pay mapping. An AER-defined project area must include the boundaries within which bitumen recovery may occur over the life of the project based on the current geological delineation information. Justify the inclusion of each aforementioned area in the proposed project area. Alternatively, provide an updated SAGD pay isopach map illustrating a revised proposed project area along with a written legal land description of the revised proposed project area.**

Response:

The SAGD pay isopach map has been updated to reflect the revised subsurface project boundaries (see Figure 2-1). For the purposes of this application, these areas (Sections 31, 32, 33-081-20W4M, Section 36-081-21W4M, Sections 4, 5, 9, 16-082-20W4M, and the east half of Section 19-082-23W4M) have not been included in the defined in situ Project or Initial Development Area (IDA). A separate application will be submitted to include these areas in the subsurface project boundary prior to their development.

Figure 2-1 Grand Rapids 'A' SAGD Pay Isopach with Revised Subsurface Project Area



The updated legal land description for the subsurface Project Area is:

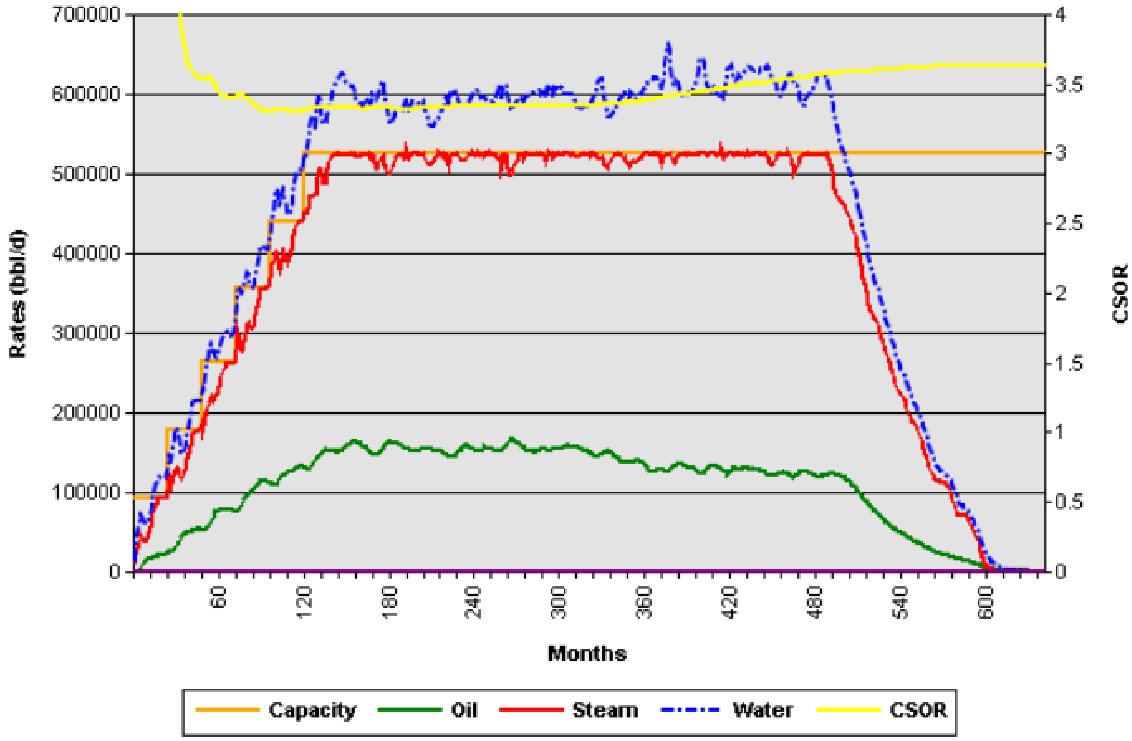
- Sections 32 to 36 of 81-23 W4M
- East ½ of section 1, west ½ of 2, east ½ of 3, east ½ of 10, west ½ of 11, east ½ of 12, east ½ of 13, west ½ of 14, east ½ of 15, 20 to 22, west ½ of 23, east ½ of 24, 25, east ½ of 26 of 82-23 W4M
- Sections 6-8, 13-24, 27-34 of 82-22 W4M
- Sections 2-5, 9, 12-13, 16, 21, 24 of 83-22 W4M
- Sections 1-21, 28-30 of 82-21 W4M
- Sections 1-5, 9-12 of 83-21 W4M
- Sections 6-8, 17 & 18 of 82-20 W4M and
- Sections 5-8, 17-20, 29-30 of 83-20 W4M

The resource available in the Grand Rapids ‘A’ is more than sufficient to meet the stated expectations, and the removal of these sections from the Project Area does not significantly impact the Project forecast due to the late-time development of these lands. The forecast, reproduced below as Figure 2-2 (originally shown as SIR Round 1, Figure 37-1), continues to be achievable based on the anticipated results of the pilot with key points summarized below.

- Surface facility bottlenecks restricted injection and production rates prior to September 2013. These bottlenecks have now been largely removed resulting in greater rates and improved performance.
    - P1 achieved a peak oil production rate of 100 m^3/d on August 1, 2013, and achieved an average oil production rate in August of 70 m^3/d.
    - The average SOR for both wellpairs for July-December 2013 is less than 4, consistent with the SOR presented for the project in Figure 2-2 (originally shown as SIR Round 1, Figure 37-1).
- Operational and wellbore issues have caused poor steam conformance in both wellpairs. Other Cenovus projects demonstrate that improved steam conformance leads to improved production.
    - Early in 2014, workovers are planned for both wellpairs to improve conformance. Insulated tubing will be installed in P2 to reduce the heat transfer to the emulsion through the heel hotspot. The recompletion technology for P1 is still being investigated.

A detailed review of the pilot performance will be given at our annual performance review scheduled for April, 2014.

Figure 2-2 Rate Forecasts (SIR Round 1, Figure 37-1)



3. Update Tables 12-1 and 33-1 of the SIR 1 Responses to exclude pads that are not within the proposed initial development area.

Response:

Round 1 Tables 12-1 and 33-1 have been updated and are provided in Tables 3-1 and 3-2. This update is required as a result of the removal of pads from the original IDA.

Table 3-1 Developable Bitumen in Place by Initial Development Area SAGD Pads

New Pad #	New Pad Phase	OBIP [m³]	OBIP [bbls]
1	A	4,476,403	28,155,682
3	A	4,191,186	26,361,722
4	A	4,171,747	26,239,454
5	A	4,381,552	27,559,086
6	A	4,245,211	26,701,528
7	A	4,741,512	29,823,162
9	A	4,266,782	26,837,205
Total		**30,474,393**	**191,677,839**

Table 3-2 Initial Development Area Well Pads

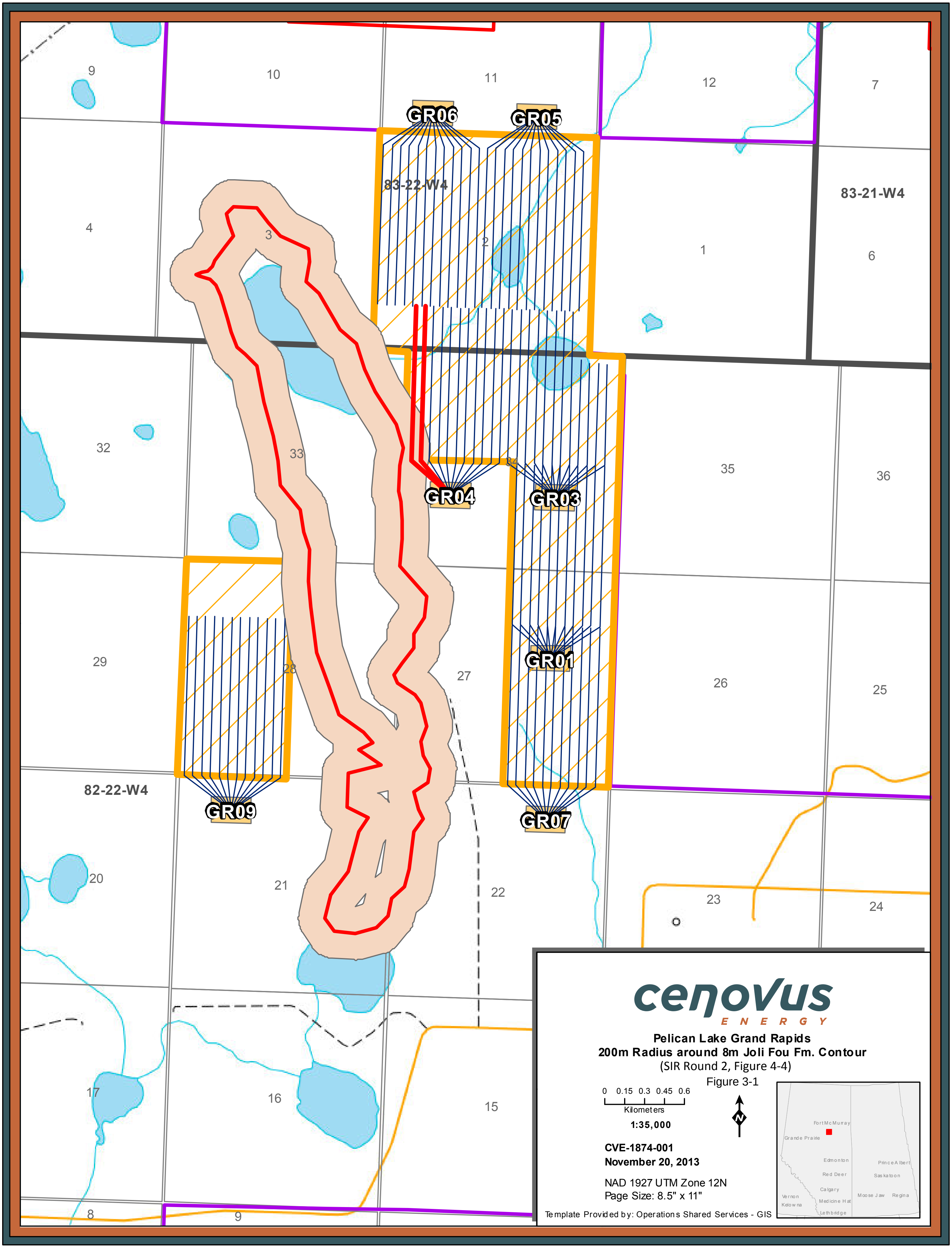
Pad Number	Number of Well Pairs	Target Horizontal Length [m]	Inter Well Pair Spacing [m]
1	11	1,200	67
3	12	8 at 1,100 4 at 700	67
4	9	1,100	67
5	12	1,200	67
6	12	1,200	67
7	12	1,200	67
9	12	1,200	67

A 200 m buffer from the Joli Fou Fm. 8 m contour was introduced; see Figure 3-1 (originally shown as Round 2 SIR 4, Figure 4-4). The coal work done by Marchioni (2013) and referenced in the reponse to Round 2, SIR 6c indicates that full structural integrity in coal is retained 17 m from an erosional edge. Due to improved ductility characteristics of the Joli Fou Fm., as opposed to the brittle nature of coal, structural integrity should be retained at less than 17 m. A 200 m buffer from this incision point exceeds a 10X safety factor based on the application of the Marchioni (2013) results to the Joli Fou Fm..

The 200 m buffer also exceeds the simulated reach of 100°C as described in the response to Round 2, SIR 24; "Under the simulated strategy to operate SAGD at 130 kPa above the lean zone pressure, the 100°C heat will migrate between 70 m and 105 m." Using the 100°C isotherm as a conservative indicator for mobile fluids travelled under the proposed operating conditions, utilization of the 200 m buffer provides an approximate 2X safety factor ensuring fluid containment in the Grand Rapids 'A'.

Cenovus maintains the position that the mudstone is a competent unconventional caprock. Due to the limited data in the area where the mudstone is the principle caprock (as per Figure 3-1), the above described 200 m buffer has been applied from the 8 m Joli Fou Fm. isopach until the competency of the mudstone can be validated by the AER. Additional data will be collected during the 2013-2014 winter drilling program to confirm the competency of the mudstone, and ongoing consultation with the AER will continue in 2014.

Cenovus is committed to monitoring steam chamber development adjacent to the Joli Fou Fm. incision edge and is confident that containment risks will be appropriately mitigated. Steam chamber development will be monitored directly within the Grand Rapids 'A' and indirectly through groundwater monitoring locations in adjacent aquifers (Figure 9-1).


9
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83-21-W4
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GR09
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cenovus
ENERGY
Pelican Lake Grand Rapids
200m Radius around 8m Joli Fou Fm. Contour
(SIR Round 2, Figure 4-4)
Figure 3-1
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GEOLOGY

4. SIR Response 2, Question 11, Page 38: Cenovus states, "Using geophysical well log analysis, image logs, core analysis and description in conjunction with the 3D seismic, it is possible to demonstrate that remnant Joli Fou Fm. exists throughout the SIR Round 1 IDA." Figure 11-1 East West Seismic Slice, Page 40: The 8-21-082-22W4M (8-21) well data was tied-in to the 3D seismic data to interpret the channel incision up to the Grand Rapids A to the east. However, it appears from the 8-21 well logs that a Joli Fou transgressive lag and thickness of around 6 - 12 metres is observed.

a. Explain the criteria used to interpret and map the Joli Fou seismic marker. Note that the red marker that was used to pick the Joli Fou Formation at the 8-19-082-22W4M (8-19) well also appears to be present at the 8-21 well.

b. Provide a cross section with available well logs and a discussion describing the rationale for why the transgressive pebbles lags (Joli Fou) were not interpreted by 3D seismic observed in the 8-21 well logs.

c. Provide an updated Joli Fou isopach map as considered necessary.

d. Provide an updated Fig. 11-1 that includes a vertical scale.

Response:

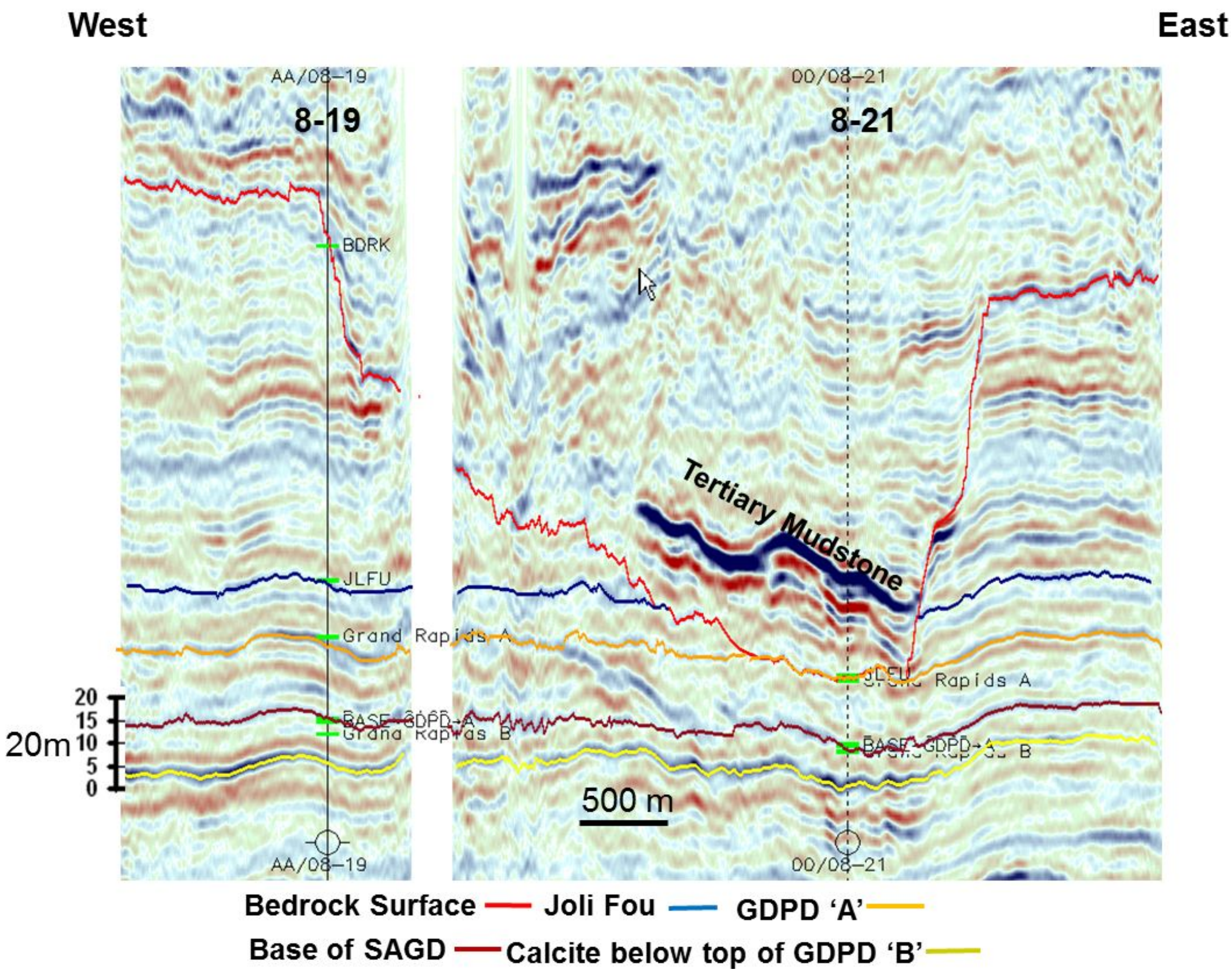
a. The interpreted top for the Joli Fou is the thin bright blue line as identified in the legend in the updated figure (Figure 4-1). This interpreted top is picked from the Joli Fou seismic reflector which is the thin blue reflector just underneath the red reflector where the Joli Fou text is placed on the image. The blue reflector represents a positive reflection coefficient which is caused by the impedance increase from the Viking sediments to the Joli Fou sediments (impedance is the product of formation velocity and bulk density). The blue reflector is thin and weak because the impedance contrast between the Joli Fou and the Viking is not huge. The Joli Fou reflector is first picked by tying the time-depth correlation on sonic log at all well locations (there are green tick markers representing the formation tops from well logs). The Joli Fou reflector is then tracked between the wells in the 3D seismic within the same waveform phase and within certain reflection strength (or called "seismic amplitude"). The correlation criteria have been input as tracking mode in the interpretation software. If the reflector coefficient did not meet the criteria, it is not selected. The Joli Fou blue reflector has been truncated by the younger incised valley system. The Joli Fou reflector is not visible at the 8-21 well.

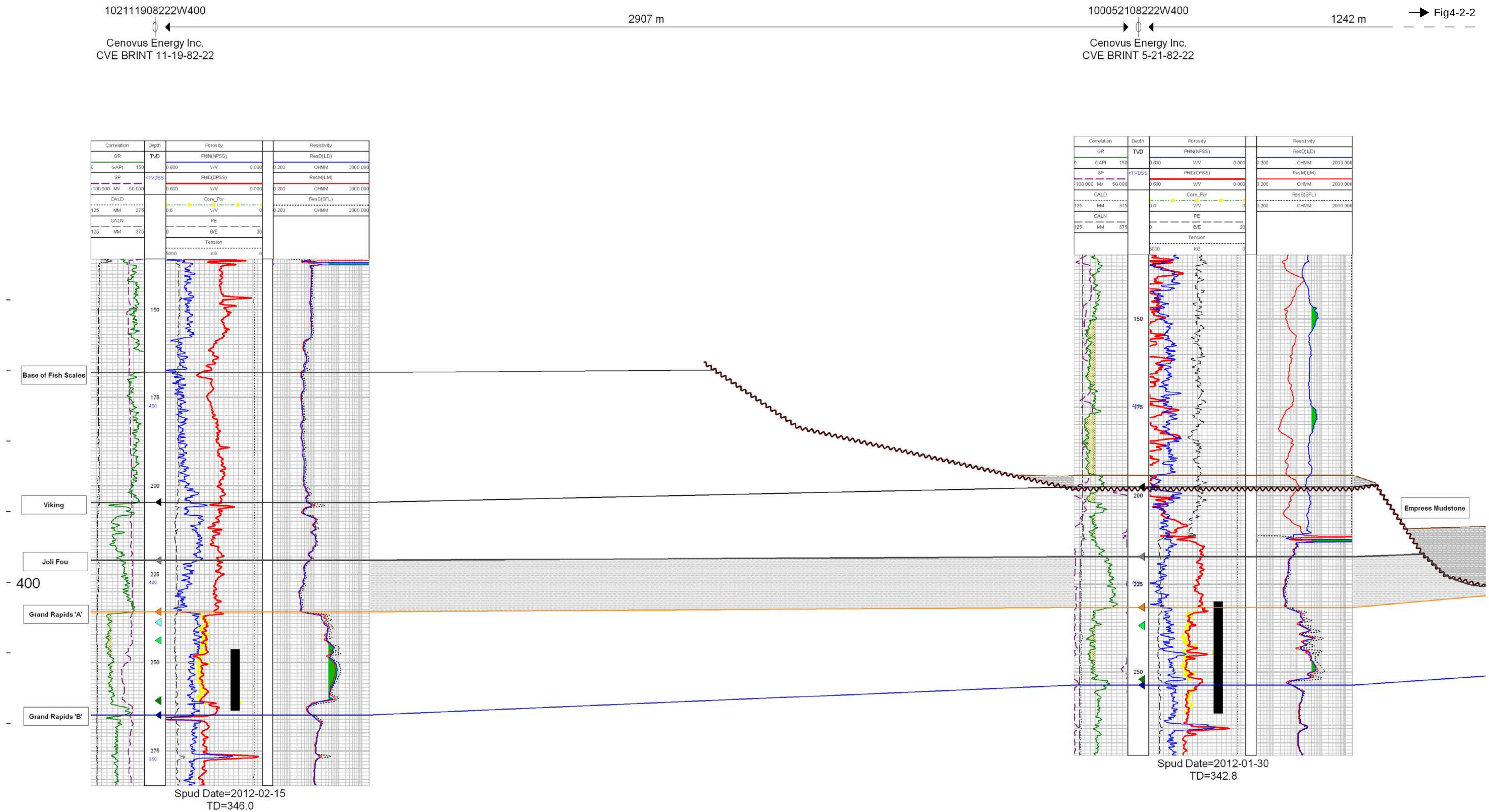
b. The current interpretation has the majority of the Joli Fou eroded at the 8-21 location and only 1.5 m of Joli Fou is present. Figure 4-2 is the W-E cross-section including the 8-21 well. Due to the seismic resolution (±2 m), the Joli Fou and GDPD "A" are mapped as one event for the 8-21 well (this is called "tuning effect").

c. An updated Joli Fou Isopach is not required as the Joli Fou at this location is only 1.5 m as currently mapped. It is important to focus on the resistivity signature from the well log and incorporate a broad assessment including correlation of the wells in proximity when evaluating the Joli Fou.

d. See Figure 4-1 for an update including the vertical scale.

Figure 4-1 East-West Seismic Slice (Updated SIR 2, Figure 11-1)





PROJECT

PELICAN LAKE
GRAND RAPIDS PROJECT

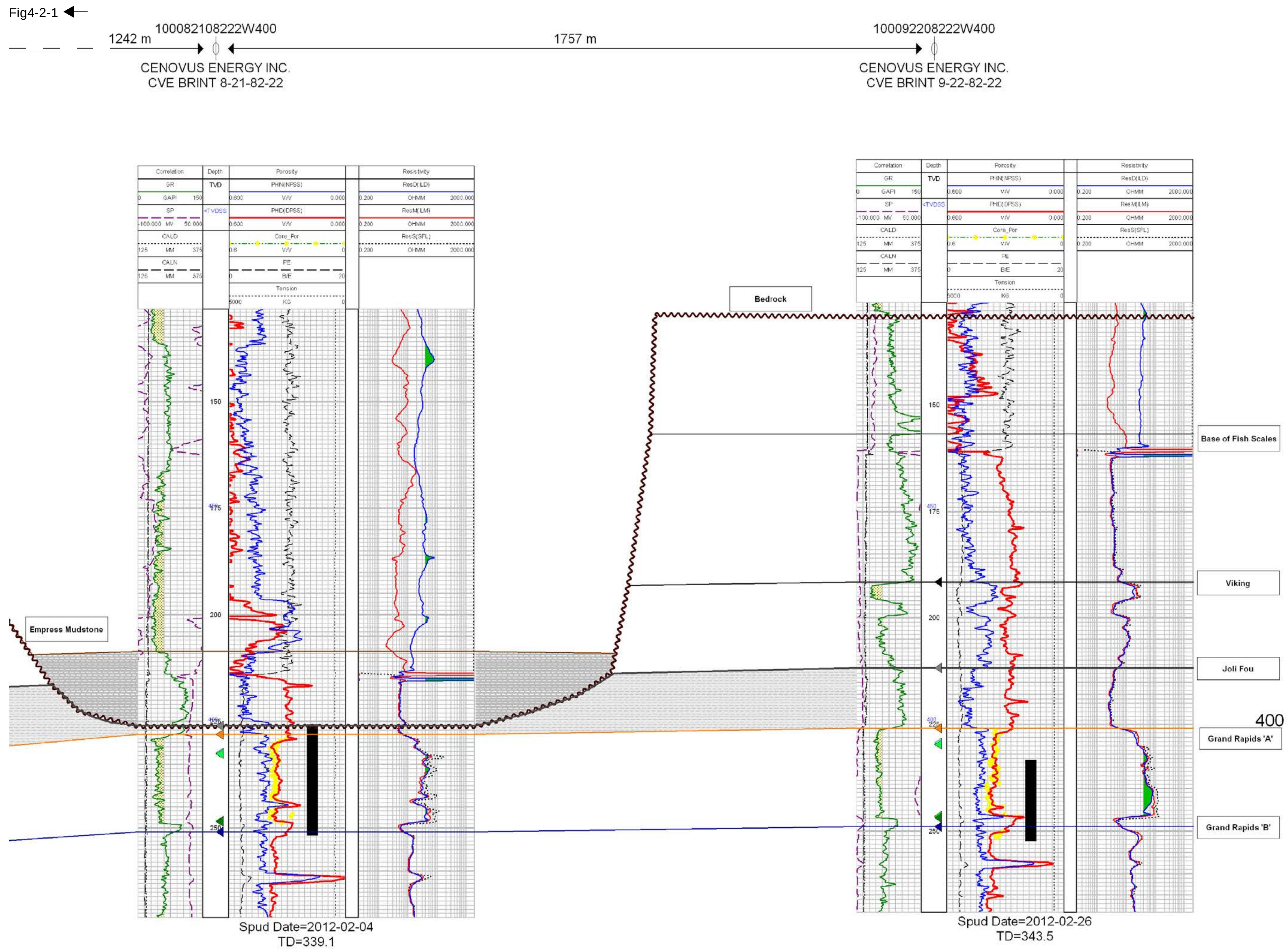
TITLE

SEISMIC: EAST-WEST CROSS SECTION 7

cenovus ENERGY

PROJECT 10-1346-0006	FILE No.
SCALE AS SHOWN	REV. 0

FIGURE: 4-2-1



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PROJECT

PELICAN LAKE
GRAND RAPIDS PROJECT

TITLE

SEISMIC: EAST-WEST CROSS SECTION 7

PROJECT	10-1346-0006	FILE No.	
SCALE AS SHOWN		REV.	0

FIGURE: 4-2-2

HYDROGEOLOGY

5. SIR Responses 2, Question 6, Page 11

a. Update Figures 6-7 and 6-8 to show the location of the observation wells with respect to the proposed well pairs and the Joli Fou incision. Figure 6-7 should also show continuous water level or pressure measurements attained from pressure transducers deployed in the 05-11, 6-14, and 4-27 observations wells. The DST records for the two depth intervals at 09-03 should also be provided to support the response.

b. Considering the limited pressure difference between the Grand Rapids A lean zone and the Viking Formation presented in Figure 6-7, discuss how and where Cenovus will monitor the pressure in the Viking Formation within the proposed initial development to ensure effective pressure monitoring.

Response:

a. The locations included in Round 2, Figure 6-7 have been added to the Project Area Mudstone Isopach (Figure 5-1) and to the IDA Mudstone Isopach (Figure 5-2). Round 2, Figure 6-8 has all available water quality data within the Hydrogeology Regional Study Area. Therefore, only wells located inside of the Project Area were included in Figure 5-1.

Round 2, Figure 6-7 has been updated with the continuous monitoring data from 4-27-82-22 W4M, and is included as Figure 5-3. Please note that 5-11-82-23 W4M and 6-14-82-23 W4M were bottom hole pressures collected from tests, and are not set up for continuous groundwater monitoring. Documents for the 1AA/09-03-83-22W4 DSTs are provided in Appendix 5-1.

b. The Viking pressures presented in Round 2, Figure 6-7 are from DSTs to the north of the Project Area performed by Laricina Energy Ltd. Where the incision erodes into the Viking, there exists the potential for localized groundwater mounding due to communication between the Empress and Viking aquifers.

The closest Viking monitoring well to the IDA is located at 103/12-11-82-22 W4M, at the Grand Rapids SAGD Pilot. The relatively high pressures seen to date at the 12-11 location have been interpreted to be due to low permeability in the aquifer. This is also supported by carbon dating, which indicates the age of the Viking water at 12-11 to be 28250 ±150 BP (compared to Empress at F2/13-07-82-22W4 which was reported at 17564 ±45 BP).

Figure 5-1 Mudstone Isopach Illustrating Pressure and Chemistry Locations

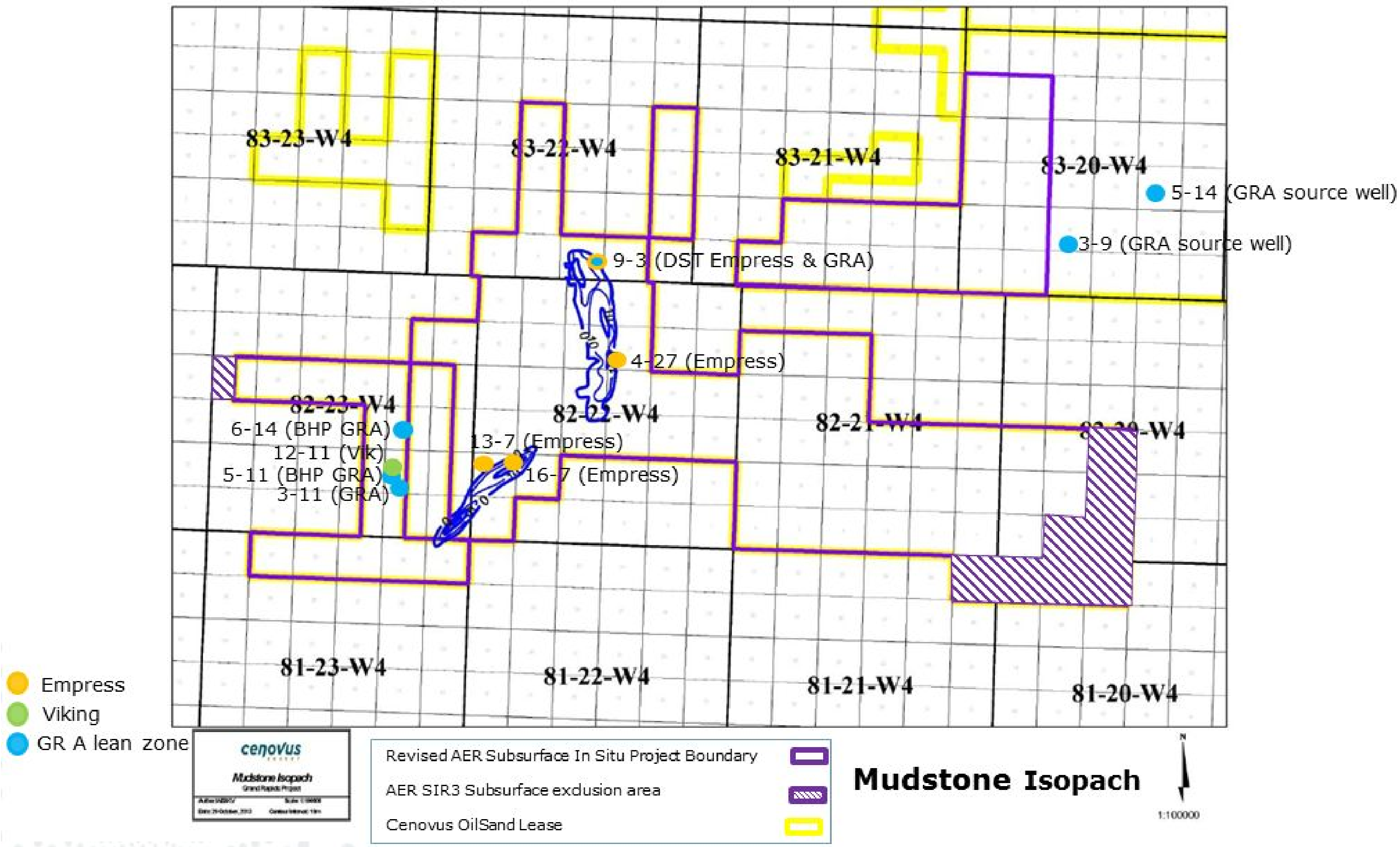


Figure 5-2 IDA Mudstone Isopach Observation Well Locations

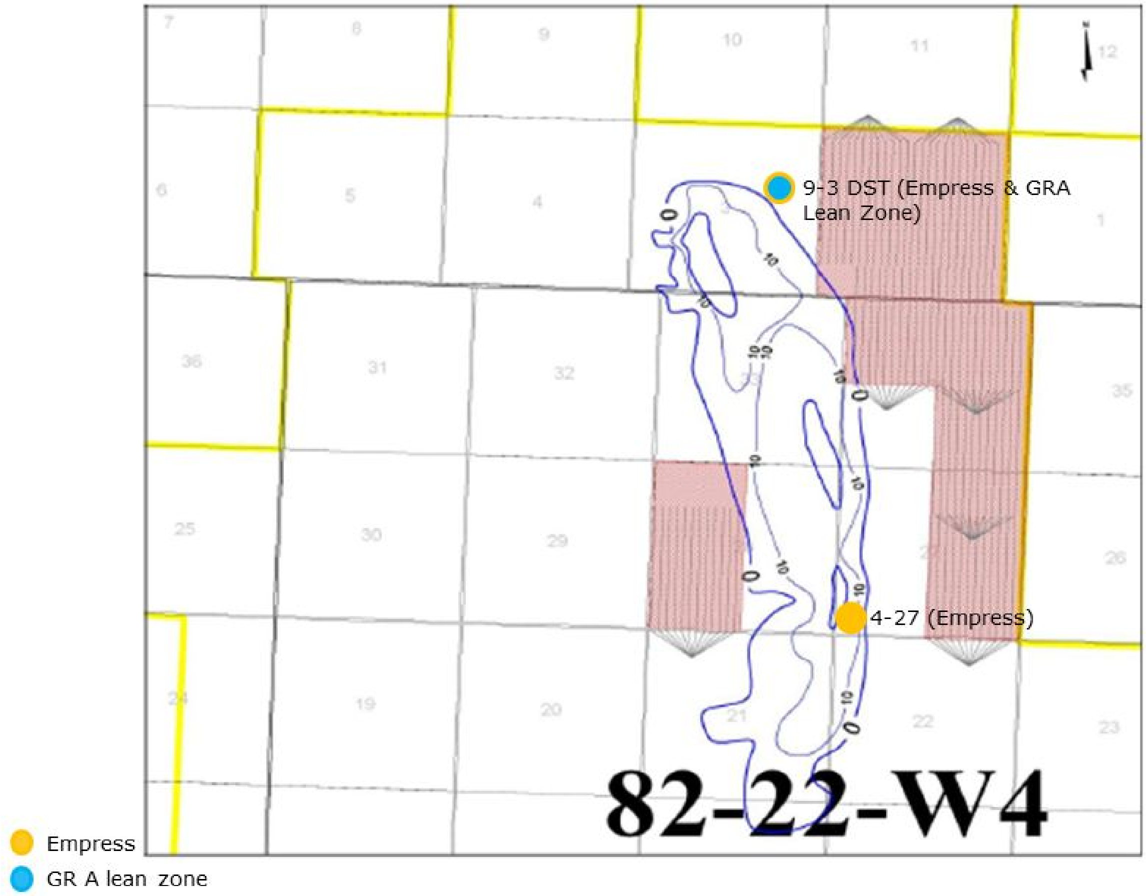
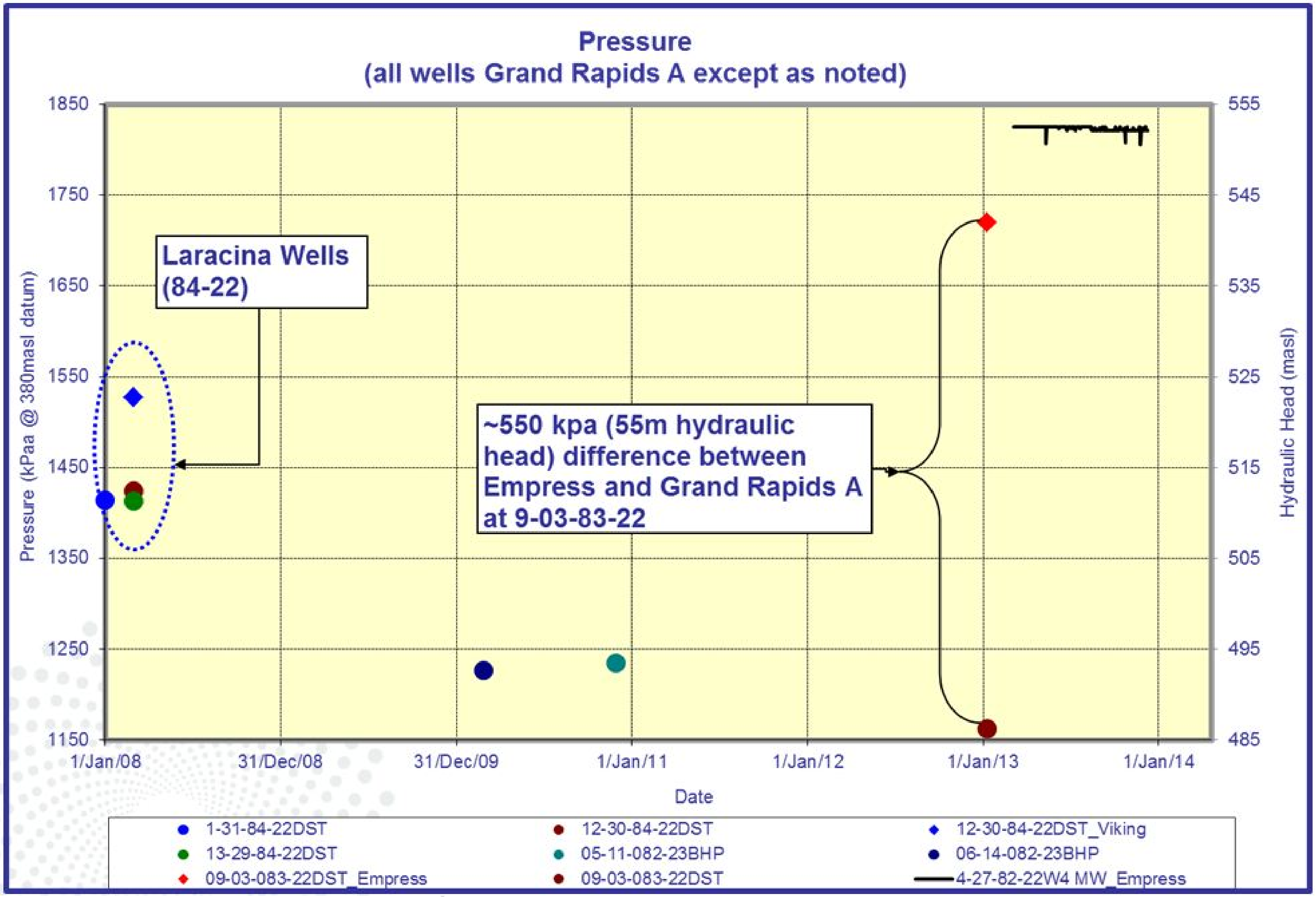


Figure 5-3 Aquifer Pressure Data (Updated SIR 2, Figure 6-7)



Additional groundwater monitoring wells will be drilled in the future, and current plans would see a minimum of three additional Viking monitoring wells be completed in the IDA (SIR 9, Figure 9-1).

6. SIR Response 2, Question 10(b), Page 34

Cenovus commits to 4 DSTs in the sand and gravel channel aquifer, but does not clearly indicate it will install observation wells after the DSTs. Confirm that 4 observation wells will be installed in the sand and gravel channel aquifer overlying the mud interval at the 4 proposed DST locations. In the response, discuss additional hydraulic testing Cenovus plans to undertake in the Grand Rapids A lean zone and the sand and gravel aquifer and discuss how Cenovus plans to monitor these wells moving forward.

Response:

Within the IDA, pressure data will be collected in the both the basal sand and gravel aquifer and the lean zone, by both DST and continuous monitoring. The locations were selected in order to facilitate a potential production test at a later date.

Three DSTs will be performed in the upcoming drilling season; the locations are:

- 1AA/8-28-82-22W4 (sand and gravel aquifer);
- 1AA/16-28-82-22W4 (GR A lean zone); and
- 1AA/03-33-82-22W4 (sand and gravel aquifer).

Four monitoring wells will be added in the upcoming drilling season; the locations are:

- 1AA/8-28-82-22W4 (GR A lean zone);
- 1AA/16-28-82-22W4 (sand and gravel aquifer);
- 1AA/03-33-82-22W4 (GR A lean zone); and
- 103/15-36-81-23W4 (sand and gravel aquifer).

The monitoring wells will be perforated and completed with pumps and pressure and temperature sensors. These locations will be operated in conjunction with the Grand Rapids SAGD Pilot Groundwater Monitoring Program (please refer to Round 2, SIR 10).

7. SIR Responses 2, Question 14(c), Page 54

The stated groundwater flow rate of 2 to 4 m/year for the Grand Rapids A lean zone appears to assume that the baseline heads in the Grand Rapids A lean zone will apply during SAGD recovery operations. During the operation of the pilot project, pressure responses were observed in the Grand Rapids A lean zone 3 days after starting up Well Pair 1. The responses indicate the Grand Rapids A lean zone may experience a 500 kPa pressure increase during start up (Figure 21-1, Page 72) with an additional 300 kPa pressure increase after the steam chamber rises to the lean zone. This corresponds with a total pressure increase of 800 kPa projected for the Grand Rapids A lean zone. If a higher pressure increase might be expected in the Grand Rapids A lean zone, clearly state the maximum pressure. Confirm that this is the maximum expected pressure increase for the Grand Rapids A lean zone. Recalculate the expected groundwater flow rate during operations.

Response:

The average linear groundwater velocity calculated for Round 2, SIR 14 did utilize baseline heads within the Grand Rapids A lean zone. This was done in order to compare the aquifer parameters between the Empress (at CNRL's Pad Z8) and the Grand Rapids A lean zone down gradient of the IDA. This was not intended to provide an estimate of groundwater velocity with respect to thermal operations, which are further complicated by air injection and lean zone production. The calculation for average linear velocity is based on Darcy's flow, which is not representative of the unsaturated conditions created by air injection.

Pressure changes within the lean zone will be local in impact and short term in duration. The pressures presented in Round 2, Figure 21-1, show the change in pressures two years after start up, incorporating the cumulative pressure effects from startup, lean zone production and air injection. The maximum BHP will not exceed 3,400 kPaa as mentioned in Round 2, SIR 20.

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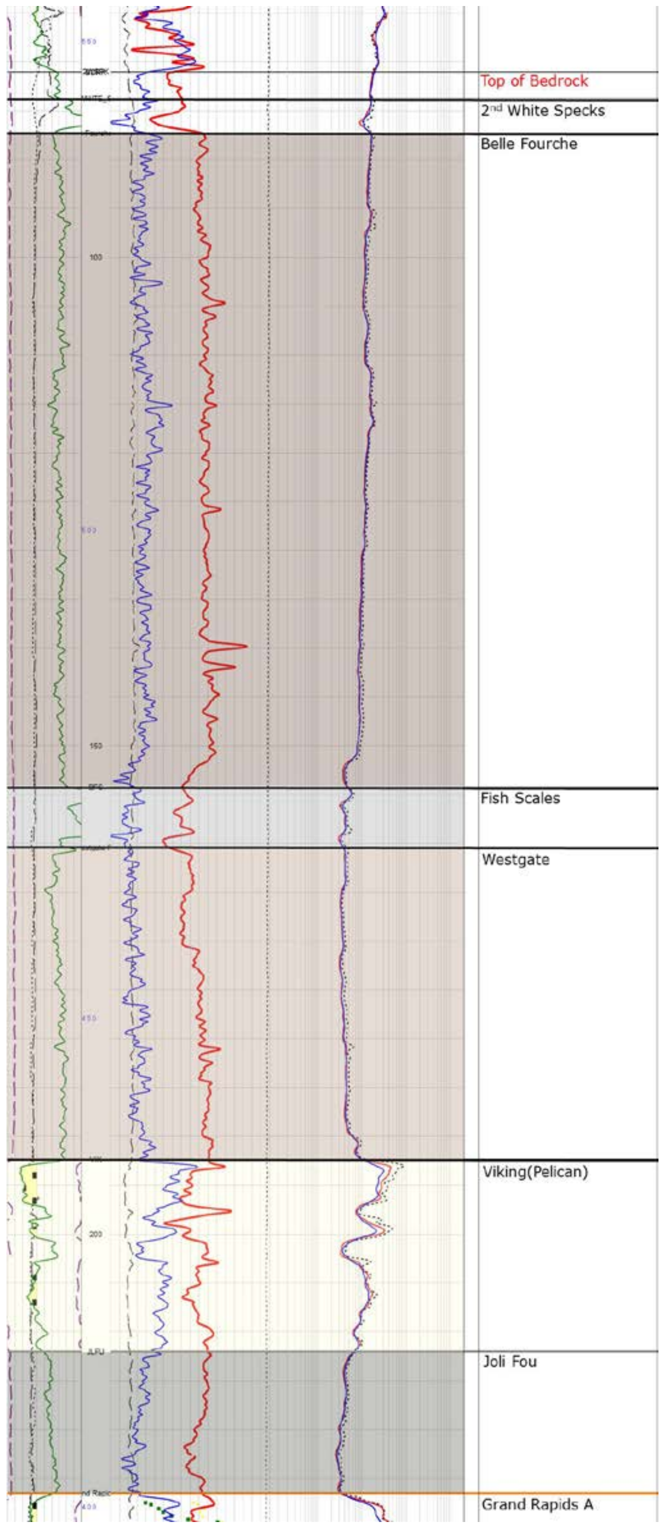
8. SIR Responses 2, Question 16, Figure 16-1, Page 59

The resolution provided is poor quality. Provide a higher resolution type image log where the scales and depths can be read.

Response:

Round 2, Figure 16-1 has been updated and is shown in Figure 8-1.

Figure 8-1 Type Log (Updated SIR 2, Figure 16-1)



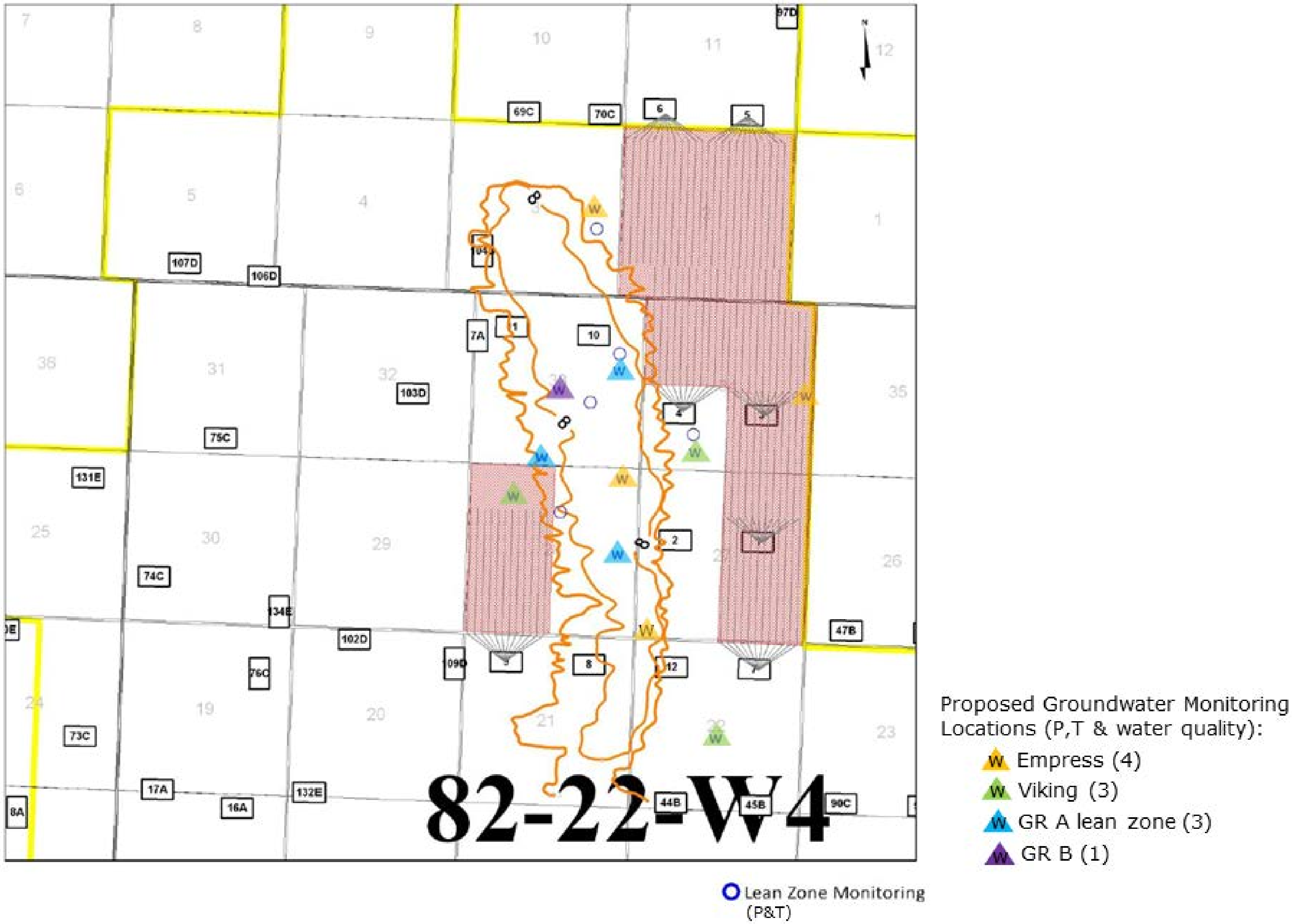
9. SIR Responses 2, Question 24, Figure 24-6, Page 80

Clarify which zone the groundwater monitoring wells will monitor. W just states Water Monitoring, but it does not specify a monitoring zone.

Response:

The groundwater monitoring zones identified include the Quaternary/Tertiary, Viking, Grand Rapids A lean zone, and Grand Rapids B aquifers. Round 2, Figure 24-6 has been updated and colour coded with potential monitoring zones (Figure 9-1). The locations in Figure 9-1 are preliminary and may be adjusted with additional data.

Figure 9-1 Water Monitoring Locations (Updated SIR 2, Figure 24-6)



EXISTING WELLBORES AND RESERVOIR FLUID CONTAINMENT

10. SIR Responses 2, Question 25, Page 83:

a. **Cenovus indicated that the 00/15-02-083-22W4/0 (15-2) well is the only well that may be impacted by thermal operations within the proposed IDA with planned remediation action. Provide further information on the planned remediation to demonstrate that the 15-2 well can be successfully remediated and repaired to ensure reservoir fluid containment. For example, is Cenovus planning to run a cement bond log to assess hydraulic isolation behind the production casing before undertaking remediation work? Note that a nonroutine abandonment or repair plan as per *Directive 020* is expected to be submitted in the future for AER review and approval based on the cement bond log results to ensure reservoir fluid containment.**

b. **Three evaluations wells within the proposed IDA terminate in the Clearwater Formation, AA/07-34-082-22W4/0, AA/16-34-082-22W4/0 and AA/03-02-083-22W4/0. AER records show that these wells were abandoned with a continuous cement plug from well total depth to surface. Provide information about the type of cement used to abandon these wells. Also provide a comparison between the cement volumes used for the abandonment and the calculated wellbore capacities for each of these wells to demonstrate that the cement plugs will ensure reservoir fluid containment.**

Response:

a. A casing bond log will be performed on the 15-2 well as per step 7 of the flowchart contained in the response to Round 1, SIR 43b. The CBL will be used to assess hydraulic isolation behind the production casing and will be further utilized as an aid to developing an effective abandonment plan for AER review as a non-routine abandonment as per Directive 20. After AER approval for abandonment is obtained, the abandonment will take place.

b. The abandonment data requested are contained in Table 10-1.

Table 10-1 Requested Abandonment Details for IDA Wells

Well	Cement Plug Type	Cement Additives	Cement Tonnage [T]	Hole Size [mm]	TD [m]	Wellbore Capacity [m^3]	Cement Volume Pumped [m^3]	Cement Top [m]	Cement Excess [%]
AA/07-34-082-22W4M/00	Thermal 40 (preblend in bag)	0.5% CFR; 5% CFR	19	200	345	10.84	14.2	3.8	131
AA/16-34-082-22W4M/00	Proteus Core	1% CFR-2 + 2% CaCl2	15.2	159	337.4	6.68	13.6	0	204
AA/03-02-083-22W4M/00	Proteus Core	1% CFR-2 + 2% CaCl2	15.9	159	256	5.07	14.2	0	280

ENVIRONMENTAL AND SUSTAINABLE RESOURCES DEVELOPMENT

AQUATICS

11. Cenovus indicates that "Based on the results of the analysis completed for Fish and Fish Habitat, monitoring programs are not planned outside those identified for groundwater, hydrology and water quality components. Should results of these monitoring programs indicate monitoring of aquatic biota is warranted, a program will be developed in consultation with regulators." While changes Key Ecosystem Functions will influence aquatic ecosystems, mechanistic linkages between changes in an aquatic ecosystem and the degree of change in fish habitat, fish community, or benthic invertebrate population are not always clear. Changes in Key Ecosystem Functions should not be the sole trigger for monitoring changes in aquatic ecosystems where fish habitat, and fish abundance, distribution, and health may be influenced.

a. Provide scientific rationale for the thresholds that will be used and how those indicators will be linked to changes in the aquatic ecosystem.

b. Provide the methodology that will be used to sample the fish and fish habitat and factors (biotic/abiotic) on which monitoring will be focused. Clearly define the scope, goals and action plans of the monitoring program.

c. Provide threshold values and scientific rationale behind them that will be used to determine the extent of effects of development and operational activities on fish and fish habitat.

d. Explain how changes in the aquatic ecosystem that cannot be measured or detected by monitoring Key Ecosystem Functions will be quantified.

e. Discuss Cenovus's confidence that all mechanistic drivers associated with project-related land use changes and the aquatic ecosystem are understood and measured. For example, the Alberta Southern Rockies Watershed Project has reported long-term water quality and productivity changes associated with forest harvest and fire. Discuss whether our understanding of land use change and its influence on the aquatic ecosystem is sufficient to construct a predictive model that would accurately predict short and long-term change associated with the project and cumulative effects.

f. **If so, discuss whether Cenovus will lead the development of such a model and the data collection required to verify its precision.**

g. **If not, discuss Cenovus's commitment to monitoring fish and fish habitat to, at minimum, understand whether a change is occurring locally.**

h. **On the eastern side of the province industry works cooperatively to monitor fish and aquatics regionally through the Regional Aquatics Monitoring Program (RAMP). How will potential regional fisheries and aquatic changes be monitored in this region? How will Cenovus lead the development of a regional monitoring program to understand how fish and aquatic ecology will be influenced by industrial development in this area of the province?**

Response:

a. Monitoring programs are planned for groundwater, hydrology and water quality components. Groundwater, hydrology and water quality programs will be designed following project approval and will be developed in consultation with regulatory agencies, including AESRD. This approach is consistent with monitoring programs currently implemented and proposed at in-situ oil sands projects. As described in the Environmental Impact Assessment (EIA) and responses to Round 2, SIR 41 and Round 1, SIR 95, Cenovus does not plan on conducting fish and fish habitat monitoring as part of the planned monitoring programs for the Project.

The key consideration in the development of a monitoring program of fish and fish habitat is the predicted absence of a residual effect on fish and fish habitat. Based on the conclusions of the EIA, no trigger was identified that suggests broad monitoring should be implemented over and above local monitoring/mitigation associated with best practices (e.g., watercourse crossings). The largest potential effect to fish and fish habitat from SAGD developments is from the development of linear infrastructure (i.e., road and pipeline crossings across watercourses).

To mitigate this potential adverse effect, Cenovus has committed to monitoring the construction and operation of watercourse crossings. This includes following appropriate regulatory guidance (e.g., Codes of Practice), developing an appropriate design for the crossing, and implementing watercourse crossing monitoring programs. More details on monitoring of watercourse crossings are provided in the response to Round 2 SIR 41.

Should results of these groundwater, hydrology, water quality, and/or watercourse crossing monitoring programs differ from EIA predictions, identify a potential adverse effect, and/or indicate that a causal relationship to fish and fish habitat may be valid, a detailed monitoring plan to understand the magnitude and geographical extent of the effect will be completed in consultation with regulatory agencies. Additional monitoring, including that for fish and fish habitat may be implemented. If warranted, a program to monitor for potential adverse effects on fish and fish habitat that would utilize thresholds or targets based on scientific rationale and include indicators to evaluate changes in the aquatic ecosystem will be developed in consultation with appropriate regulatory agencies, including AESRD. It is anticipated that thresholds or targets would provide a means of measuring performance to identify progress and would be intended to encourage adaptation and innovation.

b. As described in the response to SIR 11a, a monitoring program for fish and fish habitat is not proposed for the Project as no linkage to residual effects was identified in the EIA. However, as described previously, if a fish and fish habitat monitoring program is required (i.e., based on the results from the groundwater, hydrology and/or water quality programs), the methodology to sample fish and fish habitat will be developed in consultation with AESRD. The sampling methodology would be consistent, where appropriate, with standard methods for fish inventory and habitat data collection, which were employed for baseline sampling. It is anticipated that thresholds or targets developed through these programs would provide a means of measuring performance to identify progress and would be intended to encourage adaptation and innovation.

c. Monitoring programs for groundwater, hydrology and water quality will be developed once the Project has been approved. Thresholds or targets will be identified during the development of the respective programs. It is anticipated that thresholds or targets developed through these programs would provide a means of measuring performance to identify progress and would be intended to encourage adaptation and innovation. It is anticipated that regulatory agencies including AESRD would be involved during the development of these programs. This is consistent with the approach for other approved in-situ oil sands developments.

d. Monitoring key ecosystem functions (i.e., changes to surface water quantity and quality, as well as habitat related to watercourse crossings) will provide an indication of any potential effects of the development and operational activities on fish and fish habitat. Consultation with regulatory agencies when threshold limits or targets are approached, as identified in the groundwater, hydrology and/or water quality programs, will indicate whether a fish and fish habitat program with targets, outcomes and significant parameters will be developed. Mitigation and monitoring programs developed for this Project will be effects-based. Targets and outcomes will be used to provide a means of measuring performance and to allow for mitigation measures to be revised, improved upon or new mitigation actions to be developed, if required.

e. The EIA identified and assessed the potential effects to the aquatic ecosystem from land use changes resulting from the Project. The areas of surface disturbance associated with the Project within each watershed were calculated in the hydrology assessment, and any potential changes to surface water flows/channels, sediment loading, water quality, and fish and fish habitat were subsequently assessed. Based on the conclusions of the EIA, additional modelling with respect to land use change and the aquatic ecosystem is not necessary at this time.

f. Cenovus is not prepared to lead but would support and participate in an industry initiative for the development of a land use/aquatic ecosystem model (e.g., COSIA, AESRD or AESRD-led group). Cenovus would also consider providing data, where appropriate.

g. As per the response to SIR 11a., Cenovus does not plan to monitor fish and fish habitat unless the results of the groundwater, hydrology and/or water quality programs indicate threshold limits or targets are approached.

h. Cenovus is not prepared to lead but would support and participate in the development of a regional aquatics monitoring program in the Wabasca area. A regional monitoring framework or program, if deemed appropriate, is seen a collaborative effort involving all of the SAGD operators in the region. If a regional aquatics monitoring program was to be developed by another group or organization (e.g, COSIA), Cenovus would consider contributing data to the regional effort, where appropriate.

HEALTH

12. Appendix 68-1, Section 1, Page 1.

a. Include a description of any concerns arising from public consultations that relate to multi-media exposure and how the assessment will address these concerns.

Response:

a. No concerns relating to multi-media exposure were identified during public consultation for the Project.

13. Appendix 68-1, Section 2, Page 2.

Cenovus states *Air concentrations and dry deposition rates were predicted to be the highest at Chipewyan Lake and wet deposition rates were predicted to be the highest at Wabasca IR 166C. Therefore, Chipewyan Lake and Wabasca IR 166C were modelled and represent the highest exposure among the aboriginal residential locations*.

a. Provide additional rationale to support the selection of only 2 locations for multi-media modeling of aboriginal exposure out of all the aboriginal residential locations identified (i.e., Wabasca, Wabasca-Desmarais, Wabasca [IRs 166, 166A, 166B, 166C, 166D], Chipewyan Lake, Sandy Lake Settlement, Trout Lake).

b. Confirm there are no additional permanent receptor locations at which receptors are likely to receive higher exposures than the 2 locations included in the HHRA.

Response:

a. The locations of Chipewyan Lake and Wabasca IR 166C were selected based on their proximity to the Project and because they represent locations with the highest total exposure for aboriginal residents. Total exposure was based on the sum of exposure from the following pathways:

- air inhalation;
- soil ingestion;
- berry ingestion;
- leaf ingestion;
- root ingestion;
- moose ingestion;
- fish ingestion;
- water ingestion;
- soil dermal contact; and
- soil dust inhalation.

Air concentrations were based on the modelled annual air concentrations. Soil concentrations were calculated as the sum of the incremental soil concentration (based on modelled wet and dry deposition rates) and the background soil concentration (based on measured data). The incremental soil concentrations vary by receptor location while the same background soil concentration was adopted for all receptor locations. Water and fish concentrations were based on measured data within the local study area and did not vary among receptor locations. Berry, leaf, root and moose concentrations were modelled based on the soil concentrations and other site-specific, chemical-specific and receptor-specific parameters. Locations with the highest soil concentrations will have the highest berry, leaf, root and moose tissue concentrations. Overall, the locations with the highest air concentrations which are assumed to be deposited onto soil via wet and/or dry deposition will have the highest soil concentrations, and consequently, will have the highest total exposure.

Table 13-1 shows the range in annual air concentrations among the aboriginal residential locations (Wabasca, Wabasca-Desmarais, Wabasca [IRs 166, 166A, 166B, 166C, 166D], Chipewyan Lake, Sandy Lake Settlement and Trout Lake) for the Application Case. Chipewyan Lake is the location that has the highest annual air concentrations for all chemicals, indicating that exposure due to air inhalation will be highest at this location.

Table 13-1 Range in Application Case Annual Air Concentrations for Aboriginal Residential Locations

Chemical	Minimum (µg/m^3)	Maximum (µg/m^3)	Location of Maximum
Arsenic	1.5E-6	3.4E-6	Chipewyan Lake
Barium	3.0E-5	6.5E-5	Chipewyan Lake
Beryllium	1.1E-7	2.6E-7	Chipewyan Lake
Cadmium	1.7E-5	5.1E-5	Chipewyan Lake
Chromium	2.6E-5	6.5E-5	Chipewyan Lake
Cobalt	3.1E-6	9.4E-6	Chipewyan Lake
Copper	8.5E-6	2.1E-5	Chipewyan Lake
Lead	6.7E-6	1.7E-5	Chipewyan Lake
Manganese	9.7E-6	2.6E-5	Chipewyan Lake
Mercury	1.7E-6	3.5E-6	Chipewyan Lake
Molybdenum	9.7E-6	2.2E-5	Chipewyan Lake
Nickel	4.3E-5	1.0E-4	Chipewyan Lake
Selenium	6.5E-6	1.6E-5	Chipewyan Lake
Vanadium	3.4E-5	7.6E-5	Chipewyan Lake
Zinc	2.7E-4	6.4E-4	Chipewyan Lake
Benzo(a)anthracene	2.1E-7	6.0E-7	Chipewyan Lake
Benzo(a)anthracene surrogate	1.4E-6	3.7E-6	Chipewyan Lake
Benzo(a)pyrene	1.3E-7	3.8E-7	Chipewyan Lake
Benzo(a)pyrene surrogate	2.8E-7	6.8E-7	Chipewyan Lake
Benzo(g,h,i)perylene	2.1E-7	5.2E-7	Chipewyan Lake
Benzo(b)fluoranthene	4.0E-7	1.2E-6	Chipewyan Lake
Benzo(k)fluoranthene	1.9E-7	5.1E-7	Chipewyan Lake
Chrysene	3.0E-7	7.2E-7	Chipewyan Lake
Dibenzo(a,h)anthracene	1.7E-7	5.0E-7	Chipewyan Lake
Indeno(1,2,3-c,d)pyrene	1.7E-7	4.6E-7	Chipewyan Lake
Fluoranthene	1.1E-6	3.5E-6	Chipewyan Lake
Pyrene	1.6E-6	4.9E-6	Chipewyan Lake

Table 13-2 shows the range in incremental soil concentrations among the aboriginal residential locations for the Application Case. Wabasca IR 166C and Chipewyan Lake have the highest soil concentrations for all chemicals except for barium and mercury, for which Wabasca IR 166A has the highest concentrations. For barium, the incremental soil concentration is 0.0043 mg/kg at Wabasca IR 166A and 0.0042 mg/kg at Wabasca IR 166C. The background soil concentration for barium is 77.27 mg/kg. The difference in barium incremental soil concentrations between Wabasca IR 166C and Wabasca 166A represents 0.0001% of the background concentration, and would make a negligible difference to total exposure. For mercury, the incremental soil concentration is 0.00024 mg/kg at Wabasca IR 166A and 0.00023 mg/kg at Wabasca IR 166C. The background soil concentration for mercury is 0.094 mg/kg. The difference in mercury incremental soil concentrations between Wabasca IR 166C and Wabasca 166A represents 0.01% of the background concentration, and would make a negligible difference to total exposure.

Wabasca IR 166C and Chipewyan Lake have the highest air and soil concentrations for all chemicals, with the exception of soil concentrations of barium and mercury, for which there is a negligible difference in total soil concentrations between the location of the maximum (Wabasca IR 166A) and Wabasca IR 166C. Therefore, the highest total exposure for aboriginal receptors is expected to occur at Wabasca IR 166C and Chipewyan Lake.

Table 13-2 Range in Application Case Incremental Soil Concentrations for Aboriginal Residential Locations

Chemical	Minimum (mg/kg)	Maximum (mg/kg)	Location of Maximum
Arsenic	1.5E-4	2.2E-4	Wabasca (IR 166C)
Barium	2.8E-3	4.3E-3	Wabasca (IR 166A)
Beryllium	1.2E-5	1.7E-5	Wabasca (IR 166C)
Cadmium	1.9E-3	2.5E-3	Wabasca (IR 166C)
Chromium	3.0E-3	4.2E-3	Wabasca (IR 166C)
Cobalt	3.4E-4	4.8E-4	Wabasca (IR 166C)
Copper	8.8E-4	1.2E-3	Wabasca (IR 166C)
Lead	7.3E-4	1.0E-3	Wabasca (IR 166C)
Manganese	1.1E-3	1.6E-3	Wabasca (IR 166C)
Mercury	1.5E-4	2.4E-4	Wabasca (IR 166A)
Molybdenum	9.9E-4	1.5E-3	Wabasca (IR 166C)
Nickel	5.1E-3	6.8E-3	Wabasca (IR 166C)
Selenium	7.6E-4	1.1E-3	Wabasca (IR 166C)
Vanadium	3.8E-3	5.0E-3	Wabasca (IR 166C)
Zinc	3.0E-2	4.1E-2	Wabasca (IR 166C)
Benzo(a)anthracene	3.5E-6	4.9E-6	Chipewyan Lake
Benzo(a)anthracene surrogate	2.4E-5	3.2E-5	Wabasca (IR 166C)
Benzo(a)pyrene	2.3E-6	3.1E-6	Chipewyan Lake
Benzo(a)pyrene surrogate	4.2E-6	5.8E-6	Wabasca (IR 166C)
Benzo(g,h,i)perylene	3.0E-6	4.2E-6	Wabasca (IR 166C)
Benzo(b)fluoranthene	5.9E-6	9.1E-6	Wabasca (IR 166C)
Benzo(k)fluoranthene	3.1E-6	4.2E-6	Wabasca (IR 166C)
Chrysene	4.2E-6	5.9E-6	Wabasca (IR 166C)
Dibenzo(a,h)anthracene	2.7E-6	4.0E-6	Chipewyan Lake
Indeno(1,2,3-c,d)pyrene	3.0E-6	3.9E-6	Chipewyan Lake
Fluoranthene	1.6E-5	2.6E-5	Chipewyan Lake
Pyrene	2.2E-5	3.6E-5	Wabasca (IR 166C)

b. As described in the response to SIR 13a, the locations with the highest total exposure will be those in close proximity to the Project and with the highest modelled air concentrations that are assumed to be deposited via dry and/or wet deposition and consequently, will have the highest soil concentrations. Those locations are Chipewyan Lake and Wabasca IR 166C. For barium and mercury in soil, Wabasca IR 166A has soil concentrations that are higher than Wabasca IR 166C by less than 0.02% of background concentrations, indicating that there would be a negligible difference in total exposure and risk if they were calculated for Wabasca IR 166A instead of Wabasca IR 166C.

14. Appendix 68-1, Section 2.2.1, Page 4.

Cenovus states *Using a weight of evidence approach, any chemical with at least two of the three physical-chemical properties indicating non-volatile is considered non-volatile*.

a. Provide a reference to support the rationale that 2 out of 3 physical-chemical properties are required to indicate a chemical is non-volatile. If none can be provided include any chemical screened off on this basis (i.e., evaluate all chemicals with at least 1 physical-chemical property for non-volatility).

Response:

a. The purpose of the multi-media assessment is to evaluate the risk from those chemicals that are emitted as a result of Project activities and may deposit and persist or accumulate in soil, vegetation, animal tissue, water or fish. For chemicals that are primarily found in air, exposure and risk from inhalation exposure has been evaluated and presented in the EIA.

Molecular weight and vapour pressure provide an indication of whether a chemical is likely to be found as a vapour at room temperature. The higher the vapour pressure and lower the molecular weight, the more likely that a chemical will volatilize and occur as a vapour. The Henry's Law Constant provides an indication of whether a chemical is more likely to be found in the atmosphere or dissolved in water, specifically in rain or the water in rivers and lakes. It was considered a reasonable approach to assume that if two or more of these parameters met the criteria for non-volatility, then the chemical would be retained for the multi-media assessment, based on professional judgement. Table 14-1 shows the chemicals for which only one physico-chemical property met the criteria for non-volatility (and were not retained for the multi-media assessment).

Table 14-1 Screening Against Volatility Criteria

COC	Molecular Weight [g/mol]	Vapour Pressure [mm Hg]	Henry's Law [atm-m^3/mol]	Reference
Volatile Organic Carbons (VOCs)				
Ethanol	46.07	59.3	**7.4E-6**	HSDB 2012 and Mackay et al. 2006
Formaldehyde	30.03	3,890	**3.37E-7**	HSDB 2012
Methanol	32.04	127	**6.1E-6**	HSDB 2012 and Mackay et al. 2006
Phenol	94.1	0.353	**1.5E-6**	HSDB 2012 and Mackay et al. 2006
Polycyclic Aromatic Hydrocarbons (PAHs)				
Anthracene	178	**8.00E-06**	3.90E-05	Health Canada 2009
Fluorene	166	**7.00E-04**	7.80E-05	Health Canada 2009
Phenanthrene	178	**2.00E-04**	3.20E-05	Health Canada 2009

Note: Bolded and shaded cells indicate chemicals with a molecular weight of >200 g/mol, vapour pressure <0.001 mm Hg or Henry's Law Constant <1E-5 atm m^3/mol; nv = no value.

To evaluate whether the chemicals listed in Table 14-1 should be added to the multi-media assessment, a closer evaluation of their environmental fate is required.

Ethanol and methanol have the following properties (HSDB 2012):

- present as a vapour in the atmosphere;
- react with hydroxyl radicals in the atmosphere with an estimated half-life of 36 hours (ethanol) and 17 days (methanol);
- volatilize from dry and moist soil surfaces and water surfaces;
- biodegrade in soil and water with estimated half-lives of a few days; and
- potential for bioconcentration in aquatic organisms is low.

Although the Henry's Law Constants for ethanol and methanol are slightly below the non-volatility criteria (7E-6 and 6E-6 vs. 1E-5 atm m^3/mol), because ethanol and methanol are generally expected to either volatilize or degrade in soil and water, they were not retained for the multi-media assessment.

Formaldehyde has the following properties (HSDB 2012):

- present as a vapour in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 41 hours;
- susceptible to direct photolysis with an estimated half-life of six hours in simulated sunlight;
- volatilizes from dry soil surfaces;
- biodegrades in soil and water under both aerobic and anaerobic conditions with estimated half-lives of a few days; and

- potential for bioconcentration in aquatic organisms is low.

Formaldehyde degrades quickly in the atmosphere. The Henry's Law Constant for formaldehyde is low enough that it may be washed out of the atmosphere by precipitation and found in moist soil and lakes and rivers; however, formaldehyde biodegrades in water and does not bioconcentrate. Therefore, it is not expected to be present in appreciable amounts in vegetation, animal tissue or fish. As formaldehyde does not persist or accumulate in the environment, it was not retained for the multi-media assessment.

Phenol has the following properties (HSDB 2012):

- present as a vapour in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 15 hours;
- reacts with nitrate radicals in the atmosphere at night with an estimated half-life of 12 minutes;
- biodegrades in soil with an estimated half-life of 2 to 5 days, even in subsurface soil;
- mineralizes (i.e., breaks down completely) in water within days; and
- bioaccumulation of phenol in aquatic organisms is unlikely.

Phenol has a short half-life in air, water and soil and is not expected to persist or accumulate in terrestrial or aquatic environments. Therefore, it was not retained for the multi-media assessment.

Anthracene has the following properties (HSDB 2012):

- exists in both the vapor and particulate phases in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of four hours;
- particulate phase anthracene can be removed from the atmosphere by wet and dry deposition;
- volatilizes from moist soil surfaces and water surfaces, attenuated by adsorption to organic matter;
- biodegrades in soil with estimated half-lives of 50 to 134 days;
- bioconcentration in aquatic organisms is moderate to very high; and
- subject to photolysis in sunlit surface waters with estimated half-lives of less than an hour.

Although atmospheric half-lives for anthracene are short, because it is subject to particle-bound wet and dry deposition and may accumulate in aquatic organisms, it was evaluated in the revised multi-media risk assessment. Results are presented in Appendix 14-1.

Fluorene has the following properties (HSDB 2012):

- exists primarily in the vapour phase in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 29 hours;
- particulate phase fluorene can be removed from the atmosphere by wet and dry deposition;
- biodegrades readily in soil and water under aerobic conditions; biodegradation can be slow under anaerobic conditions; and
- estimated half-lives in soil range from 2 to 64 days.

Although atmospheric half-lives for fluorene are short, because it is subject to particle-bound wet and dry deposition and may persist in soil and water depending on the conditions, it was evaluated in the revised multi-media risk assessment. Results are presented in Appendix 14-1.

Phenanthrene has the following properties (HSDB 2012):

- exists in both the vapour and particulate phases in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 2 to 65 days;
- particulate phase phenanthrene can be removed from the atmosphere by wet and dry deposition;
- volatilizes from moist soil surfaces and water surfaces; attenuated by adsorption to organic matter;
- biodegrades in soil with estimated half-lives of 3 to 26 days;
- biodegrades in water with estimated half-lives of 1.3 to 13 days;
- subject to photolysis with estimated half-lives of 6 to 100 hours during the day; and
- bioconcentration in aquatic organisms is high to very high.

Although phenanthrene degrades in air, soil and water, because it is subject to particle-bound wet and dry deposition and may bioconcentrate in aquatic organisms, it was evaluated in the revised multi-media risk assessment. Results are presented in Appendix 14-1.

15. Appendix 68-1, Section 2.2.1, Table 2, Page 5.

a. Explain why PHC deposition rates were not included in this Table.

b. Provide evidence to support that project operations do not result in PHC emissions (apart from aliphatic C2-C6) as a result of natural gas and produced gas combustion.

Response:

a. There were no non-volatile PHCs emitted by the Project, and thus, deposition rates were not modelled.

b. The only hydrocarbons that were emitted by the Project were butane, ethane, hexane, pentane and propane as a result of boiler / heater exhaust. The modelling methods and input sources are provided in the air quality assessment in the EIA (Volume 3, Section 1).

16. Appendix 68-1, Section 2.2.1, Table 3, Page 7.

a. Explain why log Kow was not included in this Table.

b. Explain why chemicals with log Kow values >3.5 (e.g., hexane and isopropylbenzene, and several PAH) were excluded from multi-media assessment.

Response:

a. The purpose of Table 3, shown in Appendix 68-1, Section 2.2.1, Page 7, was to screen for volatility, as an indicator of whether the chemicals are likely to be found primarily as vapours in the atmosphere. As indicated in the response to Round 1 SIR 173, log Kow is an indicator of bioaccumulation potential. The chemical-specific propensity to exist in the vapour phase or be volatile is indicated by a high vapour pressure, low molecular weight and/or high Henry's Law Constant. Both air concentrations and an inhalation assessment were completed for volatile chemicals in the EIA. Chemicals that are primarily found as vapours, tend to degrade easily and are not expected to be found in appreciable quantities in soil or water, were not retained for the multi-media assessment. Screening for bioaccumulation potential and persistence was carried out subsequent to the screening for volatility, so that only chemicals that were expected to be found in soil or water were evaluated.

b. The pathway by which chemicals may reach local terrestrial and aquatic environments is by atmospheric transport and deposition. The chemicals that satisfied the volatility criteria such as hexane, isopropylbenzene and several Polycyclic Aromatic Hydrocarbons (PAHs) are expected to be found predominantly in the vapour phase. Inhalation exposure of these Chemicals of Potential Concern (COPCs) was evaluated in the EIA. Based on their physical-chemical properties, deposition to soil and waterbodies is expected to be negligible. In addition, many of them will be degraded in the atmosphere within a few days, with estimated atmospheric half-lives of (HSDB 2012):

- Isopropylbenzene: 2.5 days;
- Hexane: 24 hours;
- Acenaphthene: 7.2 hours;
- Acenaphthylene: 5 hours; and
- Naphthalene: 18 hours.

17. Appendix 68-1, Section 3.2, Page 17.

Cenovus states *For dermal bioavailability, the RAFs were obtained from Health Canada (2010) and the Ontario Ministry of the Environment (2011)*.

a Provide the relative dermal absorption factors assumed for the HHRA.

Response:

a. The relative absorption factors (RAFs) for soil dermal contact are presented in Table 17-1.

Table 17-1 Relative Absorption Factors for Soil Dermal Contact

Chemical	RAF (unitless)	Reference
Arsenic	0.03	Health Canada 2010, MOE 2011
Barium	0.10	Health Canada 2010, MOE 2011
Beryllium	0.10	MOE 2011
Cadmium	0.01	Health Canada 2010, MOE 2011
Chromium	0.10	Health Canada 2010, MOE 2011
Cobalt	0.01	MOE 2011
Copper	0.06	Health Canada 2010, MOE 2011
Lead	1.0	MOE 2011
Manganese	1	Default
Mercury	0.10	MOE 2011
Molybdenum	0.01	Health Canada 2010, MOE 2011
Nickel	0.20	MOE 2011

Table 17-1 Relative Absorption Factors for Soil Dermal Contact (continued)

Chemical	RAF (unitless)	Reference
Selenium	0.01	Health Canada 2010
Vanadium	0.1	MOE 2011
Zinc	0.10	Health Canada 2010
Anthracene	0.13	MOE 2011
Benzo(a)anthracene	0.13	MOE 2011
Benzo (a) anthracene surrogate	0.13	MOE 2011
Benzo(a)pyrene	0.148	Health Canada 2010
Benzo (a) pyrene surrogate	0.148	Health Canada 2010
Benzo(b)fluoranthene	0.13	MOE 2011
Benzo(g,h,i)perylene	0.13	MOE 2011
Benzo(k)fluoranthene	0.13	MOE 2011
Chrysene	0.13	MOE 2011
Dibenzo(a,h)anthracene	0.13	MOE 2011
Fluoranthene	0.13	MOE 2011
Fluorene	0.13	MOE 2011
Indeno(1,2,3-cd)pyrene	0.13	MOE 2011
Phenanthrene	0.13	MOE 2011
Pyrene	0.148	Health Canada 2010

18. Appendix 68-1, Section 3.2, Page 18.

Cenovus states *For arsenic, a RAF of 0.5 was applied for the ingestion of soil, vegetation, and meat. This assumption is based on lower bioavailability of soil-borne arsenic reported in animal feeding studies that range from less than 10% to 50% (ATSDR 2007). Several factors influence arsenic bioavailability in soil including arsenic speciation, low solubility, and inaccessibility due to the presence of secondary reaction products or insoluble matrix components (ATSDR 2007). This is supported by studies completed with in vitro simulations of the gastric or intestinal fluids (ATSDR 2007).*

The forms of arsenic in fish and shellfish (i.e., arsenobetaine and arsenocholine) have been reported to be essentially non-toxic. However, a small percentage in fish tissue may be in the toxic inorganic form. Therefore, an inorganic arsenic fish content of 10% was used in calculations for arsenic exposures via the fish pathway (ATSDR 2007).

a. Provide primary literature sources to support the RAF and fish content assumed for arsenic.

b. Health Canada (2012) recommends a RAF of 1.0 always be assumed for oral exposures. Provide an evaluation of arsenic without applying the RAF or assuming a 10% fish content.

Response:

a. The RAF of 0.5 was based on lower bioavailability of soil-borne arsenic reported in animal feeding studies that range from less than 10% to 50% (Freeman et al. 1993; Davis et al. 1992). In the study by Freeman et al. (1993), bioavailability of arsenic was measured in rabbits ingesting doses of smelting soils that contained arsenic primarily in the form of sulfides. Rabbits were given a single oral (capsule) administration of soil at three different dose levels (0.78, 1.95 and 3.9 mg As/kg, respectively). Control groups included untreated controls, an intravenous sodium arsenate group (1.95 As/kg), and a gavage sodium arsenate group (1.95 As/kg). Bioavailability was assessed by comparing the amount of arsenic that was excreted after ingestion of the soil to that excreted after an intravenous dose of sodium arsenate. The relative oral bioavailabilities of arsenic for the soil ingestion group and the gavage group in comparison with the intravenous group were 24±3.2% and 50±5.7%, respectively. In the study by Davis et al. (1992), rabbits dosed with sodium arsenite (0.8 mg AS/kg) had five times greater blood arsenic concentrations than rabbits dosed with arsenic-containing soil (2.8 mg As/kg), suggesting a lower bioavailability of the arsenic in soil.

   Several factors influence arsenic bioavailability in soil including arsenic speciation, low solubility, and inaccessibility due to the presence of secondary reaction products or insoluble matrix components (Davis et al. 1992). This is supported by studies completed with in vitro simulations of the gastric or intestinal fluids (Hamel et al. 1998; Pouschat and Zagury 2006; Rodriguez et al. 1999; Ruby et al. 1996, 1999; Williams et al. 1998).

   Hamel et al. (1998), used synthetic gastric juice to estimate the bioaccessible fraction of metals in the stomach with varying liquid to solid ratios. The researchers found that bioaccessibility may vary in different soils and with varying liquid to solid ratios.

   In the study by Rodriguez et al. (1999), the relative bioavailability of arsenic in mine and wastes (soils and materials) was estimated in juvenile swine that received daily doses of soil or sodium arsenite for 15 days. Samples included iron slag deposits and calcine deposits that had arsenic concentrations of 330 to 17,500 µg/g. Relative bioavailability (waste:sodium arsenate) ranged from 3% to 43% for 13 samples (mean, 21%) and was higher in iron slag wastes (mean, 25%) than in calcine wastes (mean, 13%).

   Williams et al. (1998), used synthetic gastric juice to mimic gastric conditions in a two year old child. The authors found that absorption of arsenic from contaminated soil was likely to be up to five times lower than the total concentration of arsenic in the soil.

   The primary reference supporting the assumed inorganic fish content value of 10% was a technical summary prepared by the U.S. EPA (2003), which states that about 85 to >95% of arsenic in the edible parts of marine fish and shellfish is organic arsenic (e.g., arsenobetaine, arsenochloline, dimethylarsinic acid) and that approximately 10% is inorganic arsenic (De Gieter et al. 2002; Goessler et al. 1997; Johnson and Roose 2002;

Ochsenkuhn-Petropulu et al. 1997). Less is known about arsenic in freshwater species, but there is evidence that organic arsenic may be as prevalent as in marine species.

Concentrations of total and toxic (inorganic) arsenic in liver and muscle tissue were measured in 25 sea fish and four shellfish species from the North Sea (De Gieter et al. 2002). Toxic fractions were below 10% in all species.

Goessler et al. (1997), measured arsenic concentrations in a three-organism food chain within a rock pool, including seaweed (*Hormosira banksii*) and two gastropods (*Morulla marginalba, Austrocochlea constricta*). Organic arsenic (arsenobetaine) accounted for 95% of arsenic in the carnivorous gastropod *M. marginalba*.

Fish and shellfish from Puget Sound were analyzed for total arsenic, inorganic arsenic, monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA) (Johnson and Roose 2002). Inorganic arsenic typically accounted for 0.2% or less of the total arsenic in fish and crab. Inorganic arsenic was 0.4% to 1.2% of total arsenic in clams.

Arsenobetaine was found to be the predominant arsenic compound having a content >90% of the total arsenic in the marine organisms tested (Ochsenkuhn-Petropulu et al. 1997). In marine snails, nearly all the arsenic was in a non-toxic form.

In freshwater prawn, the arsenic species consisted of 75.2% of a dimethyl-arsenic compound and 22.9% of a trimethyl-arsenic compound (Kaise et al. 1997). Other researchers have shown that organic arsenic in freshwater species is considerably less prevalent compared to marine species (Maeda et al. 1990, 1992, 1993; Suhendrayatna et al. 2001, 2002a,b).

Planktonic grazing guppies which fed on arsenic-rich algae had inorganic arsenic concentrations that were 75% to 88% of total arsenic (Maeda et al. 1990). However, carnivorous guppies feeding on the algae-eating guppies had inorganic arsenic concentrations that were 15% of total arsenic. Similar results were found in a subsequent study (Maeda et al. 1992). In a similar study with carp, inorganic arsenic concentrations were 78.8% of total arsenic (Maeda et al. 1993).

In a food chain investigation, inorganic arsenic was the predominate form of arsenic in each species following arsenite exposure (Suhendrayatna et al. 2001). Following arsenite exposure, *D. magna, N. denticulate* and *T. mossambica* had 98% to 99%, 68% to 93% and 75% non-methylated arsenical species, respectively.

Japanese medaka exposed to As(III) had inorganic arsenic compounds as the predominant species found in the tissues: 21% to 60% As(V) and 40% to 72% of As(III) (Suhendrayatna et al. 2002a). In a similar study, Tilapia exposed to As(III) also had predominately inorganic arsenic in tissues (63 to 78% of total arsenic).

b. In the revised multi-media assessment (Appendix 14-1), arsenic results are presented without applying the RAF or assuming a 10% inorganic arsenic fish content. Exposure ratios for arsenic were greater than one for non-carcinogenic and carcinogenic risks. The change in arsenic risk from Baseline Case to Application Case was less than 0.02%.

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19. Appendix 68-1, Section 3.5, Page 24.

Cenovus states *Consistent with risk assessment guidance (Health Canada 2010), the toddler life phase (i.e., seven months to four years) was chosen as the most sensitive child life stage*.

a. Calculate potential risks for all receptor lifestages (infant, toddler, child, adolescent and adult) and report the most sensitive.

Response:

a. Risks for all receptor lifestages were calculated and are presented below in Table 19-1. The toddler is the most sensitive lifestage (i.e. has the highest Exposure Ratios [ERs]) for all of the PAHs as well as lead, mercury and selenium, and the infant is the most sensitive lifestage for the rest of the metal COPCs. Full results for the toddler and infant are included in Appendix 14-1. The results are presented below for Chipewyan Lake; the results for Wabasca IR 166C are consistent in terms of the infant and toddler being the most sensitive lifestages.

Table 19-1 Exposure Ratios for All Life Stages – Application Case – Chipewyan Lake

Chemical	Infant	Toddler	Child	Adolescent	Adult
Arsenic	2.0	1.8	1.4	1.0	0.86
Barium	1.7	0.82	0.60	0.41	0.39
Beryllium	0.061	0.048	0.035	0.025	0.024
Cadmium	0.57	0.40	0.30	0.22	0.18
Chromium	0.0055	0.0038	0.0029	0.0021	0.0018
Cobalt	0.43	0.27	0.19	0.14	0.12
Copper	0.21	0.13	0.085	0.051	0.042
Lead	0.00038	0.00045	0.00036	0.00025	0.00022
Manganese	29	15	12	7.5	6.1
Mercury	0.13	0.61	0.53	0.35	0.32
Molybdenum	0.31	0.18	0.14	0.10	0.086
Nickel	0.64	0.42	0.32	0.23	0.21
Selenium	0.16	0.17	0.14	0.094	0.088
Vanadium	0.093	0.068	0.045	0.031	0.033
Zinc	0.69	0.52	0.41	0.29	0.25
Anthracene	0.00011	0.00019	0.00015	0.00011	0.00010

Table 19-1 Exposure Ratios for All Life Stages – Application Case – Chipewyan Lake (continued)

Chemical	Infant	Toddler	Child	Adolescent	Adult
Fluoranthene	0.00086	0.0014	0.0012	0.00081	0.00078
Fluorene	0.00086	0.0012	0.0010	0.00067	0.00060
Pyrene	0.0011	0.0019	0.0016	0.0011	0.0010

Note: Shaded cells are the highest exposure ratios for each chemical across all lifestages, which indicates the lifestage that is most sensitive to exposure for that chemical. The most sensitive lifestages (infant and toddler) were evaluated in Appendix 14-1.

20. Appendix 68-1, Section 4, Table 19, Page 28 and Table 22, Page 31.

a. Provide a write-up (toxicity profile) for each chemical included in the multi-media assessment that identifies and describes the toxicological basis for the exposure limits reviewed and the exposure limit selected.

Response:

a. Toxicity profiles are included in Attachment B of the revised multi-media assessment (Appendix 14-1).

21. Appendix 68-1, Section 4.1, Table 22, Page 31.

Health Canada (2012) provides potency equivalence factors for a wider range of carcinogenic PAH, including fluoranthene and phenanthrene.

a. Include fluoranthene and phenanthrene (VP <0.001 mm Hg, logKow>3.5) in the evaluation of carcinogenic effects using the potency equivalence factors identified by Health Canada.

Response:

a. Fluoranthene and phenanthrene are now evaluated as carcinogens and the results are presented in the revised multi-media assessment (Appendix 14-1).

22. Appendix 68-1, Section 5, Page 32.

a. Provide a detailed worked example of risk estimates for a carcinogen and a non-carcinogen.

Response:

a. A worked example of the non-carcinogenic and carcinogenic exposure and risk estimates for arsenic, for the Baseline Case at Chipewyan Lake, is provided below. The equations are based on Health Canada (2010).

Non-Carcinogenic Assessment (Arsenic, Baseline Case, Toddler, Chipewyan Lake)

Air Inhalation Pathway

Estimated Daily Intake

$$EDI_{air} = \frac{C_a \times IR_a \times AF_{inh} \times EF \times ED}{BW \times AT \times CF_1 \times CF_2}$$

Where,
EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg day)
C_a = COPC concentration in air (µg/m^3)
IR_a = Inhalation rate (m^3/d)
AF_{inh} = Inhalation absorption factor (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion factor (365 d/yr)
CF_2 = Conversion factor (1000 µg/mg)

$$EDI_{air} = \frac{3.09 \times 10^{-6} \mu g/m^3 \times 8.3\ m^3/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5 yr \times 365\ d/yr \times 1000 \mu g/mg}$$

$$EDI_{air} = 1.55 \times 10^{-9}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{air} = \frac{EDI_{air} \times BW}{RfC \times IR_{air}}$$

Where,
ER_{air} = Exposure ratio for air pathway
EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg day)
BW = Body weight (kg)
RfC = Reference concentration (mg/m^3)
IR_a = Inhalation rate (m^3/d)

$$ER_{air} = \frac{1.55 \times 10^{-9} mg/kg \cdot day \times 16.5kg}{0.000015\ mg/m^3 \times 8.3\ m^3/d}$$

$$ER_{air} = 2.06 \times 10^{-4}$$

Soil ingestion pathway

Estimated Daily Intake

$$EDI_{soil} = \frac{C_s \times IR_s \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$$

Where,
EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg day)
C_s = COPC concentration in soil (mg/kg)
IR_s = Soil ingestion rate (kg/d)
AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{soil} = \frac{3.73\ mg/kg \times 0.00008\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5yr \times 365\ d/yr}$$

$$EDI_{soil} = 1.81 \times 10^{-5}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{soil} = \frac{EDI_{soil}}{RfD}$$

Where,
ER_{soil} = Exposure ratio for soil ingestion pathway
EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{soil} = \frac{1.81 \times 10^{-5} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{soil} = 0.0603$$

Berry ingestion pathway

Estimated Daily Intake

$$EDI_{berry} = \frac{C_{berry} \times IR_{berry} \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$$

Where,
EDI_{berry} = Estimated Daily Intake due to ingestion of berries (mg/kg day)
C_{berry} = COPC concentration in berries (mg/kg)
IR_{berry} = Berry ingestion rate (kg/d)

AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless)
ED = Exposure duration (yr)
EF = Exposure frequency (d/yr)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{berry} = \frac{0.02\ mg/kg \times 0.00052\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5yr \times 365\ d/yr}$$

$$EDI_{berry} = 7.22 \times 10^{-7}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{berry} = \frac{EDI_{berry}}{RfD}$$

Where,
ER_{berry} = Exposure ratio for berry ingestion pathway
EDI_{berry} = Estimated Daily Intake due to ingestion of berries (mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{berry} = \frac{7.22 \times 10^{-7} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{berry} = 0.00241$$

Leaf ingestion pathway

Estimated Daily Intake

$$EDI_{leaf} = \frac{C_{leaf} \times IR_{leaf} \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$$

Where,
EDI_{leaf} = Estimated Daily Intake due to ingestion of leaves (mg/kg day)
C_{leaf} = COPC concentration in leaves (mg/kg)
IR_{leaf} = Leaf ingestion rate (kg/d)
AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{leaf} = \frac{0.03\ mg/kg \times 0.033\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5yr \times 365\ d/yr}$$

$$EDI_{leaf} = 6.29 \times 10^{-5}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{leaf} = \frac{EDI_{leaf}}{RfD}$$

Where,
ER_{leaf} = Exposure ratio for leaf ingestion pathway
EDI_{leaf} = Estimated Daily Intake due to ingestion of leaves (mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{leaf} = \frac{6.29 \times 10^{-5} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{leaf} = 0.21$$

Root ingestion pathway

Estimated Daily Intake

$$EDI_{root} = \frac{C_{root} \times IR_{root} \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$$

Where,
EDI_{root} = Estimated Daily Intake due to ingestion of roots (mg/kg day)
C_{root} = COPC concentration in roots (mg/kg)
IR_{root} = Root ingestion rate (kg/d)
AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{root} = \frac{0.17\ mg/kg \times 0.026\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5 yr \times 365\ d/yr}$$

$$EDI_{root} = 2.71 \times 10^{-4}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{root} = \frac{EDI_{root}}{RfD}$$

Where,
ER_{root} = Exposure ratio for root ingestion pathway
EDI_{root} = Estimated Daily Intake due to ingestion of roots (mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{root} = \frac{2.71 \times 10^{-4} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{root} = 0.902$$

Moose ingestion pathway

Estimated Daily Intake

$$EDI_{moose} = \frac{C_{moose} \times IR_{moose} \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$$

Where,
EDI_{moose} = Estimated Daily Intake due to ingestion of moose (mg/kg day)
C_{moose} = COPC concentration in moose (mg/kg)
IR_{moose} = Moose ingestion rate (kg/d)
AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{moose} = \frac{0.0027\ mg/kg \times 0.085\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5yr \times 365\ d/yr}$$

$$EDI_{moose} = 1.38 \times 10^{-5}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{moose} = \frac{EDI_{moose}}{RfD}$$

Where,
ER_{moose} = Exposure ratio for moose ingestion pathway
EDI_{moose} = Estimated Daily Intake due to ingestion of moose (mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{moose} = \frac{1.38 \times 10^{-5} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{moose} = 0.0458$$

Fish ingestion pathway

Estimated Daily Intake

$$EDI_{fish} = \frac{C_{fish} \times IR_{fish} \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$$

Where,
EDI_{fish} = Estimated Daily Intake due to ingestion of fish (mg/kg day)
C_{fish} = COPC concentration in fish (mg/kg)
IR_{fish} = Fish ingestion rate (kg/d)
AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (yr)

CF_1 = Conversion Factor (365 d/yr)

$$EDI_{fish} = \frac{0.03\ mg/kg \times 0.095\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5 yr \times 365\ d/yr}$$

$$EDI_{fish} = 1.49 \times 10^{-4}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{fish} = \frac{EDI_{fish}}{RfD}$$

Where,
ER_{fish} = Exposure ratio for fish ingestion pathway
EDI_{fish} = Estimated Daily Intake due to ingestion of fish (mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{fish} = \frac{1.49 \times 10^{-4} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{fish} = 0.498$$

Water ingestion pathway

Estimated Daily Intake

$$EDI_{water} = \frac{C_w \times IR_w \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$$

Where,
EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg day)
C_w= COPC concentration in water (mg/L)
IR_w = Water ingestion rate (L/d)
AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{water} = \frac{0.001\ mg/L \times 0.6\ L/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 4.5 yr \times 365\ d/yr}$$

$$EDI_{water} = 3.64 \times 10^{-5}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{water} = \frac{EDI_{water}}{RfD}$$

Where,
ER_{water} = Exposure ratio for water ingestion pathway
EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg day)

RfD = oral Reference dose (mg/kg day)

$$ER_{water} = \frac{3.64 \times 10^{-5} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{water} = 0.121$$

Soil Dermal contact pathway

Estimated Daily Intake

$$EDI_{dermal} = \frac{C_s \times SL_H \times EF \times SA_H \times AF_{skin} \times DE}{BW \times CF_1}$$

Where,
EDI_{dermal} = Estimated Daily Intake due to dermal contact with soil (mg/kg day)
C_s= COPC concentration in soil (mg/kg)
SL_H = Soil loading to exposed skin (kg/cm^2-event)
EF = Exposure frequency (d/yr)
SA_H = Surface area exposed (cm^2)
AF_{skin} = Absorption factor for the skin (unitless)
DE = Dermal events (events/d)
BW = Body weight (kg)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{dermal} = \frac{3.73\ mg/kg \times 0.0000001\ kg/cm^2 \times 365\ d/yr \times 430\ cm^2 \times 0.03\ \times 1\ event/d}{16.5\ kg \times 365\ d/yr}$$

$$EDI_{dermal} = 2.92 \times 10^{-7}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{dermal} = \frac{EDI_{dermal}}{RfD}$$

Where,
ER_{dermal} = Exposure ratio for soil dermal contact pathway
EDI_{dermal} = Estimated Daily Intake due to soil dermal contact (mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{dermal} = \frac{2.92 \times 10^{-7} mg/kg \cdot day}{0.0003\ mg/kg \cdot day}$$

$$ER_{dermal} = 0.000972$$

Soil inhalation of dust pathway

Estimated Daily Intake

$$EDI_{dust} = \frac{C_s \times IR_a \times AF_{inh} \times EF \times ED \times C_d}{BW \times AT \times CF_1}$$

Where,
EDI_{dust} = Estimated Daily Intake due to inhalation of dust (mg/kg day)
C_s = COPC concentration in soil (mg/kg)
IR_a = Inhalation rate (m^3/d)
AF_{inh} = Inhalation absorption factor (unitless)
EF = Exposure frequency (d/yr)
ED = Exposure duration (yr)
C_d = Dust concentration (kg/m^3)
BW = Body weight (kg)
AT = Averaging time (yr)
CF_1 = Conversion Factor (365 d/yr)

$$EDI_{dust} = \frac{3.73\ mg/kg \times 8.3\ m^3/d \times 1 \times 365\ d/yr \times 4.5\ yr \times 7.6 \times 10^{-10}\ kg/m^3}{16.5\ kg \times 4.5yr \times 365\ d/yr}$$

$$EDI_{dust} = 1.43 \times 10^{-9}\ mg/kg \cdot day$$

Exposure Ratio

$$ER_{dust} = \frac{EDI_{dust}}{RfD}$$

Where,
ER_{dust} = Exposure ratio for dust inhalation pathway
EDI_{dust} = Estimated Daily Intake due to inhalation of dust(mg/kg day)
RfD = oral Reference dose (mg/kg day)

$$ER_{dust} = \frac{1.43 \times 10^{-9} mg/kg \cdot day}{0.0003\ mg/kg\ \cdot day}$$

$$ER_{dust} = 4.75 \times 10^{-6}$$

Total Exposure Ratio (All pathways)

$$ER_{Total} = ER_{air} + ER_{soil} + ER_{berry} + ER_{leaf} + ER_{root} + ER_{moose} + ER_{fish} + ER_{water} + ER_{dust} + ER_{dermal}$$

$$ER_{Total} = 0.00021 + 0.060 + 0.0024 + 0.21 + 0.90 + 0.046 + 0.50 + 0.12 + 0.00097 + 0.0000048$$

$$ER_{Total} = 1.84$$

Cancer Assessment (Arsenic, Baseline Case, Composite Receptor, Chipewyan Lake)

Air Inhalation Pathway

Infant

Estimated Daily Intake

$$EDI_{air} = \frac{3.09 \times 10^{-6} \mu g/m^3 \times 2.2\ m^3/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr \times 1000 \mu g/mg}$$

$$EDI_{air} = 5.52 \times 10^{-12}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{air} = \frac{EDI_{air} \times IUR \times BW}{IR_a}$$

Where,
$ILCR_{air}$ = Incremental Lifetime Cancer Risk for air pathway
EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg-d)
IUR = Inhalation Unit Risk $(mg/m^3)^{-1}$
BW = Body weight (kg)
IR_a = Inhalation rate (m^3/d)

$$ILCR_{air} = \frac{5.52 \times 10^{-12} mg/kg \cdot day \times 6.4\ (mg/m^3)^{-1} \times 8.2\ kg}{2.2\ m^3/d}$$

$$ILCR_{air} = 1.32 \times 10^{-10}$$

Exposure Ratio

$$ER_{air} = ILCR_{air} \times 100{,}000$$

$$ER_{air} = (1.32 \times 10^{-10}) \times 100{,}000$$

$$ER_{air} = 1.32 \times 10^{-5}$$

Toddler

Estimated Daily Intake

$$EDI_{air} = \frac{3.09 \times 10^{-6} \mu g/m^3 \times 8.3\ m^3/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75 yr \times 365\ d/yr \times 1000 \mu g/mg}$$

$$EDI_{air} = 9.32 \times 10^{-11}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{air} = \frac{EDI_{air} \times IUR \times BW}{IR_a}$$

Where,
$ILCR_{air}$ = Incremental Lifetime Cancer Risk for air pathway
EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg-d)
IUR = Inhalation Unit Risk $(mg/m^3)^{-1}$
BW = Body weight (kg)
IR_a = Inhalation rate (m^3/d)

$$ILCR_{air} = \frac{9.32 \times 10^{-11} mg/kg \cdot day \times 6.4\ (mg/m^3)^{-1} \times 16.5\ kg}{8.3\ m^3/d}$$

$$ILCR_{air} = 1.19 \times 10^{-9}$$

Exposure Ratio

$$ER_{air} = ILCR_{air} \times 100{,}000$$

$$ER_{air} = (1.19 \times 10^{-9}) \times 100{,}000$$

$$ER_{air} = 1.19 \times 10^{-4}$$

Child

Estimated Daily Intake

$$EDI_{air} = \frac{3.09 \times 10^{-6} \mu g/m^3 \times 14.5\ m^3/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75 yr \times 365\ d/yr \times 1000 \mu g/mg}$$

$$EDI_{air} = 1.27 \times 10^{-10}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{air} = \frac{EDI_{air} \times IUR \times BW}{IR_a}$$

Where,
$ILCR_{air}$ = Incremental Lifetime Cancer Risk for air pathway
EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg-d)
IUR = Inhalation Unit Risk $(mg/m^3)^{-1}$
BW = Body weight (kg)
IR_a = Inhalation rate (m^3/d)

$$ILCR_{air} = \frac{1.27 \times 10^{-10} mg/kg \cdot day \times 6.4\ (mg/m^3)^{-1} \times 32.9\ kg}{14.5\ m^3/d}$$

$$ILCR_{air} = 1.84 \times 10^{-9}$$

Exposure Ratio

$$ER_{air} = ILCR_{air} \times 100{,}000$$

$$ER_{air} = (1.84 \times 10^{-9}) \times 100{,}000$$

$$ER_{air} = 1.84 \times 10^{-4}$$

Teen

Estimated Daily Intake

$$EDI_{air} = \frac{3.09 \times 10^{-6} \mu g/m^3 \times 15.6\ m^3/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75 yr \times 365\ d/yr \times 1000 \mu g/mg}$$

$$EDI_{air} = 8.61 \times 10^{-11}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{air} = \frac{EDI_{air} \times IUR \times BW}{IR_a}$$

Where,
$ILCR_{air}$ = Incremental Lifetime Cancer Risk for air pathway
EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg-d)
IUR = Inhalation Unit Risk $(mg/m^3)^{-1}$
BW = Body weight (kg)
IR_a = Inhalation rate (m^3/d)

$$ILCR_{air} = \frac{8.61 \times 10^{-11} mg/kg \cdot day \times 6.4\ (mg/m^3)^{-1} \times 59.7\ kg}{15.6\ m^3/d}$$

$$ILCR_{air} = 2.11 \times 10^{-9}$$

Exposure Ratio

$$ER_{air} = ILCR_{air} \times 100{,}000$$

$$ER_{air} = (2.11 \times 10^{-9}) \times 100{,}000$$

$$ER_{air} = 2.11 \times 10^{-4}$$

Adult

Estimated Daily Intake

$$EDI_{air} = \frac{3.09 \times 10^{-6} \mu g/m^3 \times 15.6\ m^3/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75 yr \times 365\ d/yr \times 1000 \mu g/mg}$$

$$EDI_{air} = 5.45 \times 10^{-10}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{air} = \frac{EDI_{air} \times IUR \times BW}{IR_a}$$

Where,
$ILCR_{air}$ = Incremental Lifetime Cancer Risk for air pathway
EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg-d)
IUR = Inhalation Unit Risk $(mg/m^3)^{-1}$
BW = Body weight (kg)
IR_a = Inhalation rate (m^3/d)

$$ILCR_{air} = \frac{5.45 \times 10^{-10} mg/kg \cdot day \times 6.4\ (mg/m^3\ )^{-1} \times 70.7\ kg}{15.6\ m^3/d}$$

$$ILCR_{air} = 1.58 \times 10^{-8}$$

Exposure Ratio

$$ER_{air} = ILCR_{air} \times 100{,}000$$

$$ER_{air} = (1.58 \times 10^{-8}) \times 100{,}000$$

$$ER_{air} = 1.58 \times 10^{-3}$$

Composite Receptor

Exposure Ratio

$$ER_{air} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{air} = 1.32 \times 10^{-5} + 1.19 \times 10^{-4} + 1.84 \times 10^{-4} + 2.11 \times 10^{-4} + 1.58 \times 10^{-3}$$

$$ER_{air} = 2.11 \times 10^{-3}$$

Soil ingestion pathway

Infant

Estimated Daily Intake

$$EDI_{soil} = \frac{3.73\ mg/kg \times 0.00002\ kg/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{soil} = 6.07 \times 10^{-8}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{soil} = EDI_{soil} \times SF$$

Where,
$ILCR_{soil}$ = Incremental Lifetime Cancer Risk for soil ingestion pathway
EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{soil} = 6.07 \times 10^{-8} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{soil} = 1.09 \times 10^{-7}$$

Exposure Ratio

$$ER_{soil} = ILCR_{soil} \times 100{,}000$$

$$ER_{soil} = (1.09 \times 10^{-7}) \times 100{,}000$$

$$ER_{soil} = 1.09 \times 10^{-2}$$

Toddler

Estimated Daily Intake

$$EDI_{soil} = \frac{3.73\ mg/kg \times 0.00008\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{soil} = 1.09 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{soil} = EDI_{soil} \times SF$$

Where,
$ILCR_{soil}$ = Incremental Lifetime Cancer Risk for soil ingestion pathway
EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{soil} = 1.09 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{soil} = 1.95 \times 10^{-6}$$

Exposure Ratio

$$ER_{soil} = ILCR_{soil} \times 100{,}000$$

$$ER_{soil} = (1.95 \times 10^{-6}) \times 100{,}000$$

$$ER_{soil} = 1.95 \times 10^{-1}$$

Child

Estimated Daily Intake

$$EDI_{soil} = \frac{3.73\ mg/kg \times 0.00002\ kg/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{soil} = 2.12 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{soil} = EDI_{soil} \times SF$$

Where,
$ILCR_{soil}$ = Incremental Lifetime Cancer Risk for soil ingestion pathway
EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{soil} = 2.12 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{soil} = 3.81 \times 10^{-7}$$

Exposure Ratio

$$ER_{soil} = ILCR_{soil} \times 100{,}000$$

$$ER_{soil} = (3.81 \times 10^{\,-7}) \times 100{,}000$$

$$ER_{soil} = 3.81 \times 10^{\,-2}$$

Teen

Estimated Daily Intake

$$EDI_{soil} = \frac{3.73\ mg/kg \times 0.00002\ kg/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{soil} = 1.33 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{soil} = EDI_{soil} \times SF$$

Where,
$ILCR_{soil}$ = Incremental Lifetime Cancer Risk for soil ingestion pathway
EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{soil} = 1.33 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{soil} = 2.40 \times 10^{-7}$$

Exposure Ratio

$$ER_{soil} = ILCR_{soil} \times 100{,}000$$

$$ER_{soil} = (2.40 \times 10^{\,-7}) \times 100{,}000$$

$$ER_{soil} = 2.40 \times 10^{\,-2}$$

Adult

Estimated Daily Intake

$$EDI_{soil} = \frac{3.73\ mg/kg \times 0.00002\ kg/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{soil} = 8.44 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{soil} = EDI_{soil} \times SF$$

Where,
$ILCR_{soil}$ = Incremental Lifetime Cancer Risk for soil ingestion pathway

EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{soil} = 8.44 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{soil} = 1.52 \times 10^{-6}$$

Exposure Ratio

$$ER_{soil} = ILCR_{soil} \times 100{,}000$$

$$ER_{soil} = (1.52 \times 10^{-6}) \times 100{,}000$$

$$ER_{soil} = 1.52 \times 10^{-1}$$

Composite Receptor

Exposure Ratio

$$ER_{soil} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{soil} = 1.09 \times 10^{-2} + 1.95 \times 10^{-1} + 3.81 \times 10^{-2} + 2.40 \times 10^{-2} + 1.52 \times 10^{-1}$$

$$ER_{soil} = 0.42$$

Berry ingestion pathway

Infant

Estimated Daily Intake

$$EDI_{berry} = \frac{0.02\ mg/kg \times 0.0000938\ kg/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{berry} = 1.75 \times 10^{-9}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{berry} = EDI_{berry} \times SF$$

Where,
$ILCR_{berry}$ = Incremental Lifetime Cancer Risk for berry ingestion pathway
EDI_{berry} = Estimated Daily Intake due to ingestion of berries (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{berry} = 1.75 \times 10^{-9} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{berry} = 3.16 \times 10^{-9}$$

Exposure Ratio

$$ER_{berry} = ILCR_{berry} \times 100{,}000$$

$$ER_{berry} = (3.16 \times 10^{-9}) \times 100{,}000$$

$$ER_{berry} = 3.16 \times 10^{-4}$$

Toddler

Estimated Daily Intake

$$EDI_{berry} = \frac{0.02\ mg/kg \times 0.000518\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{berry} = 4.33 \times 10^{-8}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{berry} = EDI_{berry} \times SF$$

Where,
$ILCR_{berry}$ = Incremental Lifetime Cancer Risk for berry ingestion pathway
EDI_{berry} = Estimated Daily Intake due to ingestion of berries (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{berry} = 4.33 \times 10^{-8} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{berry} = 7.80 \times 10^{-8}$$

Exposure Ratio

$$ER_{berry} = ILCR_{berry} \times 100{,}000$$

$$ER_{berry} = (7.80 \times 10^{-8}) \times 100{,}000$$

$$ER_{berry} = 7.80 \times 10^{-3}$$

Child

Estimated Daily Intake

$$EDI_{berry} = \frac{0.02\ mg/kg \times 0.001204\ kg/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{berry} = 7.86 \times 10^{-8}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{berry} = EDI_{berry} \times SF$$

Where,
$ILCR_{berry}$ = Incremental Lifetime Cancer Risk for berry ingestion pathway
EDI_{berry} = Estimated Daily Intake due to ingestion of berries (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{berry} = 7.86 \times 10^{-8} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{berry} = 1.41 \times 10^{-7}$$

Exposure Ratio

$$ER_{berry} = ILCR_{berry} \times 100{,}000$$

$$ER_{berry} = (1.41 \times 10^{-7}) \times 100{,}000$$

$$ER_{berry} = 1.41 \times 10^{-2}$$

Teen

Estimated Daily Intake

$$EDI_{berry} = \frac{0.02\ mg/kg \times 0.000966\ kg/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{berry} = 3.97 \times 10^{-8}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{berry} = EDI_{berry} \times SF$$

Where,
$ILCR_{berry}$ = Incremental Lifetime Cancer Risk for berry ingestion pathway
EDI_{berry} = Estimated Daily Intake due to ingestion of berries (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{berry} = 3.97 \times 10^{-8} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{berry} = 7.15 \times 10^{-8}$$

Exposure Ratio

$$ER_{berry} = ILCR_{berry} \times 100{,}000$$

$$ER_{berry} = (7.15 \times 10^{-8}) \times 100{,}000$$

$$ER_{berry} = 7.15 \times 10^{-3}$$

Adult

Estimated Daily Intake

$$EDI_{berry} = \frac{0.02\ mg/kg \times 0.001358\ kg/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{berry} = 3.53 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{berry} = EDI_{berry} \times SF$$

Where,
$ILCR_{berry}$ = Incremental Lifetime Cancer Risk for berry ingestion pathway
EDI_{berry} = Estimated Daily Intake due to ingestion of berries (mg/kg-d)
SF = Oral slope factor (mg/kg day)$^{-1}$

$$ILCR_{berry} = 3.53 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{berry} = 6.36 \times 10^{-7}$$

Exposure Ratio

$$ER_{berry} = ILCR_{berry} \times 100{,}000$$

$$ER_{berry} = (6.36 \times 10^{-7}) \times 100{,}000$$

$$ER_{berry} = 6.36 \times 10^{-2}$$

Composite Receptor

Exposure Ratio

$$ER_{berry} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{berry} = 3.16 \times 10^{-4} + 7.80 \times 10^{-3} + 1.41 \times 10^{-2} + 7.15 \times 10^{-3} + 6.36 \times 10^{-2}$$

$$ER_{berry} = 9.30 \times 10^{-2}$$

Leaf ingestion pathway

Infant

Estimated Daily Intake

$$EDI_{leaf} = \frac{0.03\ mg/kg \times 0.03528\ kg/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{leaf} = 9.07 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{leaf} = EDI_{leaf} \times SF$$

Where,
$ILCR_{leaf}$ = Incremental Lifetime Cancer Risk for leaf ingestion pathway
EDI_{leaf} = Estimated Daily Intake due to ingestion of leaves (mg/kg-d)
SF = Oral slope factor (mg/kg day)$^{-1}$

$$ILCR_{leaf} = 9.07 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{leaf} = 1.63 \times 10^{-6}$$

Exposure Ratio

$$ER_{leaf} = ILCR_{leaf} \times 100{,}000$$

$$ER_{leaf} = (1.63 \times 10^{-6}) \times 100{,}000$$

$$ER_{leaf} = 1.63 \times 10^{-1}$$

Toddler

Estimated Daily Intake

$$EDI_{leaf} = \frac{0.03\ mg/kg \times 0.03283\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{leaf} = 3.77 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{leaf} = EDI_{leaf} \times SF$$

Where,
$ILCR_{leaf}$ = Incremental Lifetime Cancer Risk for leaf ingestion pathway
EDI_{leaf} = Estimated Daily Intake due to ingestion of leaves (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{leaf} = 3.77 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{leaf} = 6.79 \times 10^{-6}$$

Exposure Ratio

$$ER_{leaf} = ILCR_{leaf} \times 100{,}000$$

$$ER_{leaf} = (6.79 \times 10^{-6}) \times 100{,}000$$

$$ER_{leaf} = 6.79 \times 10^{-1}$$

Child

Estimated Daily Intake

$$EDI_{leaf} = \frac{0.03\ mg/kg \times 0.04802\ kg/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{leaf} = 4.31 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{leaf} = EDI_{leaf} \times SF$$

Where,
$ILCR_{leaf}$ = Incremental Lifetime Cancer Risk for leaf ingestion pathway
EDI_{leaf} = Estimated Daily Intake due to ingestion of leaf (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{leaf} = 4.31 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{leaf} = 7.75 \times 10^{-6}$$

Exposure Ratio

$$ER_{leaf} = ILCR_{leaf} \times 100{,}000$$

$$ER_{leaf} = (7.75 \times 10^{-6}) \times 100{,}000$$

$$ER_{leaf} = 7.75 \times 10^{-1}$$

Teen

Estimated Daily Intake

$$EDI_{leaf} = \frac{0.03\ mg/kg \times 0.0588\ kg/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{leaf} = 3.32 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{leaf} = EDI_{leaf} \times SF$$

Where,
$ILCR_{leaf}$ = Incremental Lifetime Cancer Risk for leaf ingestion pathway
EDI_{leaf} = Estimated Daily Intake due to ingestion of leaf (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{leaf} = 3.32 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{leaf} = 5.98 \times 10^{-6}$$

Exposure Ratio

$$ER_{leaf} = ILCR_{leaf} \times 100{,}000$$

$$ER_{leaf} = (5.98 \times 10^{-6}) \times 100{,}000$$

$$ER_{leaf} = 5.98 \times 10^{-1}$$

Adult

Estimated Daily Intake

$$EDI_{leaf} = \frac{0.03\ mg/kg \times 0.06713\ kg/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{leaf} = 2.40 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{leaf} = EDI_{leaf} \times SF$$

Where,
$ILCR_{leaf}$ = Incremental Lifetime Cancer Risk for leaf ingestion pathway
EDI_{leaf} = Estimated Daily Intake due to ingestion of leaf (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{leaf} = 2.40 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{leaf} = 4.32 \times 10^{-5}$$

Exposure Ratio

$$ER_{leaf} = ILCR_{leaf} \times 100{,}000$$

$$ER_{leaf} = (4.32 \times 10^{\ -5}) \times 100{,}000$$

$$ER_{leaf} = 4.32$$

Composite Receptor

Exposure Ratio

$$ER_{leaf} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{leaf} = 0.163 + 0.679 + 0.775 + 0.598 + 4.32$$

$$ER_{leaf} = 6.54$$

Root ingestion pathway

Infant

Estimated Daily Intake

$$EDI_{root} = \frac{0.17\ mg/kg \times 0.02075\ kg/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{root} = 2.87 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{root} = EDI_{root} \times SF$$

Where,
$ILCR_{root}$ = Incremental Lifetime Cancer Risk for root ingestion pathway
EDI_{root} = Estimated Daily Intake due to ingestion of roots (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{root} = 2.87 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{root} = 5.17 \times 10^{-6}$$

Exposure Ratio

$$ER_{root} = ILCR_{root} \times 100{,}000$$

$$ER_{root} = (5.17 \times 10^{-6}) \times 100{,}000$$

$$ER_{root} = 5.17 \times 10^{-1}$$

Toddler

Estimated Daily Intake

$$EDI_{root} = \frac{0.17\ mg/kg \times 0.02625\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{root} = 1.62 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{root} = EDI_{root} \times SF$$

Where,
$ILCR_{root}$ = Incremental Lifetime Cancer Risk for root ingestion pathway
EDI_{root} = Estimated Daily Intake due to ingestion of roots (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{root} = 1.62 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{root} = 2.92 \times 10^{-5}$$

Exposure Ratio

$$ER_{root} = ILCR_{root} \times 100{,}000$$

$$ER_{root} = (2.92 \times 10^{-5}) \times 100{,}000$$

$$ER_{root} = 2.92$$

Child

Estimated Daily Intake

$$EDI_{root} = \frac{0.17\ mg/kg \times 0.04025\ kg/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{root} = 1.94 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{root} = EDI_{root} \times SF$$

Where,
$ILCR_{root}$ = Incremental Lifetime Cancer Risk for root ingestion pathway
EDI_{root} = Estimated Daily Intake due to ingestion of roots (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{root} = 1.94 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{root} = 3.50 \times 10^{-5}$$

Exposure Ratio

$$ER_{root} = ILCR_{root} \times 100{,}000$$

$$ER_{root} = (3.50 \times 10^{\ -5}) \times 100{,}000$$

$$ER_{root} = 3.5$$

Teen

Estimated Daily Intake

$$EDI_{root} = \frac{0.17\ mg/kg \times 0.05675\ kg/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{root} = 1.72 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{root} = EDI_{root} \times SF$$

Where,
$ILCR_{root}$ = Incremental Lifetime Cancer Risk for root ingestion pathway
EDI_{root} = Estimated Daily Intake due to ingestion of roots (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{root} = 1.72 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{root} = 3.10 \times 10^{-5}$$

Exposure Ratio

$$ER_{root} = ILCR_{root} \times 100{,}000$$

$$ER_{root} = (3.10 \times 10^{\ -5}) \times 100{,}000$$

$$ER_{root} = 3.10$$

Adult

Estimated Daily Intake

$$EDI_{root} = \frac{0.17\ mg/kg \times 0.047\ kg/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{root} = 9.05 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{root} = EDI_{root} \times SF$$

Where,
$ILCR_{root}$ = Incremental Lifetime Cancer Risk for root ingestion pathway
EDI_{root} = Estimated Daily Intake due to ingestion of roots (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{root} = 9.05 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{root} = 1.63 \times 10^{-4}$$

Exposure Ratio

$$ER_{root} = ILCR_{root} \times 100{,}000$$

$$ER_{root} = (1.63 \times 10^{-4}) \times 100{,}000$$

$$ER_{root} = 16.3$$

Composite Receptor

Exposure Ratio

$$ER_{root} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{root} = 0.517 + 2.92 + 3.50 + 3.10 + 16.3$$

$$ER_{root} = 26.3$$

Moose Ingestion Pathway

Infant

Estimated Daily Intake

$$EDI_{moose} = \frac{0.003\ mg/kg \times 0\ kg/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{moose} = 0\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{moose} = EDI_{moose} \times SF$$

Where,
$ILCR_{moose}$ = Incremental Lifetime Cancer Risk for moose ingestion pathway
EDI_{moose} = Estimated Daily Intake due to ingestion of moose (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{moose} = 0\ mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{moose} = 0$$

Exposure Ratio

$$ER_{moose} = ILCR_{moose} \times 100{,}000$$

$$ER_{moose} = (0) \times 100{,}000$$

$$ER_{moose} = 0$$

Toddler

Estimated Daily Intake

$$EDI_{moose} = \frac{0.003\ mg/kg \times 0.085\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{moose} = 8.25 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{moose} = EDI_{moose} \times SF$$

Where,
$ILCR_{moose}$ = Incremental Lifetime Cancer Risk for moose ingestion pathway
EDI_{moose} = Estimated Daily Intake due to ingestion of moose (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{moose} = 8.25 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{moose} = 1.49 \times 10^{-6}$$

Exposure Ratio

$$ER_{moose} = ILCR_{moose} \times 100{,}000$$

$$ER_{moose} = (1.49 \times 10^{-6}) \times 100{,}000$$

$$ER_{moose} = 0.149$$

Child

Estimated Daily Intake

$$EDI_{moose} = \frac{0.003\ mg/kg \times 0.125\ kg/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{moose} = 9.47 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{moose} = EDI_{moose} \times SF$$

Where,
$ILCR_{moose}$ = Incremental Lifetime Cancer Risk for moose ingestion pathway
EDI_{moose} = Estimated Daily Intake due to ingestion of moose (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{moose} = 9.47 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{moose} = 1.70 \times 10^{-6}$$

Exposure Ratio

$$ER_{moose} = ILCR_{moose} \times 100{,}000$$

$$ER_{moose} = (1.70 \times 10^{-6}) \times 100{,}000$$

$$ER_{moose} = 0.17$$

Teen

Estimated Daily Intake

$$EDI_{moose} = \frac{0.003\ mg/kg \times 0.175\ kg/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{moose} = 8.35 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{moose} = EDI_{moose} \times SF$$

Where,
$ILCR_{moose}$ = Incremental Lifetime Cancer Risk for moose ingestion pathway
EDI_{moose} = Estimated Daily Intake due to ingestion of moose (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{moose} = 8.35 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{moose} = 1.50 \times 10^{-6}$$

Exposure Ratio

$$ER_{moose} = ILCR_{moose} \times 100{,}000$$

$$ER_{moose} = (1.50 \times 10^{-6}) \times 100{,}000$$

$$ER_{moose} = 0.15$$

Adult

Estimated Daily Intake

$$EDI_{moose} = \frac{0.003\ mg/kg \times 0.27\ kg/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{moose} = 8.16 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{moose} = EDI_{moose} \times SF$$

Where,
$ILCR_{moose}$ = Incremental Lifetime Cancer Risk for moose ingestion pathway
EDI_{moose} = Estimated Daily Intake due to ingestion of moose (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{moose} = 8.16 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{moose} = 1.47 \times 10^{-5}$$

Exposure Ratio

$$ER_{moose} = ILCR_{moose} \times 100{,}000$$

$$ER_{moose} = (1.47 \times 10^{-5}) \times 100{,}000$$

$$ER_{moose} = 1.47$$

Composite Receptor

Exposure Ratio

$$ER_{moose} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{moose} = 0 + 0.149 + 0.17 + 0.15 + 1.47$$

$$ER_{moose} = 1.94$$

Fish Ingestion Pathway

Infant

Estimated Daily Intake

$$EDI_{fish} = \frac{0.026\ mg/kg \times 0\ kg/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{fish} = 0\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{fish} = EDI_{fish} \times SF$$

Where,
$ILCR_{fish}$ = Incremental Lifetime Cancer Risk for fish ingestion pathway
EDI_{fish} = Estimated Daily Intake due to ingestion of fish (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{fish} = 0\ mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{fish} = 0$$

Exposure Ratio

$$ER_{fish} = ILCR_{fish} \times 100{,}000$$

$$ER_{fish} = (0) \times 100{,}000$$

$$ER_{fish} = 0$$

Toddler

Estimated Daily Intake

$$EDI_{fish} = \frac{0.026\ mg/kg \times 0.095\ kg/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{fish} = 8.96 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{fish} = EDI_{fish} \times SF$$

Where,
$ILCR_{fish}$ = Incremental Lifetime Cancer Risk for fish ingestion pathway
EDI_{fish} = Estimated Daily Intake due to ingestion of fish (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{fish} = 8.96 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{fish} = 1.61 \times 10^{-5}$$

Exposure Ratio

$$ER_{fish} = ILCR_{fish} \times 100{,}000$$

$$ER_{fish} = (1.61 \times 10^{-5}) \times 100{,}000$$

$$ER_{fish} = 1.61$$

Child

Estimated Daily Intake

$$EDI_{fish} = \frac{0.026\ mg/kg \times 0.17\ kg/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{fish} = 1.25 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{fish} = EDI_{fish} \times SF$$

Where,
$ILCR_{fish}$ = Incremental Lifetime Cancer Risk for fish ingestion pathway
EDI_{fish} = Estimated Daily Intake due to ingestion of fish (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{fish} = 1.25 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{fish} = 2.25 \times 10^{-5}$$

Exposure Ratio

$$ER_{fish} = ILCR_{fish} \times 100{,}000$$

$$ER_{fish} = (2.25 \times 10^{-5}) \times 100{,}000$$

$$ER_{fish} = 2.25$$

Teen

Estimated Daily Intake

$$EDI_{fish} = \frac{0.026\ mg/kg \times 0.22\ kg/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{fish} = 9.27 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{fish} = EDI_{fish} \times SF$$

Where,
$ILCR_{fish}$ = Incremental Lifetime Cancer Risk for fish ingestion pathway

EDI_{fish} = Estimated Daily Intake due to ingestion of fish (mg/kg-d)
SF = Oral slope factor (mg/kg day)$^{-1}$

$$ILCR_{fish} = 9.27 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{fish} = 1.67 \times 10^{-5}$$

Exposure Ratio

$$ER_{fish} = ILCR_{fish} \times 100{,}000$$

$$ER_{fish} = (1.67 \times 10^{-5}) \times 100{,}000$$

$$ER_{fish} = 1.67$$

Adult

Estimated Daily Intake

$$EDI_{fish} = \frac{0.026\ mg/kg \times 0.22\ kg/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{fish} = 6.46 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{fish} = EDI_{fish} \times SF$$

Where,
$ILCR_{fish}$ = Incremental Lifetime Cancer Risk for fish ingestion pathway
EDI_{fish} = Estimated Daily Intake due to ingestion of fish (mg/kg-d)
SF = Oral slope factor (mg/kg day)$^{-1}$

$$ILCR_{fish} = 6.46 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{fish} = 1.16 \times 10^{-4}$$

Exposure Ratio

$$ER_{fish} = ILCR_{fish} \times 100{,}000$$

$$ER_{fish} = (1.16 \times 10^{-4}) \times 100{,}000$$

$$ER_{fish} = 11.6$$

Composite Receptor

Exposure Ratio

$$ER_{fish} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{fish} = 0 + 1.61 + 2.25 + 1.67 + 11.6$$

$$ER_{fish} = 17.1$$

Water Ingestion Pathway

Infant

Estimated Daily Intake

$$EDI_{water} = \frac{0.001\ mg/L \times 0.3\ L/d \times 1 \times 365\ d/yr \times 0.5\ yr}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{water} = 2.44 \times 10^{-7}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{water} = EDI_{water} \times SF$$

Where,
$ILCR_{water}$ = Incremental Lifetime Cancer Risk for water ingestion pathway
EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{water} = 2.44 \times 10^{-7} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{water} = 4.39 \times 10^{-7}$$

Exposure Ratio

$$ER_{water} = ILCR_{water} \times 100{,}000$$

$$ER_{water} = (4.39 \times 10^{-7}) \times 100{,}000$$

$$ER_{water} = 0.0439$$

Toddler

Estimated Daily Intake

$$EDI_{water} = \frac{0.001\ mg/L \times 0.6\ L/d \times 1 \times 365\ d/yr \times 4.5\ yr}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{water} = 2.18 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{water} = EDI_{water} \times SF$$

Where,
$ILCR_{water}$ = Incremental Lifetime Cancer Risk for water ingestion pathway
EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{water} = 2.18 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{water} = 3.93 \times 10^{-6}$$

Exposure Ratio

$$ER_{water} = ILCR_{water} \times 100{,}000$$

$$ER_{water} = (3.93 \times 10^{-6}) \times 100{,}000$$

$$ER_{water} = 0.393$$

Child

Estimated Daily Intake

$$EDI_{water} = \frac{0.001\ mg/L \times 0.8\ L/d \times 1 \times 365\ d/yr \times 7\ yr}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{water} = 2.27 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{water} = EDI_{water} \times SF$$

Where,
$ILCR_{water}$ = Incremental Lifetime Cancer Risk for water ingestion pathway
EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{water} = 2.27 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{water} = 4.09 \times 10^{-6}$$

Exposure Ratio

$$ER_{water} = ILCR_{water} \times 100{,}000$$

$$ER_{water} = (4.09 \times 10^{-6}) \times 100{,}000$$

$$ER_{water} = 0.409$$

Teen

Estimated Daily Intake

$$EDI_{water} = \frac{0.001\ mg/L \times 1\ L/d \times 1 \times 365\ d/yr \times 8\ yr}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{water} = 1.79 \times 10^{-6}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{water} = EDI_{water} \times SF$$

Where,
$ILCR_{water}$ = Incremental Lifetime Cancer Risk for water ingestion pathway
EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg-d)

SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{water} = 1.79 \times 10^{-6} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{water} = 3.22 \times 10^{-6}$$

Exposure Ratio

$$ER_{water} = ILCR_{water} \times 100{,}000$$

$$ER_{water} = (3.22 \times 10^{-6}) \times 100{,}000$$

$$ER_{water} = 0.322$$

Adult

Estimated Daily Intake

$$EDI_{water} = \frac{0.001\ mg/L \times 1.5\ L/d \times 1 \times 365\ d/yr \times 60\ yr}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{water} = 1.70 \times 10^{-5}\ mg/kg \cdot d$$

Incremental Lifetime Cancer Risk

$$ILCR_{water} = EDI_{water} \times SF$$

Where,
$ILCR_{water}$ = Incremental Lifetime Cancer Risk for water ingestion pathway
EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{water} = 1.70 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{water} = 3.06 \times 10^{-5}$$

Exposure Ratio

$$ER_{water} = ILCR_{water} \times 100{,}000$$

$$ER_{water} = (3.06 \times 10^{-5}) \times 100{,}000$$

$$ER_{water} = 3.06$$

Composite Receptor

Exposure Ratio

$$ER_{water} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{water} = 0.0439 + 0.393 + 0.409 + 0.322 + 3.06$$

$$ER_{water} = 4.22$$

Soil Dermal Contact Pathway

Infant

Estimated Daily Intake

$$EDI_{dermal} = \frac{3.73\ mg/kg \times 0.0000001\ kg/cm^2 \times 365\ d/yr \times 320\ cm^2 \times 0.03\ \times 1\ event/d}{8.2\ kg \times 365\ d/yr}$$

$$EDI_{dermal} = 2.91 \times 10^{-9}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dermal} = EDI_{dermal} \times SF$$

Where,
$ILCR_{dermal}$ = Incremental Lifetime Cancer Risk for soil dermal contact pathway
EDI_{dermal} = Estimated Daily Intake due to soil dermal contact (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dermal} = 2.91 \times 10^{-9} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dermal} = 5.24 \times 10^{-9}$$

Exposure Ratio

$$ER_{dermal} = ILCR_{dermal} \times 100{,}000$$

$$ER_{dermal} = (5.24 \times 10^{\ -9}) \times 100{,}000$$

$$ER_{dermal} = 5.24 \times 10^{-4}$$

Toddler

Estimated Daily Intake

$$EDI_{dermal} = \frac{3.73\ mg/kg \times 0.0000001\ kg/cm^2 \times 365\ d/yr \times 430\ cm^2 \times 0.03\ \times 1\ event/d}{16.5\ kg \times 365\ d/yr}$$

$$EDI_{dermal} = 1.94 \times 10^{-5}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dermal} = EDI_{dermal} \times SF$$

Where,
$ILCR_{dermal}$ = Incremental Lifetime Cancer Risk for soil dermal contact pathway
EDI_{dermal} = Estimated Daily Intake due to soil dermal contact (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dermal} = 1.94 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dermal} = 3.50 \times 10^{-5}$$

Exposure Ratio

$$ER_{dermal} = ILCR_{dermal} \times 100{,}000$$

$$ER_{dermal} = (3.50 \times 10^{-5}) \times 100{,}000$$

$$ER_{dermal} = 3.50$$

Child

Estimated Daily Intake

$$EDI_{dermal} = \frac{3.73\ mg/kg \times 0.0000001\ kg/cm^2 \times 365\ d/yr \times 590\ cm^2 \times 0.03\ \times 1\ event/d}{32.9\ kg \times 365\ d/yr}$$

$$EDI_{dermal} = 2.08 \times 10^{-5}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dermal} = EDI_{dermal} \times SF$$

Where,
$ILCR_{dermal}$ = Incremental Lifetime Cancer Risk for soil dermal contact pathway
EDI_{dermal} = Estimated Daily Intake due to soil dermal contact (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dermal} = 2.08 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dermal} = 3.75 \times 10^{-5}$$

Exposure Ratio

$$ER_{dermal} = ILCR_{dermal} \times 100{,}000$$

$$ER_{dermal} = (3.75 \times 10^{-5}) \times 100{,}000$$

$$ER_{dermal} = 3.75$$

Teen

Estimated Daily Intake

$$EDI_{dermal} = \frac{3.73\ mg/kg \times 0.0000001\ kg/cm^2 \times 365\ d/yr \times 800\ cm^2 \times 0.03\ \times 1\ event/d}{59.7\ kg \times 365\ d/yr}$$

$$EDI_{dermal} = 1.78 \times 10^{-5}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dermal} = EDI_{dermal} \times SF$$

Where,
$ILCR_{dermal}$ = Incremental Lifetime Cancer Risk for soil dermal contact pathway
EDI_{dermal} = Estimated Daily Intake due to soil dermal contact (mg/kg-d)

SF = Oral slope factor (mg/kg day)$^{-1}$

$$ILCR_{dermal} = 1.78 \times 10^{-5} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dermal} = 3.20 \times 10^{-5}$$

Exposure Ratio

$$ER_{dermal} = ILCR_{dermal} \times 100{,}000$$

$$ER_{dermal} = (3.20 \times 10^{\ -5}) \times 100{,}000$$

$$ER_{dermal} = 3.20$$

Adult

Estimated Daily Intake

$$EDI_{dermal} = \frac{3.73\ mg/kg \times 0.0000001\ kg/cm^2 \times 365\ d/yr \times 890\ cm^2 \times 0.03\ \times 1\ event/d}{70.7\ kg \times 365\ d/yr}$$

$$EDI_{dermal} = 1.25 \times 10^{-4}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dermal} = EDI_{dermal} \times SF$$

Where,
$ILCR_{dermal}$ = Incremental Lifetime Cancer Risk for soil dermal contact pathway
EDI_{dermal} = Estimated Daily Intake due to soil dermal contact (mg/kg-d)
SF = Oral slope factor (mg/kg day)$^{-1}$

$$ILCR_{dermal} = 1.25 \times 10^{-4} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dermal} = 2.25 \times 10^{-4}$$

Exposure Ratio

$$ER_{dermal} = ILCR_{dermal} \times 100{,}000$$

$$ER_{dermal} = (2.25 \times 10^{\ -4}) \times 100{,}000$$

$$ER_{dermal} = 22.5$$

Composite Receptor

Exposure Ratio

$$ER_{dermal} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{dermal} = 0.000524 + 3.50 + 3.75 + 3.20 + 22.5$$

$$ER_{dermal} = 33.0$$

Soil Inhalation of Dust Pathway

Infant

Estimated Daily Intake

$$EDI_{dust} = \frac{3.73\ mg/kg \times 2.2\ m^3/d \times 1 \times 365\ d/yr \times 0.5\ yr \times 7.6 \times 10^{-10}\ kg/m^3}{8.2\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{dust} = 5.07 \times 10^{-12}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dust} = EDI_{dust} \times SF$$

Where,
$ILCR_{dust}$ = Incremental Lifetime Cancer Risk for inhalation of dust pathway
EDI_{dust} = Estimated Daily Intake due to inhalation of dust (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dust} = 5.07 \times 10^{-12} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dust} = 9.13 \times 10^{-12}$$

Exposure Ratio

$$ER_{dust} = ILCR_{dust} \times 100{,}000$$

$$ER_{dust} = (9.13 \times 10^{-12}) \times 100{,}000$$

$$ER_{dust} = 9.13 \times 10^{-7}$$

Toddler

Estimated Daily Intake

$$EDI_{dust} = \frac{3.73\ mg/kg \times 8.3\ m^3/d \times 1 \times 365\ d/yr \times 4.5\ yr \times 7.6 \times 10^{-10}\ kg/m^3}{16.5\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{dust} = 8.56 \times 10^{-11}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dust} = EDI_{dust} \times SF$$

Where,
$ILCR_{dust}$ = Incremental Lifetime Cancer Risk for inhalation of dust pathway
EDI_{dust} = Estimated Daily Intake due to inhalation of dust (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dust} = 8.56 \times 10^{-11} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dust} = 1.54 \times 10^{-10}$$

Exposure Ratio

$$ER_{dust} = ILCR_{dust} \times 100{,}000$$

$$ER_{dust} = (1.54 \times 10^{-10}) \times 100{,}000$$

$$ER_{dust} = 1.54 \times 10^{-5}$$

Child

Estimated Daily Intake

$$EDI_{dust} = \frac{3.73\ mg/kg \times 14.5\ m^3/d \times 1 \times 365\ d/yr \times 7\ yr \times 7.6 \times 10^{-10}\ kg/m^3}{32.9\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{dust} = 1.17 \times 10^{-10}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dust} = EDI_{dust} \times SF$$

Where,
$ILCR_{dust}$ = Incremental Lifetime Cancer Risk for inhalation of dust pathway
EDI_{dust} = Estimated Daily Intake due to inhalation of dust (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dust} = 1.17 \times 10^{-10} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dust} = 2.10 \times 10^{-10}$$

Exposure Ratio

$$ER_{dust} = ILCR_{dust} \times 100{,}000$$

$$ER_{dust} = (2.10 \times 10^{-10}) \times 100{,}000$$

$$ER_{dust} = 2.10 \times 10^{-5}$$

Teen

Estimated Daily Intake

$$EDI_{dust} = \frac{3.73\ mg/kg \times 15.6\ m^3/d \times 1 \times 365\ d/yr \times 8\ yr \times 7.6 \times 10^{-10}\ kg/m^3}{59.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{dust} = 7.90 \times 10^{-11}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dust} = EDI_{dust} \times SF$$

Where,
$ILCR_{dust}$ = Incremental Lifetime Cancer Risk for inhalation of dust pathway

EDI_{dust} = Estimated Daily Intake due to inhalation of dust (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dust} = 7.90 \times 10^{-11} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dust} = 1.42 \times 10^{-10}$$

Exposure Ratio

$$ER_{dust} = ILCR_{dust} \times 100{,}000$$

$$ER_{dust} = (1.42 \times 10^{-10}) \times 100{,}000$$

$$ER_{dust} = 1.42 \times 10^{-5}$$

Adult

Estimated Daily Intake

$$EDI_{dust} = \frac{3.73\ mg/kg \times 15.6\ m^3/d \times 1 \times 365\ d/yr \times 60\ yr \times 7.6 \times 10^{-10}\ kg/m^3}{70.7\ kg \times 75yr \times 365\ d/yr}$$

$$EDI_{dust} = 5.00 \times 10^{-10}\ mg/kg \cdot day$$

Incremental Lifetime Cancer Risk

$$ILCR_{dust} = EDI_{dust} \times SF$$

Where,
$ILCR_{dust}$ = Incremental Lifetime Cancer Risk for inhalation of dust pathway
EDI_{dust} = Estimated Daily Intake due to inhalation of dust (mg/kg-d)
SF = Oral slope factor $(mg/kg\ day)^{-1}$

$$ILCR_{dust} = 5.00 \times 10^{-10} mg/kg \cdot d \times 1.8\ (mg/kg \cdot d)^{-1}$$

$$ILCR_{dust} = 9.01 \times 10^{-10}$$

Exposure Ratio

$$ER_{dust} = ILCR_{dust} \times 100{,}000$$

$$ER_{dust} = (9.01 \times 10^{-10}) \times 100{,}000$$

$$ER_{dust} = 9.01 \times 10^{-5}$$

Composite Receptor

Exposure Ratio

$$ER_{dust} = ER_{infant} + ER_{toddler} + ER_{child} + ER_{teen} + ER_{adult}$$

$$ER_{dust} = 9.13 \times 10^{-7} + 1.54 \times 10^{-5} + 2.10 \times 10^{-5} + 1.42 \times 10^{-5} + 9.01 \times 10^{-5}$$

$$ER_{dust} = 1.42 \times 10^{-4}$$

Cancer Assessment Total Exposure Ratio (All pathways)

$$ER_{Total} = ER_{air} + ER_{soil} + ER_{berry} + ER_{leaf} + ER_{root} + ER_{moose} + ER_{fish} + ER_{water} + ER_{dust} + ER_{dermal}$$

$$ER_{Total} = 0.00211 + 0.42 + 0.093 + 6.54 + 26.3 + 1.94 + 17.1 + 4.22 + 33.0 + 0.000142$$

$$ER_{Total} = 89.7$$

23. Appendix 68-1, Section 5.1, Table 23, Page 33.

a. Explain why the following were not considered in the table for chemical mixtures:

i. Neurotoxicity of lead and manganese following chronic oral exposures.

ii. Reproductive and developmental toxicity of lead and nickel following chronic oral exposures.

Response:

a. The chronic oral reference dose (RfD) for lead was adopted from British Columbia Ministry of the Environment (BC MOE [2013]) and was based on hypertension. Chronic oral RfDs for lead were not provided by Health Canada, United States Environmental Protection Agency (U.S. EPA) Integrated Risk Information System (IRIS) or Agency for Toxic Substances and Disease Registry (ATSDR). Therefore, only the endpoint of hypertension was originally considered for lead, not neurotoxicity or reproductive effects.

Although there have not been any RfDs developed for other health endpoints for lead, toxicity studies have shown that health effects associated with exposure to lead include neurotoxicity, developmental delays and male reproductive impairment (U.S. EPA 2013).

The chronic oral RfD for manganese was adopted from Health Canada (2010) and was based on neurotoxicity. The chronic oral RfD for nickel was adopted from Health Canada (2010) and was based on reproductive effects.

In the revised multi-media assessment (Appendix 14-1), lead and manganese are evaluated as a mixture for neurotoxicity, and lead and nickel are evaluated as a mixture for reproductive and developmental toxicity.

24. Appendix 68-1, Section 6, pages 36-38.

Risk estimates for the project alone allows for an examination of the contribution of the project alone to total health risk, particularly where risks associated with the project are more than an order of magnitude lower than baseline risk. This is also particularly relevant for carcinogens where risk is expressed in terms of incremental risk (above background) and therefore do not include background.

a. Provide exposure ratios for threshold chemicals for emissions associated with the project alone.

b. Provide the incremental cancer risks (independent of baseline) associated with carcinogens for the project alone and for future emissions (not including background).

Response:

a. Exposure ratios (ERs) for non-carcinogenic chemicals for the Project only are presented in Appendix 14-1, Table 32 (individual chemicals) and Table 34 (chemical mixtures). All ERs are less than 0.0095.

b. Exposure ratios for carcinogenic chemicals for the Project only and for the Planned Development Case (PDC) minus Baseline (future emissions without background) are presented in Appendix 14-1, Table 33 (individual chemicals) and Table 35 (chemical mixtures). All ERs for carcinogenic effects are less than 0.0075, well below the acceptable threshold of 1.

25. Appendix 68-1, Section 6, pages 36-38.

a. Provide the chronic inhalation ER values for individual chemicals or provide a reference to where these data can be located.

b. For non-carcinogens with ER > 1 - include a discussion of the contribution of individual exposure pathways. Discuss the basis and uncertainty of the selected TRV. Discuss the level of conservative exposure assumptions. If available, provide the estimated daily intake for Canadians for chemicals with ER values greater than 1.

Response:

a. Chronic inhalation ERs were provided in Round 2, Appendix 68-1, Attachment A, Tables A-10 to A-18. The ERs for the other exposure pathways are also provided in these tables. These tables are also provided in the revised multi-media assessment in Appendix 14-1.

b. A discussion, including figures, of the contribution of individual exposure pathways is provided in Appendix 14-1, Section 7. A discussion of the Toxicity Reference Values (TRVs), conservative assumptions and estimated daily intakes has also been added to Appendix 14-1, Section 7.

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APPENDIX 1-1

CANADIAN NATURAL RESOURCES LIMITED NON-OBJECTION LETTER(S)

Canadian Natural

December 11, 2013

Mr. Steve Thomas, P.Eng.
Alberta Energy Regulator
Director, Authorizations (In Situ)
Suite 1000, 250 - 5th Street SW
Calgary, AB T2P 2J6

Dear Mr. Thomas:

Re: Cenovus Energy Inc.
AER Application No. 1712169 - Pelican Lake Grand Rapids Project

Canadian Natural Resources Limited ("Canadian Natural") has completed the review of the Cenovus Energy Inc. ("Cenovus") Application for their Pelican Lake Grand Rapids Project submitted to the Alberta Energy Regulator ("AER") in December 2011 and the subsequent responses to the Supplemental Information Requests (SIR Rounds 1 and 2). In addition, Canadian Natural and Cenovus have met several times to discuss potential concerns, exchange information, and explore potential options for resolution.

Canadian Natural currently operates a polymer flood enhanced oil recovery project ("Brintnell") adjacent to the proposed Cenovus Pelican Lake Grand Rapids Project and has concerns with the planned development and the potential impact on Canadian Natural's operations.

Canadian Natural's primary concern is regarding the potential impact Cenovus' proposed thermal Project will have on wellbore integrity on any non-thermal wells completed within the Wabiskaw Formation. In the responses provided to SIR Round 2 (December 2013), Cenovus proposed a 150 m buffer between thermal and non-thermal well bores within their proposed Initial Development Area (IDA) based on simulation modeling of heat transfer within the reservoir. However Canadian Natural requires further information to understand the rationale regarding the adequacy of the 150 m buffer as geomechanical effects can occur up to a lateral distance of two times the formation depth.

Typically, non-conforming wells (such as gas, stratigraphic, and/or observation wells) would be abandoned or recompleted for compliance prior to concurrent thermal operations. The proposed concurrent operation of an enhanced oil recovery scheme with a shallower thermal operation is a unique scenario that requires further study before deciding on a buffer distance. Canadian Natural also recognizes the need to optimize the buffer distance in the interest of maximizing overall resource recovery.

To better understand the basis for an appropriate buffer and address potential uncertainties the collection of direct physical data is required.

Canadian Natural Resources Limited
Suite 2500, 855 – 2 Street SW Calgary, Alberta, Canada T2P 4J8 T 403.517.6700 F 403.517.7350 www.cnrl.com

Accordingly, it is Canadian Natural's understanding that Cenovus has agreed to undertake the following to substantiate any recommended buffer:

- development of a robust monitoring network within the Grand Rapids 'A' lean zone for thermal plume monitoring,
- continued monitoring of the inSAR monuments installed in 2013 at the Grand Rapids Pilot including installation and monitoring of additional inSAR monuments within the IDA of the Project,
- development of a geomechanical reservoir model to estimate the lateral extent of reservoir dilation and surface heave based on the inSAR data,
- development of a wellbore model using the resulting deformation parameters for shear and compaction to estimate the potential risk to non-thermal wells, and
- share learnings from Cenouvs' operating experience within the IDA that may result in future adjustments to any established buffer including data collected to understand the effects of heat and stress on wellbore integrity of non-conforming Wabiskaw wellbores.

Given the above considerations and that Cenovus has reduced their proposed IDA to minimize potential impacts during the first phase of their proposed Project, Canadian Natural does not have concerns with Cenovus proceeding with development within their proposed IDA.

However, Canadian Natural remains concerned about the risk that future development within Cenovus' proposed Project Area will create to our wellbores that penetrate the Grand Rapids. Accordingly, Canadian Natural reserves the right to file a Statement of Concern (SOC) in accordance with Section 32 of the Responsible Energy Development Act (REDA) in response to any future applications that Cenovus may file to expand their development beyond the currently proposed IDA. It is our understanding that under AER Directive 78 and Section 31 of REDA, Cenovus will be required to provide notice prior to proceeding with an expansion of their development area.

Finally, Canadian Natural will withdraw the SOC previously filed with ESRD on June 13, 2012.

Both Canadian Natural and Cenovus remain committed to working collaboratively to develop a resolution that will be acceptable to both parties.

If you require additional information, please contact the undersigned at (403) 517-7188.

Sincerely,
CANADIAN NATURAL RESOURCES LIMITED

Anita Sartori

Anita Sartori, P. Eng.
Manager, Projects and Approvals

cc. Salim Jagirdhar, AER
Vanessa White, Cenovus Energy Inc.
Trevor Cassidy, Canadian Natural
Warren Raczynski, Canadian Natural
Greg Demchuk, Cenovus Energy Inc.
Kendall Dilling, Cenovus Energy Inc.
Wayne Kennedy, Canadian Natural

Canadian Natural

December 11, 2013

Environment and Sustainable Resource Development
111, Twin Atria Building
4999-98th Avenue
Edmonton, Alberta
T6B 2X3

Attention: Director, Northern Region

Dear Sir:

Re: Cenovus Energy Inc. Pelican Lake Grand Rapids Project
EPEA Application No. 001-293251 - Withdrawal of SOC

On June 13, 2012 Canadian Natural Resources Limited (Canadian Natural) filed a Statement of Concern in response to the Notice of Application regarding the Cenovus Energy Inc. (Cenovus) Pelican Lake Grand Rapids Project.

Canadian Natural and Cenovus have agreed to work collaboratively to address the concerns previously identified. Accordingly Canadian Natural is withdrawing the Statement of Concern with respect to the Cenovus Application.

Sincerely,
CANADIAN NATURAL RESOURCES LIMITED

Anita Sartori, P. Eng.
Manager, Projects and Approvals

cc. Albert Liu, ESRD
Margot Trembath, ESRD
Salim Jagirdhar, AER
Greg Demchuk, Cenovus Energy Inc.
Trevor Cassidy, Canadian Natural
Wayne Kennedy, Canadian Natural
David Thomson, Canadian Natural

APPENDIX 5-1

DRILL STEM TEST REPORTS

Please note that gas volumes listed in the data tables for the DST test reports are due to the pressurization of the chamber as the test was done in Closed chamber mode. When the tools are first opened, you have an initial inflow that causes a pressure increase that looks like gas.

Drill Stem Test Report

Cenovus Energy Inc.

January 6, 2013

CVE Germain	**1AA / 09-03-083-22 W4M**	**DST #**	**1**
Empress	**180.00 - 205.00 mKB**	**AFE#:**	**12149519**
Well License:	**449655**	**Job # :**	**2030**

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

CLOSED CHAMBER REPORT SUMMARY

FLOW AND SHUT-IN TIMES (minutes)

Flow #1	= 3.0	Shut-In #1	= 30.0
Flow #2	= 10.3	Shut-In #2	= 30.0

FLOW RATES (m3/D)

		GAS	LIQUID
Flow #1	initial	0.00	150.00
	final	0.00	10.00
Flow #2	initial	0.00	2.00
	final	0.00	0.00

RECOVERY

LENGTH (m)	VOLUME (m3)	LIQUID DENSITY	DESCRIPTION
57.00	0.14	11.47	Muddy Water
57	0.14	11.47 (avg)	TOTAL RECOVERY

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

COMMENTS

Surface pressures and flow rates for all phases of production have been recorded on a minute by minute basis throughout both flow periods. The results in both tabular and graphical form are contained in the following report. In summary, water, with no trace of gas, was produced throughout both flow periods. The preflow was shortened to prevent the zone from killing itself with hydrostatic pressure of water produced, but it appears to have killed itself right at the end of the 3 minute preflow. The initial shut in, main flow, and final shut in were shortened due to the fact that the well had killed itself and formation pressure had already been achieved, therefore the zone would no longer flow or build up pressure on shut ins.

The top of the recovery was encountered at 57 m above the test tool and consisted of 57 meters of muddy water.

Analysis for liquid influx during this test was undertaken utilizing pressure data from the liquid recovery recorder # 76461 in conjunction with the surface pressure data. An iterative method of calculation has been employed that compares the two data files every fifteen seconds. A simple computation using the reported recovery indicates a recovery gradient of 11.47 kPa/m which is reasonable for muddy water and the reported recovery is therefore verified. Detailed calculations for each flow period show that 56 meters (0.142 m3) entered the chamber during the preflow and 1 meter (0.002) m3) entered during the main flow.

Detailed rates for both phases may be found in the following tables.

All electronic recorders have been converted and included in this report.

The bottom hole temperature was recorded as 10 degrees Celsius.

Delta-P Test Corp.

Cenovus Energy Inc.
January 6, 2013

CVE Germain	**1AA / 09-03-083-22 W4M**	**DST #**	**1**
Empress	**180.00 to 205.00 mKB**	**AFE#:**	**1.2E+07**
		Job# :	**2030**

General Information

Well License	449655	**Test Type**	Bottom Hole Inflate		
Client Representative	Dave Shaffer	**Total Depth**	205.0 m	**Hole Condition**	Good
Phone Number	403-804-8242	**K.B Elevation**	631.85 m	**Hole Deviation**	No
Head Office Contact		**Ground Elevation**	627.20 m	**Cushion?**	No
Office Phone Number		**Drill Pipe I.D.**	82.00 mm	**Tool Chased?**	No
Office Fax Number		**Heavy Weight I.D.**	0.00 mm	**Mud Drop?**	No
DST Supervisor	Glen Miller	**Drill Collar I.D.**	57.00 mm	**Mud Type**	Gel/Chem
DST Unit #	908	**Bore Hole Size**	159.00 mm	**Mud Weight**	1040 kg/m3
DST Unit Phone #	(780) 814-4702	**Element Rubber**	139.00 mm	**Mud Viscosity**	40 s/l
Drilling Contractor	P.D	**Bottom Hole Choke**	19.05 mm	**Water Loss**	6.0 cm3
Rig #	160			**Mud Hydrostatic**	10.20 kPa/m

Preflow Comments

See Delta-P closed chamber report for flow data. No gas to surface.
e

Main flow Comments

See Delta-P closed chamber report for flow data.
No gas to surface

Additional Comments

Recovery Information

Lab Company Maxxam
Total Fluid Recovered 57 m

Length		Description	Salinity (ppm)	pH
57 m	of	Muddy water		

Total Fluid Samples (Including mud tank sample)	11	
Bottom Hole Sampler Serial Numbers	E.D#1	E.D#2
Gas Bomb Serial Number(s) Preflow		
Gas Bomb Serial Number(s) Main flow		

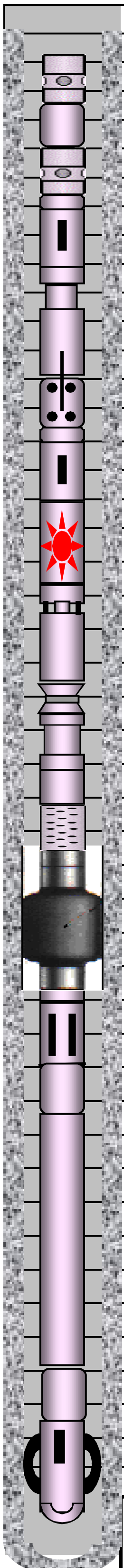
Cenovus Energy Inc.
January 6, 2013

Delta-P Test Corp.

DST # 1
AFE#: 12149519
Job# : 2030

CVE Germain
Empress

1AA / 09-03-083-22 W4M
180.00 to 205.00 mKB



Tool Description	Length (m)	Ser#
Marker Sub	0.00	
Pump Out Sub (Pin Act.)	0.31	
Cross Over Sub	0.00	
Pump Out Sub (Press. Act)	0.31	
Fluid Recorder	1.31	76461
Hydraulic Shut-in Tool	2.06	
Fluid Sampler	1.00	E.D#1
Fluid Sampler	1.00	E.D#2
Inside Recorder	1.31	76132
WTD Recorder	4.83	
Jars	1.82	
Safety Joint	0.69	
Pump	2.55	
Screen	1.05	
Top Packer	1.67	
T.C.	0.72	
Bundle Carrier	1.25	
Outside #1		75919
Outside #2		75966
Inflate Recorder		75845
Blank Off Sub	0.31	
Blank Spacing	0.00	
Crossover Sub	0.00	
Drill Collars	0.00	
Crossover Sub	0.00	
Belly Spring	2.20	
Tool Above Interval	19.91	m
DST Tool Length	24.39	m
Test Interval Length	4.48	m

Test Time, Pressure, and Flow Summary

Recorder: Outside #1 **Recorder Ser #** 75919 **Depth** 182 m

Times

	Start		End		Duration	
Preflow :	6:44:00	to	6:47:00	**Duration:**	3.0	min.
Mainflow:	7:20:00	to	7:30:00	**Duration:**	10.0	min.
Initial Shutin :	6:47:00	to	7:20:00	**Duration:**	33.0	min.
Final Shutin:	7:30:00	to	8:00:00	**Duration:**	30.0	min.

Pressures (kPa)

Preflow:	984 kPa	to	1001 kPa	**Initial Shutin:**	1009 kPa
Mainflow :	1004 kPa	to	1010 kPa	**Final Shutin:**	1009 kPa
Thirdflow:	kPa	to	kPa	**Third Shutin:**	kPa
Initial Hydrostatic:	1942 kPa			**Final Hydrostatic:**	1936 kPa

MAINFLOW: Gas Flow Rates

Time	Office Size	Flow Pressure	Flow Rates
5 min	mm	kPa	m3/D
10 min	mm	kPa	m3/D
15 min	mm	kPa	m3/D
20 min	mm	kPa	m3/D
25 min	mm	kPa	m3/D
30 min	mm	kPa	m3/D
35 min	mm	kPa	m3/D
40 min	mm	kPa	m3/D
45 min	mm	kPa	m3/D
50 min	mm	kPa	m3/D
55 min	mm	kPa	m3/D
60 min	mm	kPa	m3/D
65 min	mm	kPa	m3/D
70 min	mm	kPa	m3/D
75 min	mm	kPa	m3/D
80 min	mm	kPa	m3/D
85 min	mm	kPa	m3/D
90 min	mm	kPa	m3/D
95 min	mm	kPa	m3/D
100 min	mm	kPa	m3/D
105 min	mm	kPa	m3/D
110 min	mm	kPa	m3/D
115 min	mm	kPa	m3/D
120 min	mm	kPa	m3/D

Test Tool String Weights

Tool Weight	2000	daN	**Hole Drag Down**	0	daN
Initial String Weight	9000	daN	**Hole Drag Up**	0	daN
Unseated String	9000	daN	**Weight to Open**	5000	daN

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

FLOW DATA

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
Start Flow #1							
06:42:44	0.00	-0.24	96.14	-	-	-	0.00
06:43:14	0.50	27.00	103.60	341.74	169.85	82.31	166.51
06:43:44	1.00	21.13	114.42	507.01	451.38	155.80	0.68
06:44:14	1.50	17.79	123.35	321.01	632.81	97.30	18.90
06:44:44	2.00	9.17	128.56	149.28	732.03	44.98	9.93
06:45:14	2.50	3.30	131.16	55.07	768.98	16.61	1.94
End Flow #1							
06:45:44	0.25	0.08	132.09	0.00	781.35	0.00	0.00
06:46:14	0.75	0.32	132.70	3.00	784.53	0.88	1.15
06:46:44	1.25	0.60	132.57	-2.26	782.84	0.00	5.63
06:47:14	1.75	-1.13	132.51	0.58	783.11	0.59	0.00
06:47:44	2.25	-0.89	132.53	0.38	783.29	0.44	0.00
06:48:14	2.75	0.93	132.60	-0.55	783.16	0.00	7.38
06:48:44	3.25	0.97	132.70	-0.08	783.19	0.00	7.48
06:49:14	3.75	-0.60	132.42	-0.23	783.21	0.00	0.00
06:49:44	4.25	-0.52	132.60	0.58	783.27	0.29	0.00
06:50:14	4.75	0.72	132.66	0.37	783.61	0.00	5.51
06:50:44	5.25	-0.28	132.55	-0.92	783.42	0.00	0.00
06:51:14	5.75	1.17	132.73	0.39	783.46	0.00	8.95
06:51:44	6.25	-0.48	132.48	0.03	783.52	0.15	0.00
06:52:14	6.75	0.60	132.55	-0.23	783.45	0.00	4.82
06:52:44	7.25	-0.36	132.39	-0.18	783.46	0.00	0.00
06:53:14	7.75	-0.36	132.57	0.65	783.39	0.29	0.00
06:53:44	8.25	-0.32	132.40	-0.22	783.37	0.00	0.00
06:54:14	8.75	0.16	132.35	-0.47	783.17	0.00	1.38
06:54:44	9.25	1.45	132.64	-0.12	783.02	0.00	11.22
06:55:14	9.75	-0.32	132.51	0.42	783.22	0.29	0.00
06:55:44	10.25	-0.32	132.40	-0.27	783.20	0.00	0.00
06:56:14	10.75	1.33	132.66	0.39	783.35	0.00	10.13
06:56:44	11.25	-0.20	132.55	-0.34	783.25	0.00	0.00
06:57:14	11.75	-0.12	132.46	0.21	783.30	0.15	0.00

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
06:57:44	12.25	-0.12	132.39	-0.50	783.05	0.00	0.00
06:58:15	12.75	-0.20	132.28	0.40	783.25	0.15	0.00
06:58:45	13.25	-0.24	132.29	-0.21	783.20	0.00	0.00
06:59:15	13.75	1.69	132.66	0.01	783.17	0.00	13.19
06:59:45	14.25	-0.28	132.55	0.38	783.28	0.15	0.00
07:00:15	14.75	-0.12	132.48	-0.36	783.14	0.00	0.00
07:00:45	15.25	-0.20	132.37	0.13	783.12	0.15	0.00
07:01:15	15.75	-0.08	132.31	-0.14	783.09	0.00	0.00
07:01:45	16.25	0.08	132.28	0.44	783.24	0.15	0.39
07:02:15	16.75	-0.16	132.24	-0.12	783.17	0.00	0.00
07:02:45	17.25	-0.16	132.29	-0.01	783.19	0.00	0.00
07:03:15	17.75	-0.20	132.59	-0.49	783.02	0.00	0.00
07:03:45	18.25	-0.24	132.49	0.22	783.01	0.15	0.00
07:04:15	18.75	-0.16	132.42	-0.17	782.93	0.00	0.00
07:04:45	19.25	-0.20	132.35	0.38	782.89	0.15	0.00
07:05:15	19.75	-0.08	132.31	0.03	783.00	0.15	0.00
07:05:45	20.25	-0.20	132.24	-0.12	782.87	0.00	0.00
07:06:15	20.75	-0.20	132.57	-0.27	782.86	0.00	0.00
07:06:45	21.25	-0.08	132.51	0.57	782.94	0.15	0.00
07:07:15	21.75	0.00	132.48	0.15	782.96	0.15	0.00
07:07:45	22.25	-0.08	132.40	-0.18	782.92	0.00	0.00
07:08:15	22.75	0.00	132.35	0.04	782.92	0.00	0.00
07:08:45	23.25	-0.16	132.29	0.26	782.97	0.15	0.00

End Shut-In #1

07:09:15	0.50	0.00	132.28	-	-	-	0.00
07:09:45	1.00	-0.24	132.20	-	-	-	0.00
07:10:15	1.50	0.68	132.59	-	-	-	6.48
07:10:45	2.00	-0.08	132.49	-	-	-	0.00
07:11:15	2.50	0.00	132.46	-	-	-	0.00
07:11:45	3.00	-0.12	132.39	-	-	-	0.00
07:12:15	3.50	-0.16	132.35	-	-	-	0.00
07:12:45	4.00	-0.08	132.29	-	-	-	0.00
07:13:15	4.50	-0.08	132.26	-	-	-	0.00
07:13:45	5.00	-0.08	132.20	-	-	-	0.00
07:14:15	5.50	-0.16	132.35	-	-	-	0.00
07:14:45	6.00	-0.08	132.29	-	-	-	0.00
07:15:15	6.50	-0.16	132.20	-	-	-	0.00

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
07:15:45	7.00	0.72	132.35	-	-	-	6.87
07:16:15	7.50	-0.04	132.28	-	-	-	0.00
07:16:45	8.00	-0.16	132.22	-	-	-	0.00
07:17:15	8.50	-0.08	132.18	-	-	-	0.00
07:17:45	9.00	0.00	132.51	-	-	-	0.00
07:18:15	9.50	-0.08	132.46	-	-	-	0.00

Start Flow #2

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
07:18:45	0.00	0.08	132.44	-	-	-	0.76
07:19:15	0.50	0.00	132.57	-0.66	782.71	0.00	0.00
07:19:45	1.00	0.00	132.73	8.59	785.89	2.79	0.00
07:20:15	1.50	0.64	132.84	4.35	788.26	1.18	3.09
07:20:45	2.00	-0.08	132.84	1.78	789.43	0.59	0.00
07:21:15	2.50	0.00	132.81	1.96	790.42	0.59	0.00
07:21:45	3.00	-0.08	132.79	0.72	790.93	0.29	0.00
07:22:15	3.50	-0.16	133.08	1.16	791.41	0.44	0.00
07:22:45	4.00	-0.16	133.02	0.67	791.84	0.29	0.00
07:23:15	4.50	0.08	133.04	0.53	792.07	0.15	0.38
07:23:45	5.00	0.00	132.99	0.42	792.26	0.15	0.00
07:24:15	5.50	-0.12	132.99	0.55	792.40	0.29	0.00
07:24:45	6.00	0.00	132.99	0.22	792.52	0.15	0.00
07:25:15	6.50	-0.08	132.95	0.59	792.94	0.29	0.00
07:25:45	7.00	-0.08	132.91	-0.38	792.79	0.00	0.00
07:26:15	7.50	0.00	132.90	0.05	792.75	0.15	0.00
07:26:45	8.00	-0.16	132.86	0.48	793.00	0.15	0.00
07:27:15	8.50	-0.04	133.23	-0.24	792.93	0.00	0.00
07:27:45	9.00	0.00	133.17	0.85	793.22	0.29	0.00
07:28:15	9.50	0.00	133.13	-0.76	792.99	0.00	0.00
07:28:45	10.00	-0.12	133.12	0.33	793.04	0.15	0.00

End Flow #2

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
07:29:15	0.25	0.08	133.12	0.00	792.88	0.00	0.00
07:29:45	0.75	-0.08	133.08	-0.06	793.05	0.00	0.00
07:30:15	1.25	-0.08	133.04	0.18	793.05	0.15	0.00
07:30:45	1.75	0.00	133.04	-0.67	792.76	0.00	0.00
07:31:15	2.25	-0.04	133.01	0.10	792.92	0.00	0.00

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
07:32:15	3.25	-0.08	132.99	-0.22	792.65	0.00	0.00
07:32:46	3.75	-0.08	132.95	-0.78	792.56	0.00	0.00
07:33:16	4.25	0.00	132.95	0.19	792.67	0.00	0.00
07:33:46	4.75	0.00	132.91	-0.33	792.56	0.00	0.00
07:34:16	5.25	-0.12	132.88	0.02	792.57	0.00	0.00
07:34:46	5.75	0.08	132.86	0.41	792.62	0.15	0.39
07:35:16	6.25	0.44	132.95	-0.09	792.65	0.00	3.43
07:35:46	6.75	0.08	132.93	-0.11	792.66	0.00	0.59
07:36:16	7.25	-0.12	132.88	-0.55	792.44	0.00	0.00
07:36:46	7.75	-0.08	132.86	0.20	792.42	0.15	0.00
07:37:16	8.25	0.08	132.86	-0.96	792.28	0.00	0.99
07:37:46	8.75	-0.08	132.82	-0.11	792.29	0.00	0.00
07:38:16	9.25	-0.08	132.88	0.35	792.40	0.15	0.00
07:38:46	9.75	-0.08	132.86	-0.29	792.20	0.00	0.00
07:39:16	10.25	0.00	132.86	0.62	792.41	0.15	0.00
07:39:46	10.75	-0.16	132.84	-0.64	792.21	0.00	0.00
07:40:16	11.25	-0.08	132.82	0.37	792.23	0.15	0.00
07:40:46	11.75	-0.08	132.88	0.23	792.18	0.15	0.00
07:41:16	12.25	-0.16	132.84	0.01	792.19	0.00	0.00
07:41:46	12.75	0.00	132.84	-0.56	791.92	0.00	0.00
07:42:16	13.25	-0.08	132.82	0.07	792.02	0.00	0.00
07:42:46	13.75	-0.12	132.81	0.06	791.97	0.15	0.00
07:43:16	14.25	0.24	132.88	0.27	792.05	0.00	1.76
07:43:46	14.75	0.00	132.86	-0.55	791.82	0.00	0.00
07:44:16	15.25	-0.16	132.82	0.13	792.06	0.00	0.00
07:44:46	15.75	0.00	132.82	-0.44	791.75	0.00	0.00
07:45:16	16.25	0.08	132.81	0.30	791.97	0.15	0.39
07:45:46	16.75	0.00	132.86	-0.29	791.89	0.00	0.00
07:46:16	17.25	-0.16	132.82	0.08	792.03	0.15	0.00
07:46:46	17.75	-0.12	132.81	-0.46	791.73	0.00	0.00
07:47:16	18.25	0.00	132.81	0.73	791.73	0.15	0.00
07:47:46	18.75	-0.16	132.77	-0.70	791.84	0.00	0.00
07:48:16	19.25	0.00	132.77	-0.11	791.69	0.00	0.00
07:48:46	19.75	-0.12	132.81	0.82	791.92	0.29	0.00

End Shut-In #2

07:49:16	0.25	0.04	132.82	-	-	-	0.38

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
07:49:46	0.75	-0.08	132.77	-	-	-	0.00
07:50:16	1.25	-0.08	132.75	-	-	-	0.00
07:50:46	1.75	0.00	132.81	-	-	-	0.00
07:51:16	2.25	0.08	132.79	-	-	-	0.76
07:51:46	2.75	0.08	132.79	-	-	-	0.76
07:52:16	3.25	-0.08	132.73	-	-	-	0.00
07:52:46	3.75	-0.04	132.81	-	-	-	0.00
07:53:16	4.25	-0.16	132.77	-	-	-	0.00
07:53:46	4.75	0.00	132.79	-	-	-	0.00
07:54:16	5.25	0.28	132.84	-	-	-	2.67
07:54:46	5.75	-0.04	132.81	-	-	-	0.00
07:55:16	6.25	0.44	132.88	-	-	-	4.20
07:55:46	6.75	-0.08	132.86	-	-	-	0.00
07:56:16	7.25	-0.04	132.81	-	-	-	0.00
07:56:46	7.75	0.04	133.02	-	-	-	0.38
07:57:16	8.25	-0.12	132.99	-	-	-	0.00
07:57:46	8.75	0.08	132.97	-	-	-	0.76
07:58:16	9.25	-0.08	132.93	-	-	-	0.00
07:58:46	9.75	-0.08	132.93	-	-	-	0.00
07:59:16	10.25	0.00	132.91	-	-	-	0.00
07:59:46	10.75	-9.42	95.96	-	-	-	0.00
08:00:16	11.25	0.68	95.98	-	-	-	6.48
08:00:46	11.75	-0.44	95.89	-	-	-	0.00
08:01:16	12.25	0.44	96.07	-	-	-	4.19
08:01:46	12.75	0.97	96.11	-	-	-	9.15
08:02:16	13.25	0.80	96.09	-	-	-	7.63
08:02:46	13.75	0.80	96.00	-	-	-	7.63

Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

PRE TEST REPORT

Gas Specific Gravity:	0.65
Formation Depth:	192.50 mKB
Formation Pressure:	1959.65 kPa(g)
Formation Temperature:	8.77 Deg. C
Average Chamber Temperature:	5.89 Deg. C
Initial Chamber Surface Pressure:	90.00 kPa(a)
Initial Gas/N2 Head Pressure:	92.13 kPa(a)
Initial Total Cushion Pressure:	92.13 kPa(a)
Initial Cushion Length:	0.00 m
Liquid Cushion Gradient:	0.00 kPA/m
Down Hole Choke Diameter:	19.05 mm
Down Hole Choke Coefficient:	38.81 m3/D/kPa
Surface Choke Diameter:	Unspecified
Surface Choke Coefficient:	12.85 m3/D/kPa
Drill Collar Length:	91.86 m
Drill Collar I.D.:	57.00 mm
Drill Collar Capacity:	0.002552 m3/m
Drill Collar Volume:	0.234405 m3
Upper Drill Pipe Length:	75.28 m
Upper Drill Pipe I.D.:	83.00 mm
Upper Drill Pipe Capacity:	0.005411 m3/m
Upper Drill Pipe Volume:	0.407311 m3
Total Chamber Volume:	0.64 m3
Liquid Cushion Volume:	0.00 m3
Net Chamber Volume:	0.64 m3

	Max. Rate	Max. Surface Dp/Dt
Gas:	95543.29 m3/D	10132.87 kPa/min
Gas Saturated H2O:	740.87 m3/D	180.94 kPa/min
Pure Liquid Influx:	740.87 m3/D	78.57 kPa/min

	Initial Conversion Factors
Gas:	9.43 m3/D/kPa/min
Gas Saturated H2O:	4.09 m3/D/kPa/min
Pure Liquid Influx:	9.43 m3/D/kPa/min

Delta-P Test Corp.

Cenovus Energy Inc.
January 6, 2013

CVE Germain	1AA / 09-03-083-22 W4M	DST #	1
Empress	180.00 to 205.00 mKB	AFE#:	12149519
		Job# :	2030

Pipe Tally Sheet

Drill Collars		Heavy Weight		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe	
1	9.58	xo	0.25	1	9.38	11		21		31		41	
2	9.26	2		2	9.26	12		22		32		42	
3	9.09	3		3	9.44	13		23		33		43	
4	9.03	4		4	9.47	14		24		34		44	
5	8.89	5		5	9.40	15		25		35		45	
6	9.05	6		6	9.38	16		26		36		46	
7	8.82	7		7	9.48	17		27		37		47	
8	9.32	8		8	9.47	18		28		38		48	
9	9.20	9		9		19		29		39		49	
10	9.62	10		10		20		30		40		50	
DC	91.86	**HW**	0.25	**1**	75.28	**2**	0.00	**3**	0.00	**4**	0.00	**5**	0.00

Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe Total	
51		61		71		81		91		101		**1**	75.28
52		62		72		82		92		102		**2**	0.00
53		63		73		83		93		103		**3**	0.00
54		64		74		84		94		104		**4**	0.00
55		65		75		85		95		105		**5**	0.00
56		66		76		86		96		106		**6**	0.00
57		67		77		87		97		107		**7**	0.00
58		68		78		88		98		108		**8**	0.00
59		69		79		89		99		109		**9**	0.00
60		70		80		90		100		110		**10**	0.00
6	0.00	**7**	0.00	**8**	0.00	**9**	0.00	**10**	0.00	**11**	0.00	**11**	0.00
												Stabbing Valve	0.40

Before Test in Derrick		At Test Depth	In	Out	Total
Total Drill Collars	10	Total Drill Collars	10		10
Total Heavy Weight	0	Total Heavy Weight	0		0
Total Drill Pipe	9	Total Drill Pipe	8	1	9

Total DP	75.68
Total DC	91.86
Total HWT	0.25
Tool to Bottom of Top Packer	19.91
Total Strings Above Interval	187.70
Top of Interval Depth	180.00
Top Single Above Table	7.70

Procedures for running in hole with DST tools:

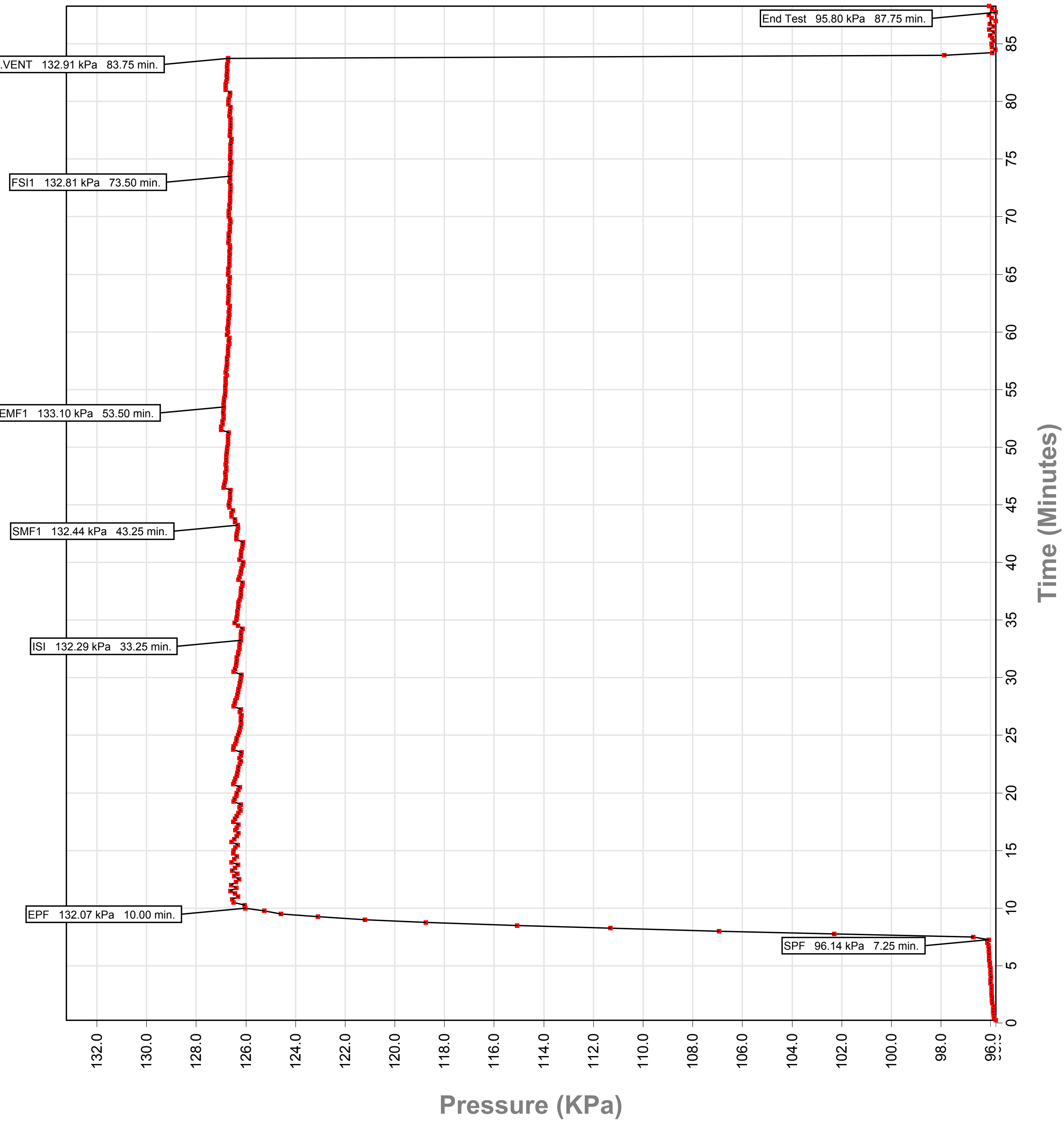
1. Run tools in slowly to avoid surge pressures
2. Do not rotate drill string
3. Pump out sub must be placed on top of first drill collar
4. Notify DST Supervisor for following conditions:
  a. If hole gets tight running in or out
  b. If a bridge is encountered
  c. If any fluid is encountered in pipe

By signing below, I certify that I am the authorized representative of the above named Operator. I have reviewed the drill pipe tally as shown above and agree that it is correct to the best of my knowledge. On behalf of the above named Operator, I agree to accept responsibility for the Drill Stem Test tools after they are placed below the table into the wellbore and will pay the actual cost of replacement, repair, or any recovery operations of the above mentioned Drill Stem Test Tools.

Company Representative:____________________________________

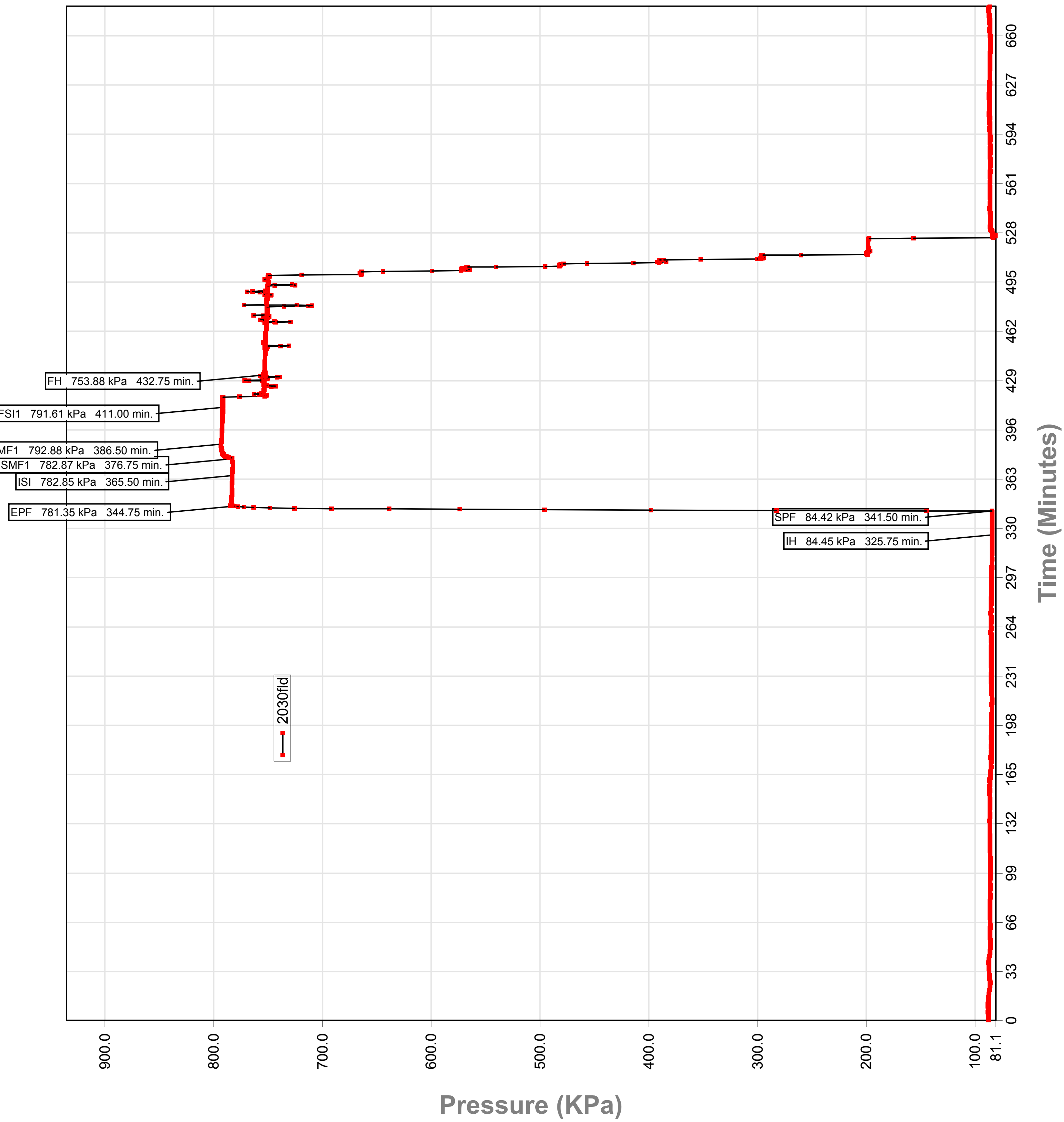
Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

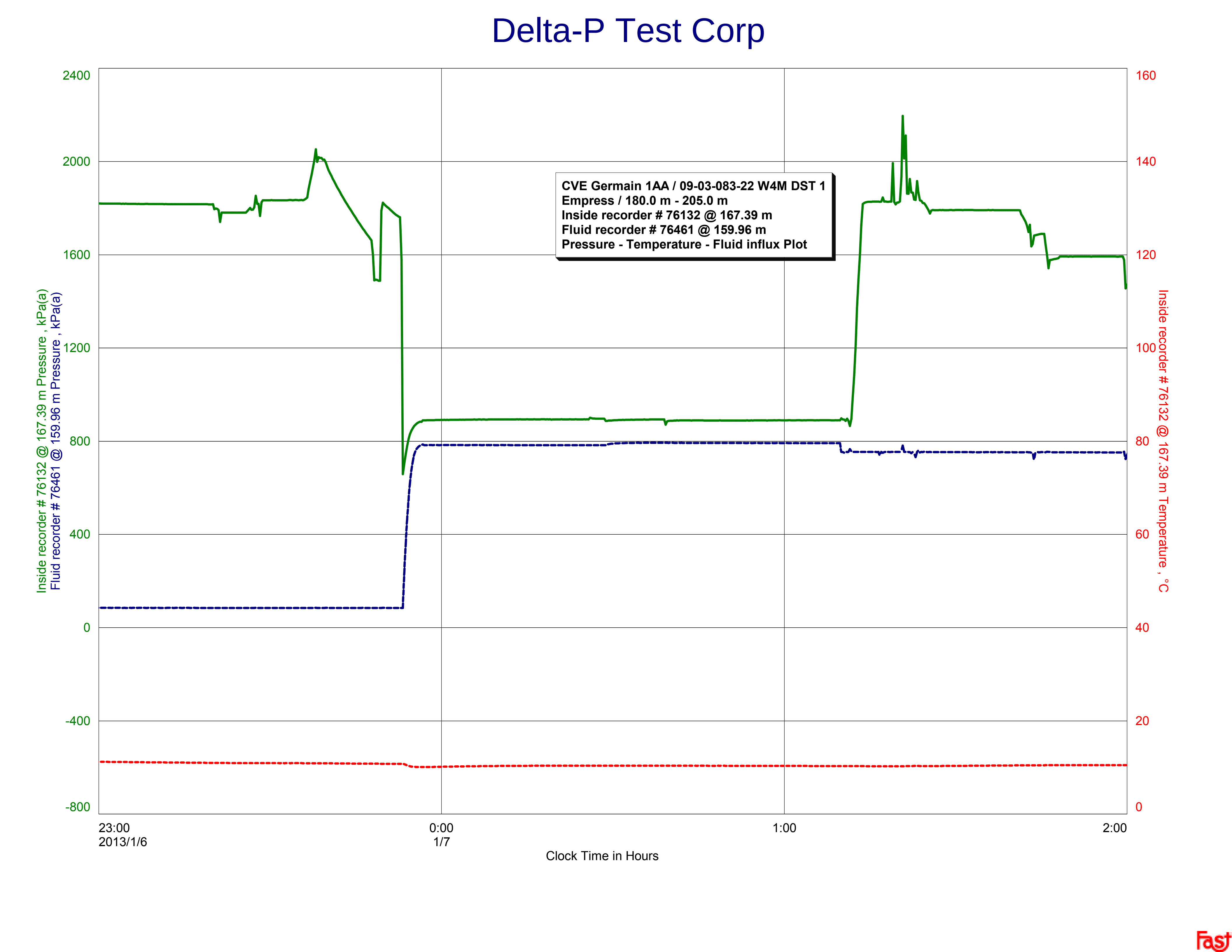
SURFACE PRESSURE CHART



Sunday, January 06, 2013
Cenovus Germain
9-3-83-22-W4M
Empress / 180 m - 205 m
DST #1

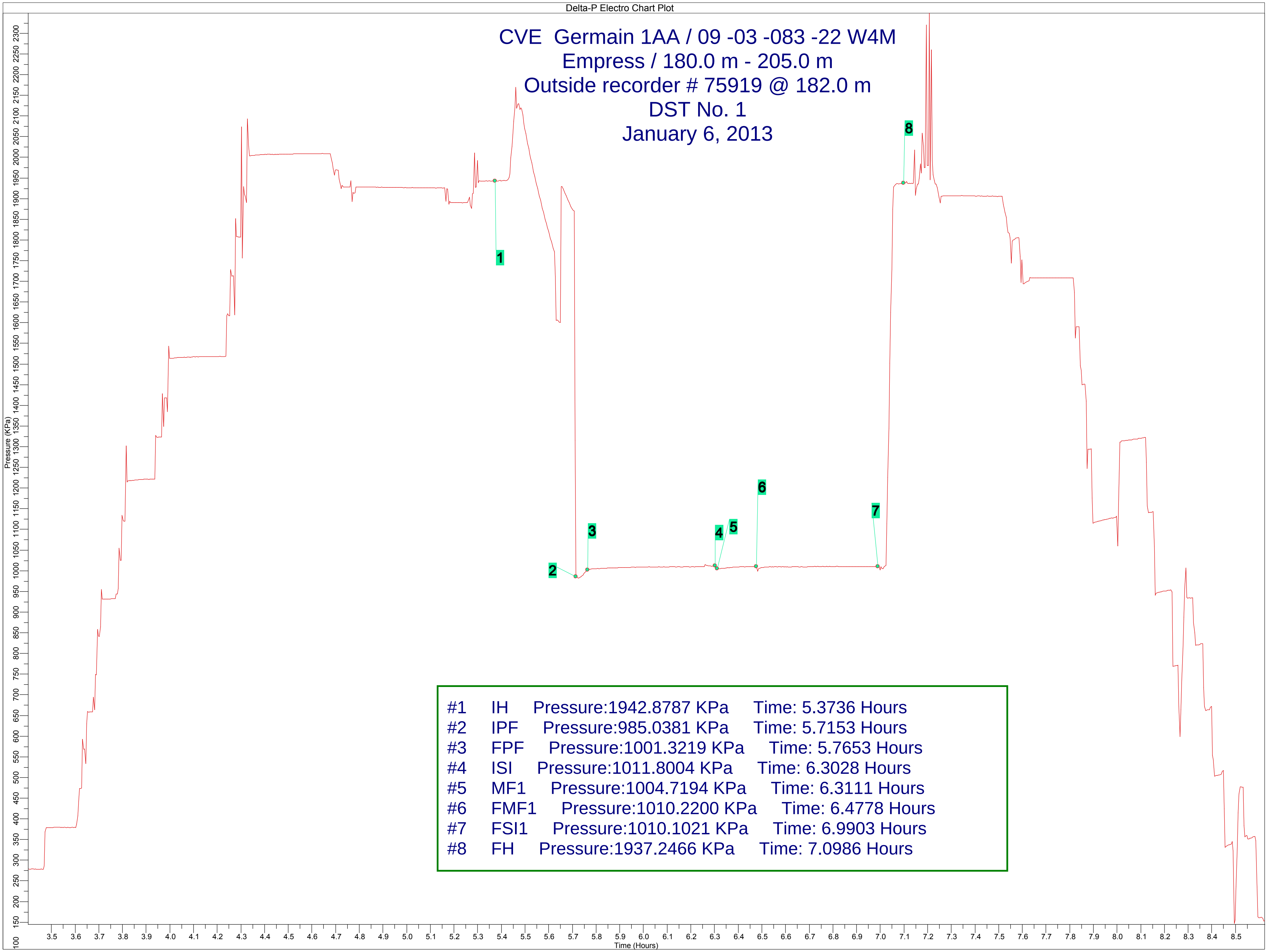
DOWNHOLE PRESSURE CHART



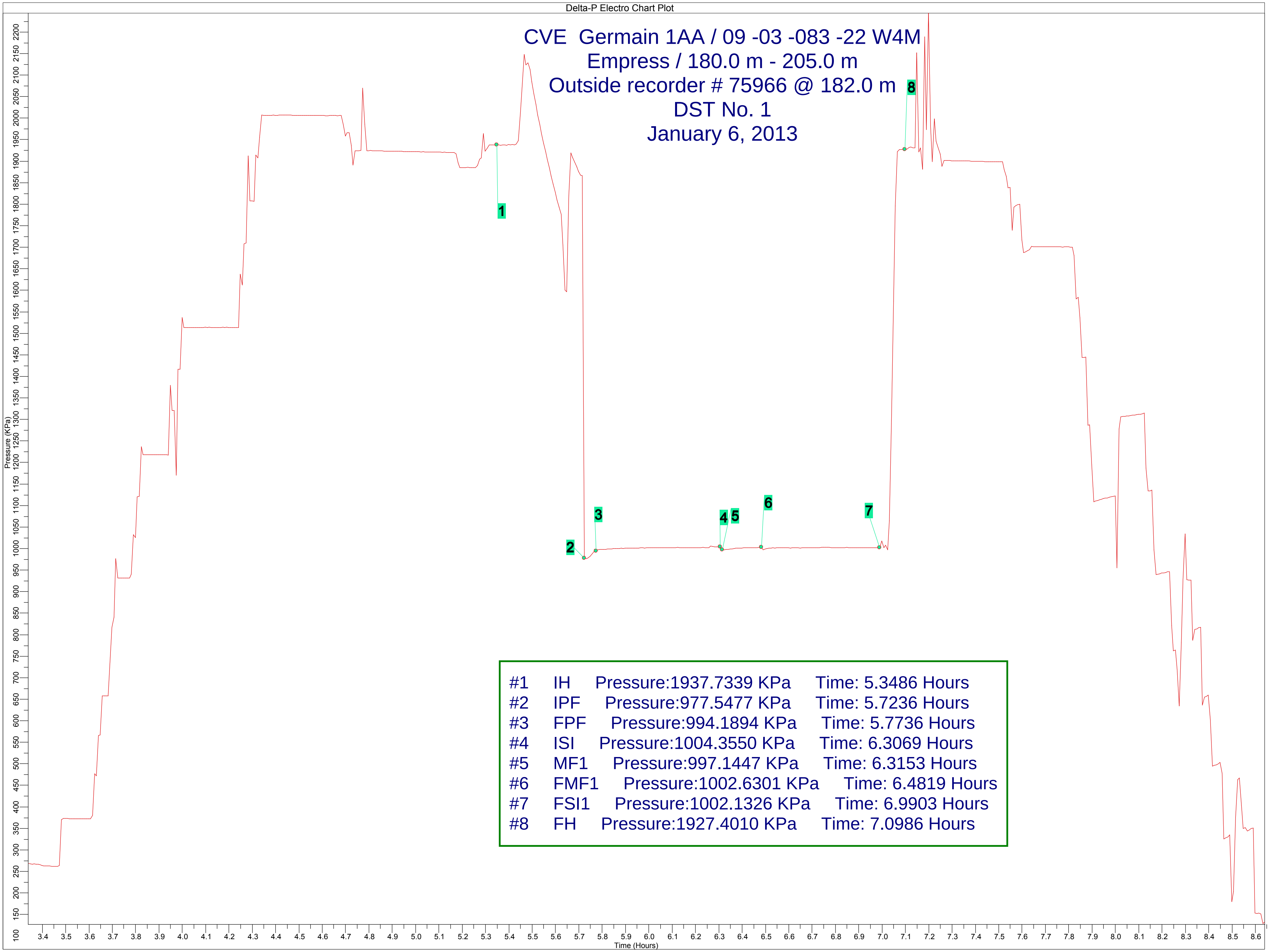


Delta-P Test Corp
CVE Germain 1AA / 09-03-083-22 W4M DST 1
Empress / 180.0 m - 205.0 m
Inside recorder # 76132 @ 167.39 m
Fluid recorder # 76461 @ 159.96 m
Pressure - Temperature - Fluid influx Plot
Inside recorder # 76132 @ 167.39 m Pressure , kPa(a)
Fluid recorder # 76461 @ 159.96 m Pressure , kPa(a)
Inside recorder # 76132 @ 167.39 m Temperature , °C
2400
2000
1600
1200
800
400
0
-400
-800
160
140
120
100
80
60
40
20
0
23:00
2013/1/6
0:00
1/7
1:00
2:00
Clock Time in Hours

Delta-P Test Corp



Delta-P test Corp



Drill Stem Test Report

Cenovus Energy Inc.

January 10, 2013

CVE Germain	1AA/9-3-083-22 W4M			DST #	4
Lean zone/transitioı	230.00	- 238.50	mKB	AFE#:	12149519
Well License:	449655			Invoice# :	2033

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

CLOSED CHAMBER REPORT SUMMARY

FLOW AND SHUT-IN TIMES (minutes)

Flow #1	= 2.0	Shut-In #1	= 60.0
Flow #2	= 2.3	Shut-In #2	= 60.0

FLOW RATES (m3/D)

		GAS	LIQUID
Flow #1	initial	0.00	60.00
	final	0.00	50.00
Flow #2	initial	0.00	40.00
	final	0.00	25.00

RECOVERY

LENGTH (m)	VOLUME (m3)	LIQUID DENSITY	DESCRIPTION
45.00	0.11	9.67	Water
45	0.11	9.67 (avg)	TOTAL RECOVERY

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

COMMENTS

Surface pressures and flow rates for all phases of production have been recorded on a minute by minute basis throughout both flow periods. The results in both tabular and graphical form are contained in the following report. In summary, water (40 m3/D decreasing to 25 m3/D), with no trace of gas, was produced throughout both flow periods. The preflow and main flow were shortened to 2 minutes to prevent the zone from killing itself from the hydrostatic pressure of the water produced.

The top of the recovery was encountered at 45 m above the test tool and consisted of 45 meters of water.

Analysis for liquid influx during this test was undertaken utilizing pressure data from the liquid recovery recorder # 76461 in conjunction with the surface pressure data. An iterative method of calculation has been employed that compares the two data files every fifteen seconds. A simple computation using the reported recovery indicates a recovery gradient of 9.67 kPa/m which is reasonable for muddy water and the reported recovery is therefore verified. Detailed calculations for each flow period show that 28.62 meters (0.073 m3) entered the chamber during the preflow and 16.32 meters (0.041 m3) entered during the main flow.

Detailed rates for both phases may be found in the following tables.

All electronic recorders have been converted and included in this report.

The bottom hole temperature was recorded as 7 degrees Celsius.

Delta-P Test Corp.

Cenovus Energy Inc.
January 10, 2013

CVE Germain	**1AA/9-3-083-22 W4M**	**DST #**	**4**
Lean zone/transition	**230.00 to 238.50 mKB**	**AFE#:**	**1.2E+07**
		Job# :	**2033**

General Information

Well License	449655	**Test Type**	Inflate Straddle		
Client Representative	Dave Shaffer	**Total Depth**	261.0 m	**Hole Condition**	Fair
Phone Number	403-804-8242	**K.B Elevation**	631.85 m	**Hole Deviation**	No
Head Office Contact		**Ground Elevation**	627.20 m	**Cushion?**	No
Office Phone Number		**Drill Pipe I.D.**	82.00 mm	**Tool Chased?**	No
Office Fax Number		**Heavy Weight I.D.**	0.00 mm	**Mud Drop?**	No
DST Supervisor	Glen Miller	**Drill Collar I.D.**	57.00 mm	**Mud Type**	Gel/chem
DST Unit #	908	**Bore Hole Size**	159.00 mm	**Mud Weight**	1060 kg/m3
DST Unit Phone #	(780) 814-4702	**Element Rubber**	139.00 mm	**Mud Viscosity**	45 s/l
Drilling Contractor	P.D	**Bottom Hole Choke**	19.05 mm	**Water Loss**	9.0 cm3
Rig #	160			**Mud Hydrostatic**	10.40 kPa/m

Preflow Comments:

See Delta-P closed chamber report for flow data.
No gas to surface

Main flow Comments:

See Delta-P closed chamber report for flow data.
No gas to surface

Additional Comments:

Recovery Information

Lab Company Maxxam Labs
Total Fluid Recovered 45 m

Length		Description	Salinity (ppm)	pH
45 m	of	water		

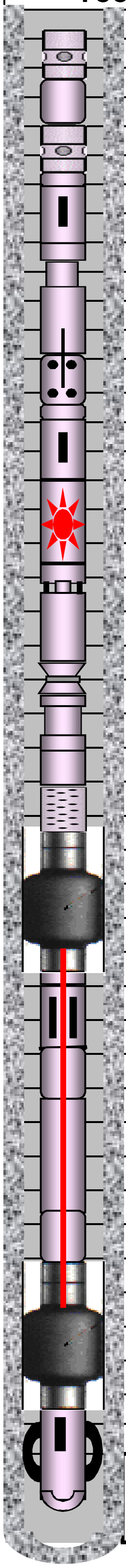
Total Fluid Samples (Including mud tank sample) 7 Sample Bottles

Bottom Hole Sampler Serial Numbers:	E.D#1	E.D#2
Gas Bomb Serial Number(s) Preflow		
Gas Bomb Serial Number(s) Main flow		
Gas Bomb Serial Number(s) Third flow		

Delta-P Test Corp.

Cenovus Energy Inc.
January 10, 2013

CVE Germain	**1AA/9-3-083-22 W4M**	**DST # 4**
Lean zone/transition	**230.00 to 238.50 mKB**	**AFE#: 12149519**
		Job# : 2033



Tool Description

Tool Description	Length (m)	Ser#
Marker Sub	0.00	
Pump Out Sub (Pin Act.)	0.31	
Cross Over Sub	0.00	
Pump Out Sub (Press. Act)	0.31	
Fluid Recorder	1.31	76461
Hydraulic Shut-in Tool	2.06	
Fluid Sampler	1.00	E.D#1
Inside Recorder	1.31	76132
WTD Recorder	4.82	
Jars	1.82	
Safety Joint	0.69	
Pump	2.55	
Screen	1.05	
Top Packer	1.67	
T.C.	0.72	
Bundle Carrier	1.25	
Outside #1		75919
Outside #2		75966
Inflate Recorder		75845
Blank Spacing	6.00	
Crossover Sub	0.00	
Drill Collars	0.00	
Crossover Sub	0.00	
Stub	0.55	
Bottom Packer	1.71	
Below Straddle Recorder		75516
Belly Spring	2.20	

Tool Above Interval	19.9	m
DST Tool Length	32.33	m
Test Interval Length	8.52	m

Test Time, Pressure, and Flow Summary

Recorder: Outside #1 **Recorder Ser #** 75919 **Depth** 232 m

Times

Preflow :	2:45:00	to	2:47:00	**Duration:**	2.0	min.
Mainflow:	3:51:00	to	3:53:00	**Duration:**	2.0	min.
Initial Shutin :	2:47:00	to	3:51:00	**Duration:**	64.0	min.
Final Shutin:	3:53:00	to	4:53:00	**Duration:**	60.0	min.

Pressures (kPa)

Preflow:	494 kPa	to	600 kPa	**Initial Shutin:**	945 kPa
Mainflow :	636 kPa	to	741 kPa	**Final Shutin:**	947 kPa
Thirdflow:	kPa	to	kPa	**Third Shutin:**	kPa
Initial Hydrostatic:	2523 kPa			**Final Hydrostatic:**	2502 kPa

MAINFLOW: Gas Flow Rates

Time	Orfice Size	Flow Pressure	Flow Rates
5 min	mm	kPa	m3/D
10 min	mm	kPa	m3/D
15 min	mm	kPa	m3/D
20 min	mm	kPa	m3/D
25 min	mm	kPa	m3/D
30 min	mm	kPa	m3/D
35 min	mm	kPa	m3/D
40 min	mm	kPa	m3/D
45 min	mm	kPa	m3/D
50 min	mm	kPa	m3/D
55 min	mm	kPa	m3/D
60 min	mm	kPa	m3/D
65 min	mm	kPa	m3/D
70 min	mm	kPa	m3/D
75 min	mm	kPa	m3/D
80 min	mm	kPa	m3/D
85 min	mm	kPa	m3/D
90 min	mm	kPa	m3/D
95 min	mm	kPa	m3/D
100 min	mm	kPa	m3/D
105 min	mm	kPa	m3/D
110 min	mm	kPa	m3/D
115 min	mm	kPa	m3/D
120 min	mm	kPa	m3/D

Test Tool String Weights

Tool Weight	2000	daN	**Hole Drag Down**	0	daN
Initial String Weight	10000	daN	**Hole Drag Up**	0	daN
Unseated String	10000	daN	**Weight to Open**	5000	daN

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

FLOW DATA

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
Start Flow #1							
02:43:52	0.00	-0.08	99.30	-	-	-	0.00
02:44:07	0.25	6.29	100.86	0.00	84.80	0.00	0.00
02:44:22	0.50	6.77	102.54	69.22	102.11	0.00	89.02
02:44:37	0.75	3.75	103.47	172.83	145.32	59.53	0.00
02:44:52	1.00	4.88	104.68	191.00	193.07	70.84	0.00
02:45:07	1.25	5.80	106.12	182.22	238.62	67.02	1.19
02:45:22	1.50	4.47	107.23	180.99	283.87	67.17	0.00
02:45:37	1.75	2.66	107.89	154.51	322.50	57.76	0.00
02:45:52	2.00	5.16	109.17	115.85	351.46	42.18	16.24
End Flow #1							
02:46:07	0.25	2.42	109.77	0.00	360.01	0.00	0.00
02:46:22	0.50	-0.73	109.59	11.65	362.92	4.70	0.00
02:46:37	0.75	-0.28	109.52	-1.64	362.51	0.00	0.00
02:46:52	1.00	-0.28	109.45	-1.84	362.05	0.00	0.00
02:47:07	1.25	0.00	109.45	-0.78	361.86	0.00	0.00
02:47:22	1.50	1.53	109.83	-0.23	361.80	0.00	19.36
02:47:37	1.75	-0.16	109.79	-0.41	361.70	0.00	0.00
02:47:52	2.00	-0.28	109.72	-0.40	361.60	0.00	0.00
02:48:07	2.25	-0.32	109.64	-0.87	361.38	0.00	0.00
02:48:22	2.50	-0.28	109.57	-0.87	361.17	0.00	0.00
02:48:37	2.75	0.00	109.57	-0.32	361.09	0.00	0.00
02:48:52	3.00	-0.20	109.52	-0.32	361.00	0.00	0.00
02:49:07	3.25	1.25	109.83	-0.93	360.77	0.00	16.25
02:49:22	3.50	-0.08	109.81	-0.07	360.76	0.00	0.00
02:49:37	3.75	-0.16	109.77	0.46	360.87	0.29	0.00
02:49:52	4.00	-0.12	109.74	-0.71	360.69	0.00	0.00
02:50:07	4.25	-0.16	109.70	0.33	360.78	0.15	0.00
02:50:22	4.50	-0.08	109.68	-0.65	360.61	0.00	0.00
02:50:37	4.75	-0.08	109.66	-0.20	360.56	0.00	0.00
02:50:52	5.00	-0.20	109.61	1.24	360.87	0.44	0.00
02:51:07	5.25	-0.16	109.57	2.56	361.51	1.03	0.00
02:51:22	5.50	0.00	109.57	2.53	362.15	1.03	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
02:51:37	5.75	-0.12	109.54	0.73	362.33	0.29	0.00
02:51:52	6.00	0.00	109.54	0.49	362.45	0.15	0.00
02:52:07	6.25	1.25	109.85	0.46	362.57	0.00	15.58
02:52:22	6.50	-0.16	109.81	-0.30	362.49	0.00	0.00
02:52:37	6.75	0.00	109.81	-0.78	362.30	0.00	0.00
02:52:52	7.00	-0.16	109.77	0.09	362.32	0.15	0.00
02:53:07	7.25	-0.12	109.74	0.14	362.36	0.00	0.00
02:53:22	7.50	0.00	109.74	0.24	362.42	0.15	0.00
02:53:37	7.75	-0.08	109.72	0.21	362.47	0.15	0.00
02:53:52	8.00	-0.16	109.68	-0.08	362.45	0.00	0.00
02:54:07	8.25	0.00	109.68	0.51	362.58	0.15	0.00
02:54:22	8.50	-0.08	109.66	0.28	362.65	0.15	0.00
02:54:37	8.75	-0.12	109.63	-0.29	362.57	0.00	0.00
02:54:52	9.00	-0.24	109.57	-0.34	362.49	0.00	0.00
02:55:07	9.25	0.24	109.63	-0.32	362.41	0.00	3.28
02:55:22	9.50	-0.16	109.59	-0.03	362.40	0.00	0.00
02:55:37	9.75	-0.16	109.55	-0.17	362.36	0.00	0.00
02:55:52	10.00	0.00	109.55	-0.07	362.34	0.00	0.00
02:56:07	10.25	1.05	109.81	-0.43	362.23	0.00	13.45
02:56:22	10.50	-0.08	109.79	0.19	362.28	0.15	0.00
02:56:37	10.75	-0.08	109.77	-0.10	362.26	0.00	0.00
02:56:52	11.00	-0.12	109.74	0.53	362.39	0.29	0.00
02:57:07	11.25	-0.08	109.72	-0.01	362.39	0.00	0.00
02:57:22	11.50	-0.16	109.68	-0.05	362.38	0.00	0.00
02:57:37	11.75	0.08	109.70	0.06	362.39	0.00	0.98
02:57:52	12.00	-0.16	109.66	-0.04	362.38	0.00	0.00
02:58:07	12.25	0.00	109.66	-0.02	362.37	0.00	0.00
02:58:23	12.50	-0.08	109.64	-0.14	362.34	0.00	0.00
02:58:38	12.75	0.00	109.64	0.15	362.38	0.15	0.00
02:58:53	13.00	-0.04	109.63	0.36	362.47	0.15	0.00
02:59:08	13.25	-0.08	109.61	0.34	362.55	0.15	0.00
02:59:23	13.50	-0.08	109.59	-0.58	362.41	0.00	0.00
02:59:38	13.75	0.00	109.59	-0.16	362.37	0.00	0.00
02:59:53	14.00	-0.16	109.55	-0.14	362.33	0.00	0.00
03:00:08	14.25	-0.04	109.54	-0.11	362.31	0.00	0.00
03:00:23	14.50	-0.08	109.52	-0.18	362.26	0.00	0.00
03:00:38	14.75	-0.08	109.50	0.06	362.28	0.00	0.00
03:00:53	15.00	0.36	109.59	-0.09	362.25	0.00	4.59
03:01:08	15.25	0.00	109.59	0.46	362.37	0.15	0.00
03:01:23	15.50	-0.20	109.54	0.13	362.40	0.15	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:01:38	15.75	0.04	109.55	-0.61	362.25	0.00	0.82
03:01:53	16.00	0.00	109.55	0.15	362.29	0.15	0.00
03:02:08	16.25	0.00	109.55	0.14	362.32	0.00	0.00
03:02:23	16.50	-0.12	109.52	-0.59	362.18	0.00	0.00
03:02:38	16.75	0.00	109.52	0.02	362.18	0.00	0.00
03:02:53	17.00	0.00	109.52	0.06	362.20	0.00	0.00
03:03:08	17.25	-0.08	109.50	-0.01	362.20	0.00	0.00
03:03:23	17.50	0.97	109.74	0.17	362.24	0.00	12.14
03:03:38	17.75	0.73	109.92	0.36	362.33	0.00	9.02
03:03:53	18.00	-0.16	109.88	-0.00	362.33	0.00	0.00
03:04:08	18.25	-0.12	109.85	-0.02	362.32	0.00	0.00
03:04:23	18.50	-0.24	109.79	-0.68	362.15	0.00	0.00
03:04:38	18.75	0.16	109.83	0.61	362.31	0.15	1.80
03:04:53	19.00	-0.24	109.77	0.35	362.39	0.15	0.00
03:05:08	19.25	0.16	109.81	-0.56	362.25	0.00	2.13
03:05:23	19.50	-0.16	109.77	0.04	362.26	0.00	0.00
03:05:38	19.75	0.00	109.77	-0.18	362.22	0.00	0.00
03:05:53	20.00	0.00	109.77	-0.08	362.20	0.00	0.00
03:06:08	20.25	-0.04	109.76	0.03	362.20	0.15	0.00
03:06:23	20.50	0.00	109.76	0.48	362.33	0.15	0.00
03:06:38	20.75	-0.08	109.74	-0.02	362.32	0.00	0.00
03:06:53	21.00	0.08	109.76	-0.23	362.26	0.00	1.15
03:07:08	21.25	-0.08	109.74	-0.10	362.24	0.00	0.00
03:07:23	21.50	-0.16	109.70	-0.22	362.18	0.00	0.00
03:07:38	21.75	-0.08	109.68	0.14	362.22	0.15	0.00
03:07:53	22.00	-0.08	109.66	0.15	362.26	0.00	0.00
03:08:08	22.25	0.00	109.66	-0.08	362.23	0.00	0.00
03:08:23	22.50	0.00	109.66	-0.14	362.20	0.00	0.00
03:08:38	22.75	-0.08	109.64	0.04	362.21	0.00	0.00
03:08:53	23.00	-0.04	109.63	-0.31	362.13	0.00	0.00
03:09:08	23.25	0.00	109.63	-0.24	362.07	0.00	0.00
03:09:23	23.50	-0.08	109.61	0.04	362.08	0.00	0.00
03:09:38	23.75	0.00	109.61	-0.04	362.07	0.00	0.00
03:09:53	24.00	-0.16	109.57	0.03	362.08	0.00	0.00
03:10:08	24.25	0.00	109.57	0.27	362.14	0.15	0.00
03:10:23	24.50	0.08	109.59	0.99	362.39	0.29	0.65
03:10:38	24.75	-0.08	109.57	0.35	362.48	0.15	0.00
03:10:53	25.00	-0.08	109.55	-0.91	362.25	0.00	0.00
03:11:08	25.25	0.08	109.57	-0.56	362.11	0.00	1.15
03:11:23	25.50	-0.20	109.52	-0.12	362.08	0.00	0.00
03:11:38	25.75	0.08	109.54	-0.65	361.92	0.00	1.32

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:11:53	26.00	-0.08	109.52	0.51	362.05	0.15	0.00
03:12:08	26.25	0.00	109.52	0.92	362.28	0.44	0.00
03:12:23	26.50	-0.08	109.50	-0.82	362.07	0.00	0.00
03:12:38	26.75	0.00	109.50	0.20	362.12	0.00	0.00
03:12:53	27.00	0.08	109.52	0.41	362.22	0.15	0.82
03:13:08	27.25	-0.08	109.50	-0.41	362.12	0.00	0.00
03:13:23	27.50	-0.16	109.46	-0.40	362.02	0.00	0.00
03:13:38	27.75	-0.04	109.45	0.15	362.06	0.00	0.00
03:13:53	28.00	0.28	109.52	0.13	362.09	0.00	3.44
03:14:08	28.25	-0.16	109.48	-0.46	361.97	0.00	0.00
03:14:23	28.50	0.08	109.50	0.11	362.00	0.00	0.98
03:14:38	28.75	-0.08	109.48	0.09	362.02	0.15	0.00
03:14:53	29.00	-0.08	109.46	-0.19	361.98	0.00	0.00
03:15:08	29.25	0.00	109.46	-0.14	361.94	0.00	0.00
03:15:23	29.50	-0.04	109.45	0.34	362.02	0.15	0.00
03:15:38	29.75	0.28	109.52	-0.04	362.02	0.00	3.61
03:15:53	30.00	-0.08	109.50	0.39	362.11	0.15	0.00
03:16:08	30.25	0.00	109.50	-0.19	362.06	0.00	0.00
03:16:23	30.50	0.00	109.50	-0.46	361.95	0.00	0.00
03:16:38	30.75	0.00	109.50	-0.25	361.89	0.00	0.00
03:16:53	31.00	-0.16	109.46	0.04	361.90	0.15	0.00
03:17:08	31.25	0.00	109.46	0.22	361.95	0.00	0.00
03:17:23	31.50	0.00	109.46	0.08	361.97	0.00	0.00
03:17:38	31.75	-0.04	109.45	0.08	361.99	0.15	0.00
03:17:53	32.00	0.04	109.46	0.19	362.04	0.00	0.49
03:18:08	32.25	1.41	109.81	-0.07	362.03	0.00	17.88
03:18:23	32.50	-0.08	109.79	-0.47	361.91	0.00	0.00
03:18:38	32.75	0.00	109.79	-0.29	361.84	0.00	0.00
03:18:53	33.00	-0.12	109.76	0.78	362.03	0.44	0.00
03:19:08	33.25	-0.08	109.74	0.71	362.21	0.29	0.00
03:19:23	33.50	0.08	109.76	0.03	362.22	0.00	0.98
03:19:38	33.75	-0.08	109.74	-0.13	362.18	0.00	0.00
03:19:53	34.00	0.00	109.74	0.03	362.19	0.00	0.00
03:20:08	34.25	0.08	109.76	-0.21	362.14	0.00	1.15
03:20:23	34.50	-0.08	109.74	-0.24	362.08	0.00	0.00
03:20:38	34.75	0.00	109.74	-0.17	362.03	0.00	0.00
03:20:53	35.00	-0.16	109.70	0.41	362.14	0.15	0.00
03:21:08	35.25	-0.08	109.68	-0.13	362.11	0.00	0.00
03:21:23	35.50	-0.16	109.64	-0.56	361.97	0.00	0.00
03:21:38	35.75	0.00	109.64	-0.11	361.94	0.00	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:21:53	36.00	0.00	109.64	0.16	361.98	0.00	0.00
03:22:08	36.25	0.00	109.64	-0.47	361.86	0.00	0.00
03:22:23	36.50	-0.04	109.63	0.26	361.92	0.15	0.00
03:22:38	36.75	-0.08	109.61	0.11	361.95	0.15	0.00
03:22:53	37.00	0.00	109.61	-0.20	361.90	0.00	0.00
03:23:08	37.25	-0.16	109.57	0.01	361.90	0.00	0.00
03:23:23	37.50	0.00	109.57	0.21	361.96	0.15	0.00
03:23:38	37.75	0.00	109.57	0.08	361.98	0.00	0.00
03:23:53	38.00	0.00	109.57	-0.46	361.86	0.00	0.00
03:24:08	38.25	-0.20	109.52	-0.11	361.83	0.00	0.00
03:24:23	38.50	0.12	109.55	0.61	361.99	0.29	1.14
03:24:38	38.75	-0.04	109.54	0.47	362.10	0.15	0.00
03:24:53	39.00	0.00	109.54	-0.54	361.97	0.00	0.00
03:25:08	39.25	0.00	109.54	-0.07	361.95	0.00	0.00
03:25:23	39.50	-0.08	109.52	-0.46	361.84	0.00	0.00
03:25:38	39.75	-0.08	109.50	-0.61	361.68	0.00	0.00
03:25:53	40.00	0.00	109.50	-0.14	361.65	0.00	0.00
03:26:08	40.25	-0.16	109.46	0.87	361.87	0.29	0.00
03:26:23	40.50	0.00	109.46	0.33	361.95	0.15	0.00
03:26:38	40.75	0.16	109.50	-0.13	361.91	0.00	2.13
03:26:53	41.00	0.00	109.50	0.05	361.93	0.00	0.00
03:27:08	41.25	-0.20	109.45	-0.28	361.86	0.00	0.00
03:27:23	41.50	0.04	109.46	0.41	361.96	0.15	0.33
03:27:38	41.75	0.08	109.48	0.77	362.15	0.29	0.65
03:27:53	42.00	0.00	109.48	-0.52	362.02	0.00	0.00
03:28:08	42.25	-0.08	109.46	-0.88	361.80	0.00	0.00
03:28:23	42.50	0.00	109.46	0.00	361.80	0.00	0.00
03:28:38	42.75	0.00	109.46	0.09	361.83	0.00	0.00
03:28:53	43.00	-0.12	109.43	-0.41	361.72	0.00	0.00
03:29:08	43.25	0.44	109.54	-0.22	361.67	0.00	5.74
03:29:23	43.50	-0.08	109.52	0.07	361.69	0.15	0.00
03:29:38	43.75	-0.16	109.48	0.64	361.85	0.29	0.00
03:29:53	44.00	0.00	109.48	0.26	361.91	0.00	0.00
03:30:08	44.25	0.00	109.48	-0.39	361.81	0.00	0.00
03:30:23	44.50	0.00	109.48	-0.49	361.69	0.00	0.00
03:30:38	44.75	-0.08	109.46	0.32	361.77	0.15	0.00
03:30:53	45.00	-0.12	109.43	0.27	361.84	0.15	0.00
03:31:08	45.25	0.36	109.52	0.01	361.84	0.00	4.59
03:31:23	45.50	0.00	109.52	-0.51	361.71	0.00	0.00
03:31:38	45.75	0.00	109.52	0.11	361.74	0.00	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:31:53	46.00	0.00	109.52	-0.15	361.70	0.00	0.00
03:32:08	46.25	-0.08	109.50	0.08	361.72	0.00	0.00
03:32:24	46.50	1.09	109.77	-0.30	361.65	0.00	13.78
03:32:39	46.75	0.52	109.90	-0.05	361.63	0.00	6.73
03:32:54	47.00	-0.08	109.88	0.58	361.78	0.29	0.00
03:33:09	47.25	0.00	109.88	0.23	361.84	0.00	0.00
03:33:24	47.50	-0.12	109.85	0.36	361.93	0.29	0.00
03:33:39	47.75	-0.08	109.83	-0.37	361.83	0.00	0.00
03:33:54	48.00	0.08	109.85	-0.06	361.82	0.00	0.98
03:34:09	48.25	0.00	109.85	0.07	361.84	0.00	0.00
03:34:24	48.50	0.00	109.85	-0.50	361.71	0.00	0.00
03:34:39	48.75	-0.16	109.81	0.23	361.77	0.15	0.00
03:34:54	49.00	0.00	109.81	0.00	361.77	0.00	0.00
03:35:09	49.25	-0.08	109.79	0.31	361.85	0.15	0.00
03:35:24	49.50	0.08	109.81	0.17	361.89	0.00	0.98
03:35:39	49.75	0.00	109.81	-0.79	361.69	0.00	0.00
03:35:54	50.00	-0.08	109.79	0.34	361.78	0.15	0.00
03:36:09	50.25	0.00	109.79	0.21	361.83	0.00	0.00
03:36:24	50.50	0.00	109.79	0.29	361.90	0.15	0.00

End Shut-In #1

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:36:39	0.25	-0.12	109.76	-	-	-	0.00
03:36:54	0.50	-0.08	109.74	-	-	-	0.00
03:37:09	0.75	0.08	109.76	-	-	-	1.07
03:37:24	1.00	0.04	109.77	-	-	-	0.53
03:37:39	1.25	-0.04	109.76	-	-	-	0.00
03:37:54	1.50	0.00	109.76	-	-	-	0.00
03:38:09	1.75	-0.08	109.74	-	-	-	0.00
03:38:24	2.00	0.00	109.74	-	-	-	0.00
03:38:39	2.25	-0.08	109.72	-	-	-	0.00
03:38:54	2.50	-0.08	109.70	-	-	-	0.00
03:39:09	2.75	0.16	109.74	-	-	-	2.14
03:39:24	3.00	-0.16	109.70	-	-	-	0.00
03:39:39	3.25	0.00	109.70	-	-	-	0.00
03:39:54	3.50	-0.08	109.68	-	-	-	0.00
03:40:09	3.75	0.08	109.70	-	-	-	1.07
03:40:24	4.00	-0.08	109.68	-	-	-	0.00
03:40:39	4.25	0.16	109.72	-	-	-	2.14
03:40:54	4.50	-0.16	109.68	-	-	-	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:41:09	4.75	-0.08	109.66	-	-	-	0.00
03:41:24	5.00	-0.08	109.64	-	-	-	0.00
03:41:39	5.25	-0.04	109.63	-	-	-	0.00
03:41:54	5.50	0.12	109.66	-	-	-	1.60
03:42:09	5.75	0.00	109.66	-	-	-	0.00
03:42:24	6.00	0.00	109.66	-	-	-	0.00
03:42:39	6.25	-0.12	109.63	-	-	-	0.00
03:42:54	6.50	0.04	109.64	-	-	-	0.53
03:43:09	6.75	0.00	109.64	-	-	-	0.00
03:43:24	7.00	-0.12	109.61	-	-	-	0.00
03:43:39	7.25	0.00	109.61	-	-	-	0.00
03:43:54	7.50	-0.08	109.59	-	-	-	0.00
03:44:09	7.75	0.08	109.61	-	-	-	1.07
03:44:24	8.00	0.08	109.63	-	-	-	1.07
03:44:39	8.25	-0.08	109.61	-	-	-	0.00
03:44:54	8.50	0.08	109.63	-	-	-	1.07
03:45:09	8.75	-0.08	109.61	-	-	-	0.00
03:45:24	9.00	-0.08	109.59	-	-	-	0.00
03:45:39	9.25	0.20	109.64	-	-	-	2.67
03:45:54	9.50	-0.04	109.63	-	-	-	0.00
03:46:09	9.75	-0.08	109.61	-	-	-	0.00
03:46:24	10.00	0.00	109.61	-	-	-	0.00
03:46:39	10.25	0.00	109.61	-	-	-	0.00
03:46:54	10.50	-0.08	109.59	-	-	-	0.00
03:47:09	10.75	-0.08	109.57	-	-	-	0.00
03:47:24	11.00	0.08	109.59	-	-	-	1.07
03:47:39	11.25	0.08	109.61	-	-	-	1.07
03:47:54	11.50	0.12	109.64	-	-	-	1.60
03:48:09	11.75	-0.04	109.63	-	-	-	0.00
03:48:24	12.00	0.00	109.63	-	-	-	0.00
03:48:39	12.25	0.00	109.63	-	-	-	0.00
03:48:54	12.50	0.00	109.63	-	-	-	0.00
03:49:09	12.75	-0.08	109.61	-	-	-	0.00
03:49:24	13.00	0.00	109.61	-	-	-	0.00
03:49:39	13.25	-0.08	109.59	-	-	-	0.00

Start Flow #2

03:49:54	0.00	0.00	109.59	-	-	-	0.00
03:50:09	0.25	4.35	110.67	0.00	362.08	0.00	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:50:24	0.50	3.38	111.51	64.15	378.12	23.08	14.81
03:50:39	0.75	5.16	112.79	129.24	410.42	47.18	7.82
03:50:54	1.00	3.30	113.61	107.27	437.24	39.54	0.00
03:51:09	1.25	3.18	114.40	94.54	460.88	34.69	0.00
03:51:24	1.50	2.05	114.91	86.77	482.57	32.34	0.00
03:51:39	1.75	2.42	115.51	74.00	501.07	27.19	0.00
03:51:54	2.00	3.02	116.26	68.64	518.23	24.99	5.39
03:52:09	2.25	1.57	116.65	57.87	532.70	21.31	0.00

End Flow #2

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:52:24	0.25	-0.32	116.57	0.00	537.49	0.00	0.00
03:52:39	0.50	-0.44	116.46	1.25	537.80	0.59	0.00
03:52:54	0.75	-0.44	116.35	0.50	537.93	0.44	0.00
03:53:09	1.00	0.97	116.59	0.06	537.94	0.00	11.72
03:53:24	1.25	-0.16	116.55	0.12	537.97	0.15	0.00
03:53:39	1.50	-0.20	116.50	0.50	538.10	0.29	0.00
03:53:54	1.75	0.16	116.54	0.44	538.21	0.15	1.69
03:54:09	2.00	-0.40	116.44	-0.16	538.17	0.00	0.00
03:54:24	2.25	-0.12	116.41	-0.46	538.05	0.00	0.00
03:54:39	2.50	0.00	116.41	-0.08	538.03	0.00	0.00
03:54:54	2.75	0.20	116.46	0.48	538.15	0.15	2.15
03:55:09	3.00	1.65	116.87	0.73	538.34	0.00	19.64
03:55:24	3.25	-0.24	116.81	0.26	538.40	0.29	0.00
03:55:39	3.50	-0.12	116.78	-0.56	538.26	0.00	0.00
03:55:54	3.75	-0.24	116.72	-0.20	538.21	0.00	0.00
03:56:09	4.00	0.00	116.72	0.06	538.22	0.00	0.00
03:56:24	4.25	-0.36	116.63	-0.02	538.22	0.00	0.00
03:56:39	4.50	0.00	116.63	-0.38	538.12	0.00	0.00
03:56:54	4.75	-0.16	116.59	-0.50	538.00	0.00	0.00
03:57:09	5.00	-0.08	116.57	0.72	538.18	0.29	0.00
03:57:24	5.25	-0.12	116.54	0.58	538.33	0.29	0.00
03:57:39	5.50	0.12	116.57	-0.00	538.32	0.00	1.58
03:57:54	5.75	-0.08	116.55	-0.23	538.27	0.00	0.00
03:58:09	6.00	0.00	116.55	0.53	538.40	0.15	0.00
03:58:24	6.25	-0.04	116.54	-0.20	538.35	0.00	0.00
03:58:39	6.50	0.20	116.59	-0.20	538.30	0.00	2.51
03:58:54	6.75	-0.20	116.54	0.13	538.33	0.15	0.00
03:59:09	7.00	-0.08	116.52	0.09	538.35	0.00	0.00
03:59:24	7.25	-0.16	116.48	-0.24	538.29	0.00	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
03:59:39	7.50	-0.08	116.46	-0.29	538.22	0.00	0.00
03:59:54	7.75	-0.20	116.41	0.70	538.39	0.44	0.00
04:00:09	8.00	0.12	116.44	-0.08	538.37	0.00	1.57
04:00:24	8.25	0.16	116.48	-0.35	538.29	0.00	2.04
04:00:39	8.50	0.08	116.50	-0.15	538.25	0.00	1.11
04:00:54	8.75	0.00	116.50	0.19	538.30	0.15	0.00
04:01:09	9.00	0.28	116.57	-0.05	538.29	0.00	3.44
04:01:24	9.25	-0.08	116.55	0.12	538.32	0.15	0.00
04:01:39	9.50	-0.04	116.54	0.42	538.42	0.15	0.00
04:01:54	9.75	-0.08	116.52	0.27	538.49	0.15	0.00
04:02:09	10.00	1.61	116.92	0.01	538.49	0.00	19.53
04:02:24	10.25	-0.16	116.88	-0.09	538.47	0.00	0.00
04:02:39	10.50	-0.04	116.87	-0.06	538.46	0.00	0.00
04:02:54	10.75	0.00	116.87	-0.30	538.38	0.00	0.00
04:03:09	11.00	-0.16	116.83	0.44	538.49	0.15	0.00
04:03:24	11.25	-0.16	116.79	0.12	538.52	0.15	0.00
04:03:39	11.50	-0.12	116.76	-0.31	538.44	0.00	0.00
04:03:54	11.75	-0.08	116.74	-0.06	538.43	0.00	0.00
04:04:09	12.00	0.16	116.78	-0.39	538.33	0.00	2.22
04:04:24	12.25	0.04	116.79	-0.24	538.27	0.00	0.47
04:04:39	12.50	-0.12	116.76	0.02	538.27	0.00	0.00
04:04:54	12.75	-0.08	116.74	-0.08	538.25	0.00	0.00
04:05:09	13.00	0.08	116.76	-0.12	538.22	0.00	1.11
04:05:24	13.25	-0.08	116.74	0.39	538.32	0.29	0.00
04:05:39	13.50	-0.08	116.72	0.67	538.49	0.29	0.00
04:05:54	13.75	-0.24	116.66	-0.23	538.43	0.00	0.00
04:06:09	14.00	0.00	116.66	-0.50	538.31	0.00	0.00
04:06:24	14.25	-0.12	116.63	-0.28	538.24	0.00	0.00
04:06:39	14.50	0.00	116.63	0.06	538.25	0.00	0.00
04:06:55	14.75	0.00	116.63	0.04	538.26	0.00	0.00
04:07:10	15.00	-0.16	116.59	0.19	538.31	0.15	0.00
04:07:25	15.25	0.00	116.59	-0.04	538.30	0.00	0.00
04:07:40	15.50	-0.08	116.57	0.05	538.31	0.00	0.00
04:07:55	15.75	-0.08	116.55	-0.02	538.31	0.00	0.00
04:08:10	16.00	0.24	116.61	-0.20	538.26	0.00	2.97
04:08:25	16.25	0.00	116.61	0.04	538.27	0.00	0.00
04:08:40	16.50	0.00	116.61	0.26	538.33	0.15	0.00
04:08:55	16.75	-0.08	116.59	-0.00	538.33	0.00	0.00
04:09:10	17.00	-0.08	116.57	-0.01	538.33	0.00	0.00
04:09:25	17.25	-0.08	116.55	0.04	538.34	0.15	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
04:09:40	17.50	0.00	116.55	-0.02	538.34	0.00	0.00
04:09:55	17.75	0.40	116.65	-0.31	538.26	0.00	5.01
04:10:10	18.00	-0.24	116.59	-0.07	538.24	0.00	0.00
04:10:25	18.25	0.00	116.59	0.42	538.35	0.15	0.00
04:10:40	18.50	-0.16	116.55	0.25	538.41	0.15	0.00
04:10:55	18.75	-0.04	116.54	-0.07	538.39	0.00	0.00
04:11:10	19.00	-0.08	116.52	-0.10	538.37	0.00	0.00
04:11:25	19.25	0.00	116.52	-0.11	538.34	0.00	0.00
04:11:40	19.50	0.00	116.52	-0.19	538.29	0.00	0.00
04:11:55	19.75	-0.08	116.50	0.33	538.38	0.15	0.00
04:12:10	20.00	-0.08	116.48	0.14	538.41	0.00	0.00
04:12:25	20.25	0.00	116.48	-0.31	538.34	0.00	0.00
04:12:40	20.50	0.00	116.48	-0.32	538.26	0.00	0.00
04:12:55	20.75	-0.20	116.43	-0.07	538.24	0.00	0.00
04:13:10	21.00	0.00	116.43	0.17	538.28	0.00	0.00
04:13:25	21.25	0.00	116.43	0.07	538.30	0.15	0.00
04:13:40	21.50	0.81	116.63	0.01	538.30	0.00	9.67
04:13:55	21.75	-0.08	116.61	0.11	538.33	0.00	0.00
04:14:10	22.00	-0.08	116.59	0.29	538.40	0.15	0.00
04:14:25	22.25	0.00	116.59	-0.14	538.37	0.00	0.00
04:14:40	22.50	-0.16	116.55	-0.19	538.32	0.00	0.00
04:14:55	22.75	0.00	116.55	-0.15	538.28	0.00	0.00
04:15:10	23.00	1.77	116.99	-0.27	538.22	0.00	21.40
04:15:25	23.25	-0.28	116.92	-0.41	538.11	0.00	0.00
04:15:40	23.50	0.08	116.94	-0.02	538.11	0.00	1.11
04:15:55	23.75	-0.28	116.87	0.75	538.30	0.44	0.00
04:16:10	24.00	0.00	116.87	0.22	538.35	0.15	0.00
04:16:25	24.25	0.00	116.87	-0.35	538.27	0.00	0.00
04:16:40	24.50	-0.08	116.85	-0.39	538.17	0.00	0.00
04:16:55	24.75	-0.08	116.83	0.06	538.18	0.00	0.00
04:17:10	25.00	-0.08	116.81	0.07	538.20	0.15	0.00
04:17:25	25.25	0.00	116.81	0.40	538.30	0.15	0.00
04:17:40	25.50	-0.08	116.79	-0.00	538.30	0.00	0.00
04:17:55	25.75	-0.12	116.76	-0.22	538.25	0.00	0.00
04:18:10	26.00	0.08	116.78	-0.21	538.20	0.00	1.11
04:18:25	26.25	0.28	116.85	0.02	538.20	0.00	3.44
04:18:40	26.50	-0.08	116.83	0.42	538.31	0.15	0.00
04:18:55	26.75	-0.16	116.79	0.47	538.42	0.29	0.00
04:19:10	27.00	0.08	116.81	-0.27	538.36	0.00	1.11
04:19:25	27.25	-0.08	116.79	-0.50	538.23	0.00	0.00
04:19:40	27.50	0.16	116.83	-0.21	538.18	0.00	2.04

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
04:19:55	27.75	0.08	116.85	0.32	538.26	0.15	0.75
04:20:10	28.00	-0.16	116.81	0.20	538.31	0.15	0.00
04:20:25	28.25	-0.12	116.78	0.43	538.42	0.15	0.00
04:20:40	28.50	0.00	116.78	-0.08	538.40	0.00	0.00
04:20:55	28.75	-0.16	116.74	-0.31	538.32	0.00	0.00
04:21:10	29.00	0.00	116.74	0.03	538.33	0.00	0.00
04:21:25	29.25	-0.08	116.72	0.85	538.54	0.29	0.00
04:21:40	29.50	-0.08	116.70	-0.28	538.47	0.00	0.00
04:21:55	29.75	0.00	116.70	0.28	538.54	0.00	0.00
04:22:10	30.00	-0.16	116.66	0.14	538.57	0.15	0.00
04:22:25	30.25	0.08	116.68	-0.08	538.55	0.00	0.93
04:22:40	30.50	0.00	116.68	-0.31	538.48	0.00	0.00
04:22:55	30.75	0.08	116.70	-0.79	538.28	0.00	1.29
04:23:10	31.00	-0.08	116.68	-0.13	538.25	0.00	0.00
04:23:25	31.25	-0.08	116.66	-0.06	538.24	0.00	0.00
04:23:40	31.50	-0.12	116.63	-0.15	538.20	0.00	0.00
04:23:55	31.75	0.00	116.63	-0.14	538.16	0.00	0.00
04:24:10	32.00	-0.08	116.61	0.12	538.19	0.15	0.00
04:24:25	32.25	0.08	116.63	0.63	538.35	0.15	0.76
04:24:40	32.50	-0.08	116.61	-0.35	538.26	0.00	0.00
04:24:55	32.75	0.16	116.65	-0.19	538.22	0.00	2.04
04:25:10	33.00	0.00	116.65	-0.05	538.20	0.00	0.00
04:25:25	33.25	0.12	116.68	0.01	538.21	0.00	1.40
04:25:40	33.50	-0.12	116.65	-0.05	538.19	0.00	0.00
04:25:55	33.75	-0.08	116.63	-0.48	538.07	0.00	0.00
04:26:10	34.00	-0.08	116.61	-0.28	538.00	0.00	0.00
04:26:25	34.25	0.00	116.61	-0.15	537.97	0.00	0.00
04:26:40	34.50	0.00	116.61	0.04	537.98	0.00	0.00
04:26:55	34.75	-0.08	116.59	0.37	538.07	0.29	0.00
04:27:10	35.00	-0.16	116.55	0.70	538.25	0.29	0.00
04:27:25	35.25	0.00	116.55	-0.13	538.21	0.00	0.00
04:27:40	35.50	-0.04	116.54	0.38	538.31	0.29	0.00
04:27:55	35.75	0.00	116.54	-0.21	538.26	0.00	0.00
04:28:10	36.00	-0.08	116.52	-0.19	538.21	0.00	0.00
04:28:25	36.25	0.08	116.54	0.05	538.22	0.00	0.93
04:28:40	36.50	-0.16	116.50	-0.29	538.15	0.00	0.00
04:28:55	36.75	0.00	116.50	0.34	538.24	0.15	0.00
04:29:10	37.00	0.08	116.52	-0.25	538.17	0.00	1.11
04:29:25	37.25	0.00	116.52	-0.44	538.06	0.00	0.00
04:29:40	37.50	-0.08	116.50	-0.11	538.04	0.00	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
04:29:55	37.75	-0.08	116.48	0.30	538.11	0.15	0.00
04:30:10	38.00	0.08	116.50	-0.01	538.11	0.00	0.93
04:30:25	38.25	-0.16	116.46	-0.01	538.11	0.00	0.00
04:30:40	38.50	0.08	116.48	0.01	538.11	0.00	0.93
04:30:55	38.75	0.00	116.48	0.43	538.22	0.15	0.00
04:31:10	39.00	-0.08	116.46	0.36	538.30	0.15	0.00
04:31:25	39.25	-0.12	116.43	-0.22	538.25	0.00	0.00
04:31:40	39.50	0.04	116.44	-0.44	538.14	0.00	0.64
04:31:55	39.75	0.24	116.50	-0.24	538.08	0.00	2.97
04:32:10	40.00	0.28	116.57	0.21	538.13	0.00	3.44
04:32:25	40.25	0.00	116.57	0.05	538.14	0.15	0.00
04:32:40	40.50	-0.08	116.55	-0.10	538.12	0.00	0.00
04:32:55	40.75	0.08	116.57	0.06	538.13	0.00	0.93
04:33:10	41.00	-0.08	116.55	0.17	538.18	0.15	0.00
04:33:25	41.25	-0.04	116.54	-0.26	538.11	0.00	0.00
04:33:40	41.50	-0.08	116.52	0.01	538.11	0.00	0.00
04:33:55	41.75	0.12	116.55	0.14	538.15	0.00	1.40
04:34:10	42.00	-0.04	116.54	-0.00	538.15	0.00	0.00
04:34:25	42.25	-0.16	116.50	-0.34	538.06	0.00	0.00
04:34:40	42.50	0.00	116.50	-0.04	538.05	0.00	0.00
04:34:55	42.75	-0.08	116.48	0.36	538.14	0.15	0.00
04:35:10	43.00	0.00	116.48	0.37	538.23	0.15	0.00
04:35:25	43.25	-0.08	116.46	0.14	538.27	0.15	0.00
04:35:40	43.50	0.08	116.48	-0.28	538.20	0.00	1.11
04:35:55	43.75	-0.08	116.46	-0.75	538.01	0.00	0.00
04:36:10	44.00	0.00	116.46	0.09	538.03	0.15	0.00
04:36:25	44.25	0.00	116.46	0.52	538.16	0.15	0.00
04:36:40	44.50	0.00	116.46	0.02	538.17	0.00	0.00
04:36:55	44.75	0.08	116.48	0.24	538.23	0.00	0.93
04:37:10	45.00	-0.08	116.46	0.84	538.44	0.44	0.00
04:37:25	45.25	-0.08	116.44	0.59	538.59	0.15	0.00
04:37:40	45.50	0.00	116.44	-1.73	538.15	0.00	0.00
04:37:55	45.75	0.08	116.46	-0.22	538.10	0.00	1.11
04:38:10	46.00	0.00	116.46	0.06	538.12	0.00	0.00
04:38:25	46.25	-0.12	116.43	-0.13	538.08	0.00	0.00
04:38:40	46.50	-0.08	116.41	-0.21	538.03	0.00	0.00
04:38:55	46.75	0.52	116.54	0.43	538.14	0.00	6.06
04:39:10	47.00	0.04	116.55	-0.19	538.09	0.00	0.64
04:39:25	47.25	-0.12	116.52	-0.06	538.08	0.00	0.00
04:39:40	47.50	0.00	116.52	-0.15	538.04	0.00	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
04:39:55	47.75	0.08	116.54	-0.15	538.00	0.00	1.11
04:40:10	48.00	0.00	116.54	0.08	538.02	0.15	0.00
04:40:25	48.25	-0.08	116.52	0.31	538.10	0.15	0.00
04:40:40	48.50	-0.08	116.50	-0.03	538.10	0.00	0.00
04:40:55	48.75	0.08	116.52	-0.04	538.09	0.00	1.11
04:41:11	49.00	0.00	116.52	0.13	538.12	0.15	0.00
04:41:26	49.25	0.20	116.57	0.15	538.16	0.00	2.33
04:41:41	49.50	-0.08	116.55	-0.15	538.12	0.00	0.00
04:41:56	49.75	-0.04	116.54	-0.59	537.97	0.00	0.00
04:42:11	50.00	0.00	116.54	0.64	538.13	0.29	0.00
04:42:26	50.25	0.36	116.63	0.50	538.26	0.00	4.19
04:42:41	50.50	-0.08	116.61	-0.18	538.21	0.00	0.00
04:42:56	50.75	0.00	116.61	-0.57	538.07	0.00	0.00
04:43:11	51.00	0.00	116.61	-0.12	538.04	0.00	0.00
04:43:26	51.25	0.00	116.61	-0.20	537.99	0.00	0.00
04:43:41	51.50	0.00	116.61	0.60	538.14	0.15	0.00
04:43:56	51.75	-0.08	116.59	0.36	538.23	0.15	0.00
04:44:11	52.00	0.00	116.59	0.03	538.24	0.00	0.00
04:44:26	52.25	-0.08	116.57	-0.23	538.18	0.00	0.00
04:44:41	52.50	0.08	116.59	-0.40	538.08	0.00	1.11
04:44:56	52.75	-0.16	116.55	0.14	538.12	0.00	0.00
04:45:11	53.00	-0.04	116.54	-0.04	538.11	0.00	0.00
04:45:26	53.25	0.00	116.54	-0.12	538.08	0.00	0.00
04:45:41	53.50	0.04	116.55	-0.22	538.02	0.00	0.64
04:45:56	53.75	-0.20	116.50	-0.18	537.97	0.00	0.00

End Shut-In #2

04:46:11	0.25	0.00	116.50	-	-	-	0.00
04:46:26	0.50	-0.08	116.48	-	-	-	0.00
04:46:41	0.75	0.00	116.48	-	-	-	0.00
04:46:56	1.00	0.00	116.48	-	-	-	0.00
04:47:11	1.25	0.00	116.48	-	-	-	0.00
04:47:26	1.50	0.00	116.48	-	-	-	0.00
04:47:41	1.75	0.00	116.48	-	-	-	0.00
04:47:56	2.00	-0.08	116.46	-	-	-	0.00
04:48:11	2.25	-0.08	116.44	-	-	-	0.00
04:48:26	2.50	-0.04	116.43	-	-	-	0.00
04:48:41	2.75	0.04	116.44	-	-	-	0.53
04:48:56	3.00	-0.04	116.43	-	-	-	0.00

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

Test Time (24 Hr.)	Flow Time (min)	Surface Dp/Dt (KPa/mn)	Surface Pressure (KPabs)	Recovery Dp/Dt (KPa/mn)	Recovery Pressure (KPabs)	Liquid Rate (m3/D)	Gas Rate (m3/D)
04:49:11	3.25	-0.08	116.41	-	-	-	0.00
04:49:26	3.50	0.08	116.43	-	-	-	1.07
04:49:41	3.75	-0.08	116.41	-	-	-	0.00
04:49:56	4.00	-57.94	102.03	-	-	-	0.00
04:50:11	4.25	-4.79	100.84	-	-	-	0.00
04:50:26	4.50	-1.17	100.55	-	-	-	0.00
04:50:41	4.75	1.09	100.82	-	-	-	14.41
04:50:56	5.00	-1.69	100.40	-	-	-	0.00
04:51:11	5.25	0.44	100.51	-	-	-	5.87
04:51:26	5.50	0.56	100.65	-	-	-	7.47
04:51:41	5.75	0.32	100.73	-	-	-	4.27
04:51:56	6.00	0.28	100.80	-	-	-	3.74
04:52:11	6.25	-1.69	100.38	-	-	-	0.00
04:52:26	6.50	0.24	100.44	-	-	-	3.20
04:52:41	6.75	0.28	100.51	-	-	-	3.74
04:52:56	7.00	0.16	100.55	-	-	-	2.14
04:53:11	7.25	0.28	100.62	-	-	-	3.74
04:53:26	7.50	0.08	100.64	-	-	-	1.07
04:53:41	7.75	0.20	100.69	-	-	-	2.67
04:53:56	8.00	0.16	100.73	-	-	-	2.14

Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

PRE TEST REPORT

Gas Specific Gravity:	0.65
Formation Depth:	234.25 mKB
Formation Pressure:	2384.67 kPa(g)
Formation Temperature:	10.03 Deg. C
Average Chamber Temperature:	6.51 Deg. C
Initial Chamber Surface Pressure:	90.00 kPa(a)
Initial Gas/N2 Head Pressure:	92.59 kPa(a)
Initial Total Cushion Pressure:	92.59 kPa(a)
Initial Cushion Length:	0.00 m
Liquid Cushion Gradient:	0.00 kPA/m
Down Hole Choke Diameter:	19.05 mm
Down Hole Choke Coefficient:	38.81 m3/D/kPa
Surface Choke Diameter:	Unspecified
Surface Choke Coefficient:	12.85 m3/D/kPa
Drill Collar Length:	91.88 m
Drill Collar I.D.:	57.00 mm
Drill Collar Capacity:	0.002552 m3/m
Drill Collar Volume:	0.234456 m3
Upper Drill Pipe Length:	122.86 m
Upper Drill Pipe I.D.:	83.00 mm
Upper Drill Pipe Capacity:	0.005411 m3/m
Upper Drill Pipe Volume:	0.664747 m3
Total Chamber Volume:	0.90 m3
Liquid Cushion Volume:	0.00 m3
Net Chamber Volume:	0.90 m3

	Max. Rate	Max. Surface Dp/Dt
Gas:	116046.05 m3/D	8802.19 kPa/min
Gas Saturated H2O:	820.78 m3/D	146.13 kPa/min
Pure Liquid Influx:	820.78 m3/D	62.26 kPa/min

	Initial Conversion Factors
Gas:	13.18 m3/D/kPa/min
Gas Saturated H2O:	5.62 m3/D/kPa/min
Pure Liquid Influx:	13.18 m3/D/kPa/min

Cenovus Energy Inc.
January 10, 2013

				DST #	4
CVE Germain	1AA/9-3-083-22 W4M			AFE#:	12149519
Lean zone/transition	230	to	238.5 mKB	Job# :	2033

Pipe Tally Sheet

Drill Collars		Heavy Weight		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe	
1	9.03	1	0.25	1	9.40	11	9.48	21		31		41	
2	9.58	2		2	9.47	12	9.45	22		32		42	
3	9.33	3		3	9.47	13	9.31	23		33		43	
4	8.88	4		4	9.47	14		24		34		44	
5	9.26	5		5	9.40	15		25		35		45	
6	9.06	6		6	9.39	16		26		36		46	
7	9.20	7		7	9.26	17		27		37		47	
8	9.10	8		8	9.45	18		28		38		48	
9	8.83	9		9	9.50	19		29		39		49	
10	9.61	10		10	9.44	20		30		40		50	
DC	91.88	**HW**	0.25	**1**	94.25	**2**	28.24	**3**	0.00	**4**	0.00	**5**	0.00

Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe		Drill Pipe Total	
51		61		71		81		91		101		**1**	94.25
52		62		72		82		92		102		**2**	28.24
53		63		73		83		93		103		**3**	0.00
54		64		74		84		94		104		**4**	0.00
55		65		75		85		95		105		**5**	0.00
56		66		76		86		96		106		**6**	0.00
57		67		77		87		97		107		**7**	0.00
58		68		78		88		98		108		**8**	0.00
59		69		79		89		99		109		**9**	0.00
60		70		80		90		100		110		**10**	0.00
6	0.00	**7**	0.00	**8**	0.00	**9**	0.00	**10**	0.00	**11**	0.00	**11**	0.00
												Stabbing Valve	0.37

Before Test in Derrick		**At Test Depth**	**In**	**Out**	**Total**
Total Drill Collars	10	Total Drill Collars	10		10
Total Heavy Weight	0	Total Heavy Weight	0		0
Total Drill Pipe	17	Total Drill Pipe	13	4	17

Total DP	122.86
Total DC	91.88
Total HWT	0.25
Tool to Bottom of Top Packer	19.90
Total Strings Above Interval	234.89
Top of Interval Depth	230.00
Top Single Above Table	4.89

Procedures for running in hole with DST tools:

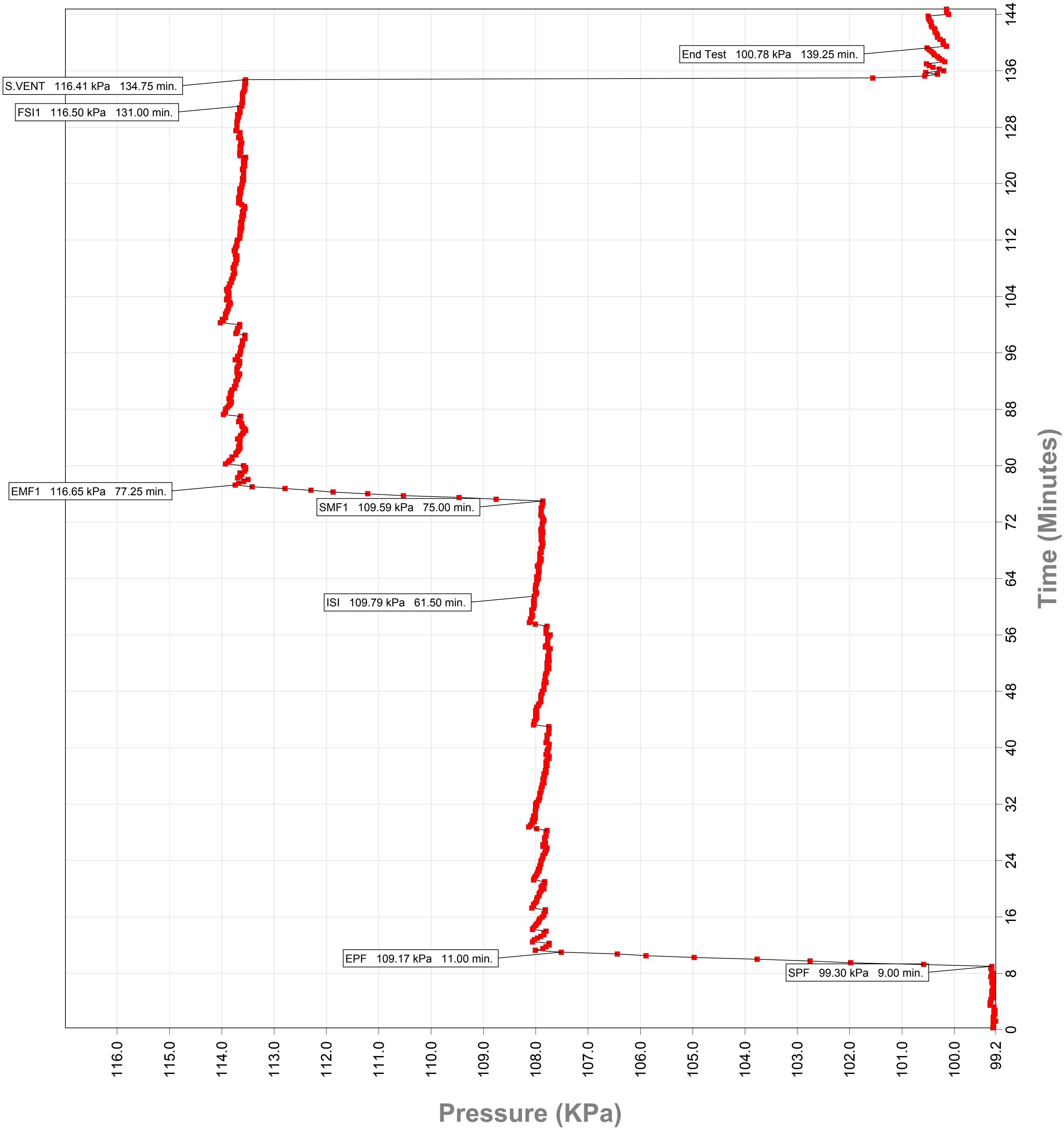
1.Run tools in slowly to avoid surge pressures
2. Do not rotate drill string
3. Pump out sub must be placed on top of first drill collar
4. Notify DST Supervisor for following conditions:
  a. If hole gets tight running in or out
  b. If a bridge is encountered
  c. If any fluid is encountered in pipe

By signing below, I certify that I am the authorized representative of the above named Operator. I have reviewed the drill pipe tally as shown above and agree that it is correct to the best of my knowledge. On behalf of the above named Operator, I agree to accept responsibility for the Drill Stem Test tools after they are placed below the table into the wellbore and will pay the actual cost of replacement, repair, or any recovery operations of the above mentioned Drill Stem Test Tools.

Company Representative:______________________________________

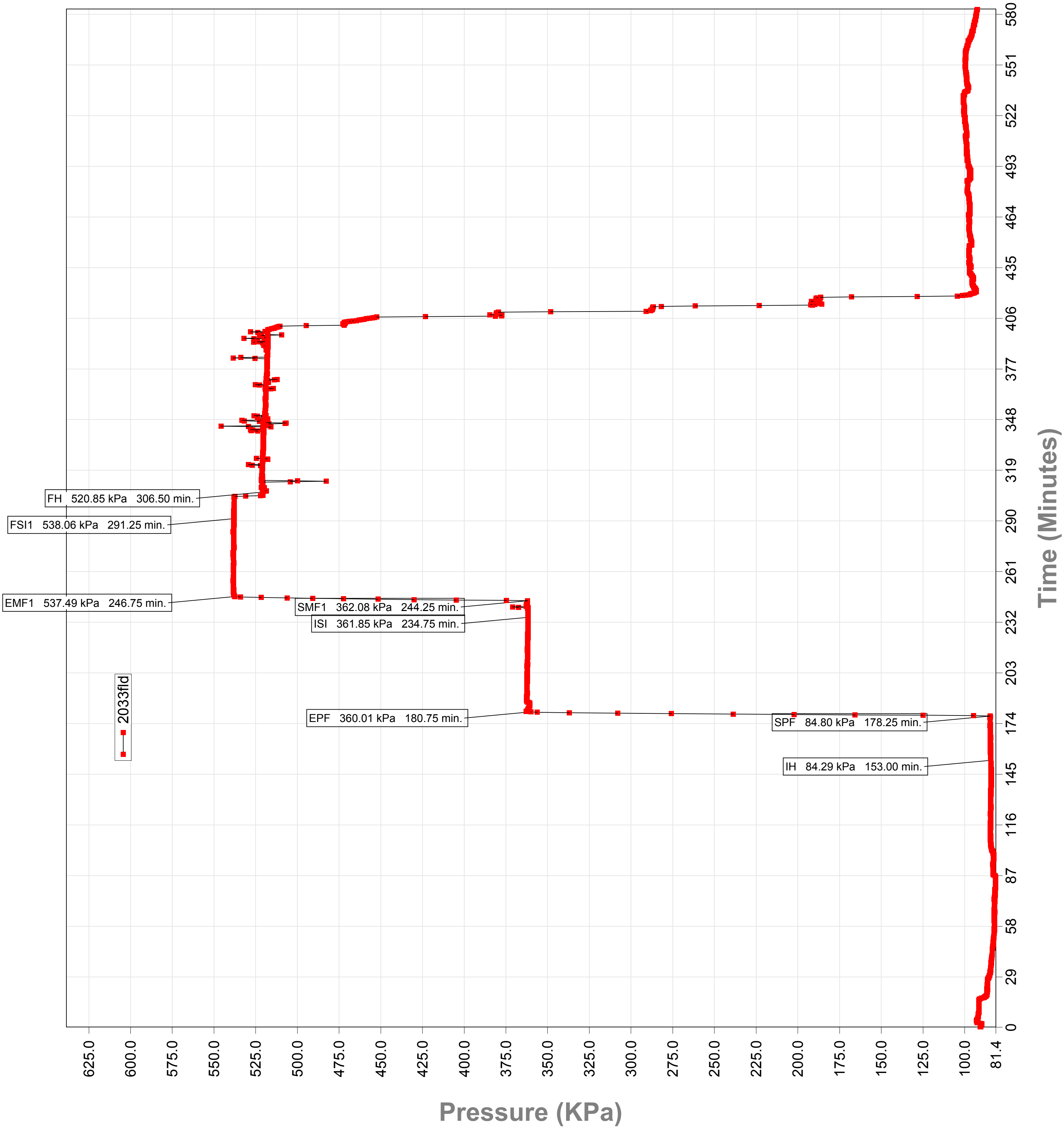
Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

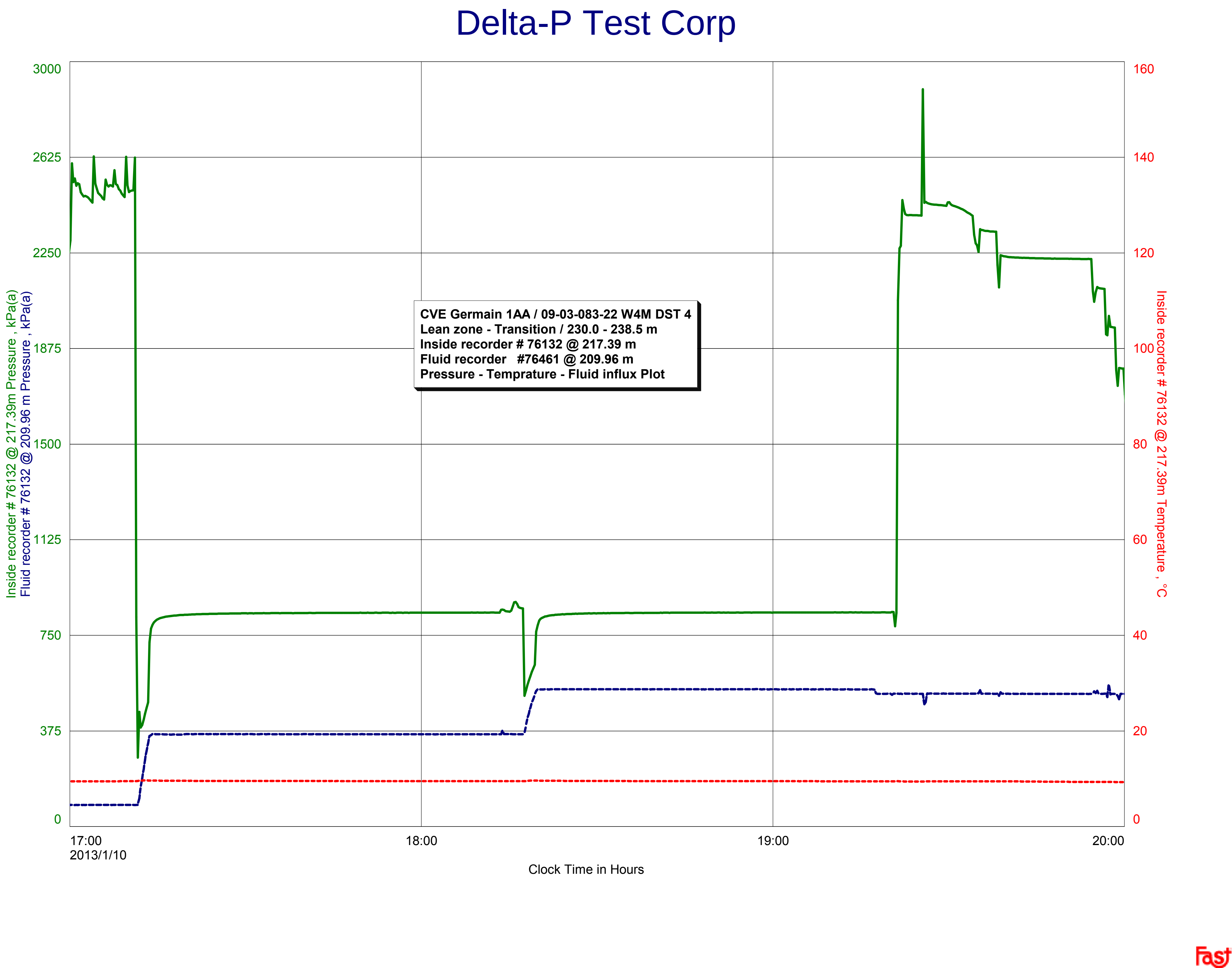
SURFACE PRESSURE CHART



Thursday, January 10, 2013
Cenovus Germain
9-3-83-22-W4M
Lean Zone 1 / 230.0 m - 238.5 m
DST #4

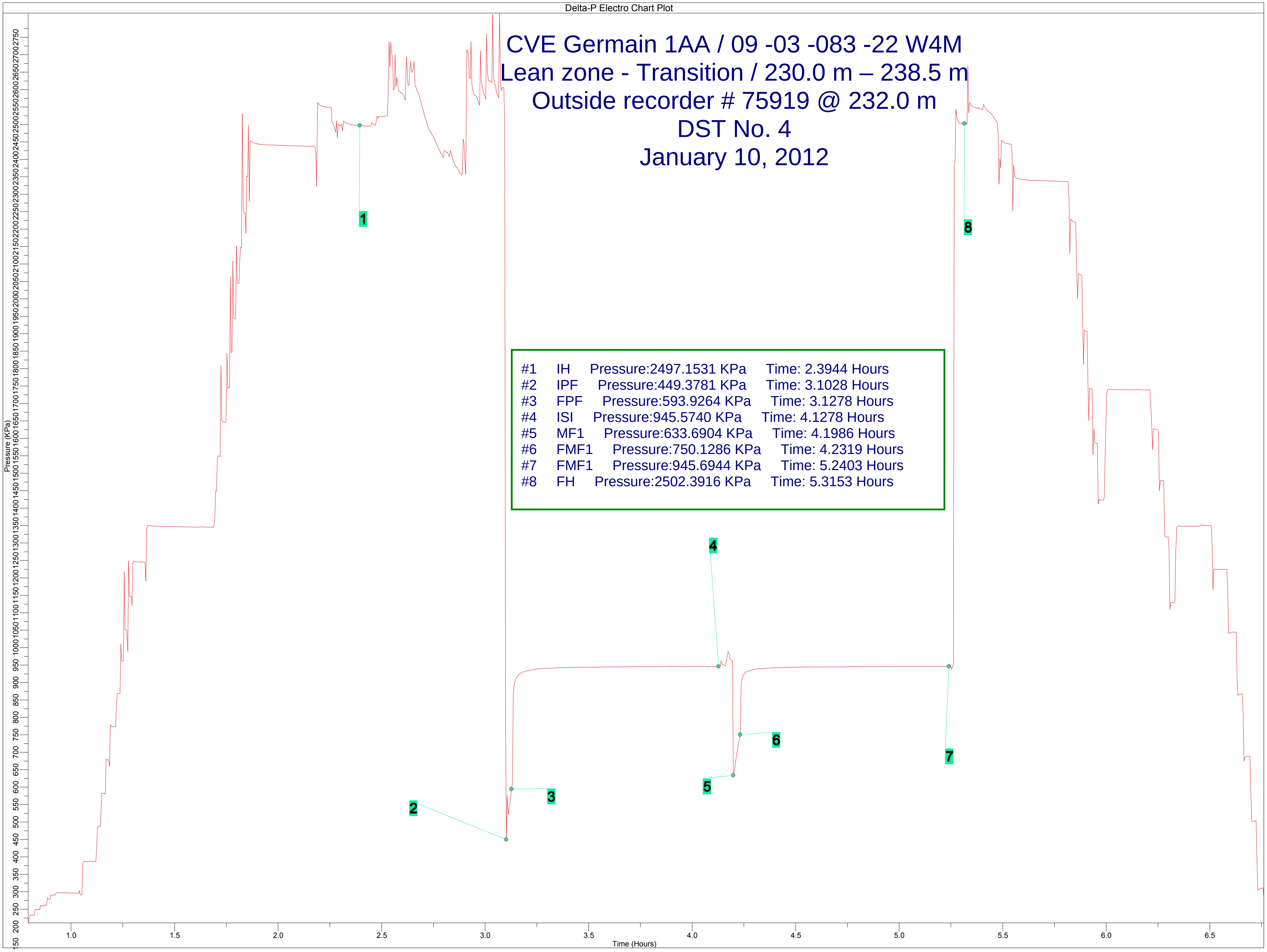
DOWNHOLE PRESSURE CHART



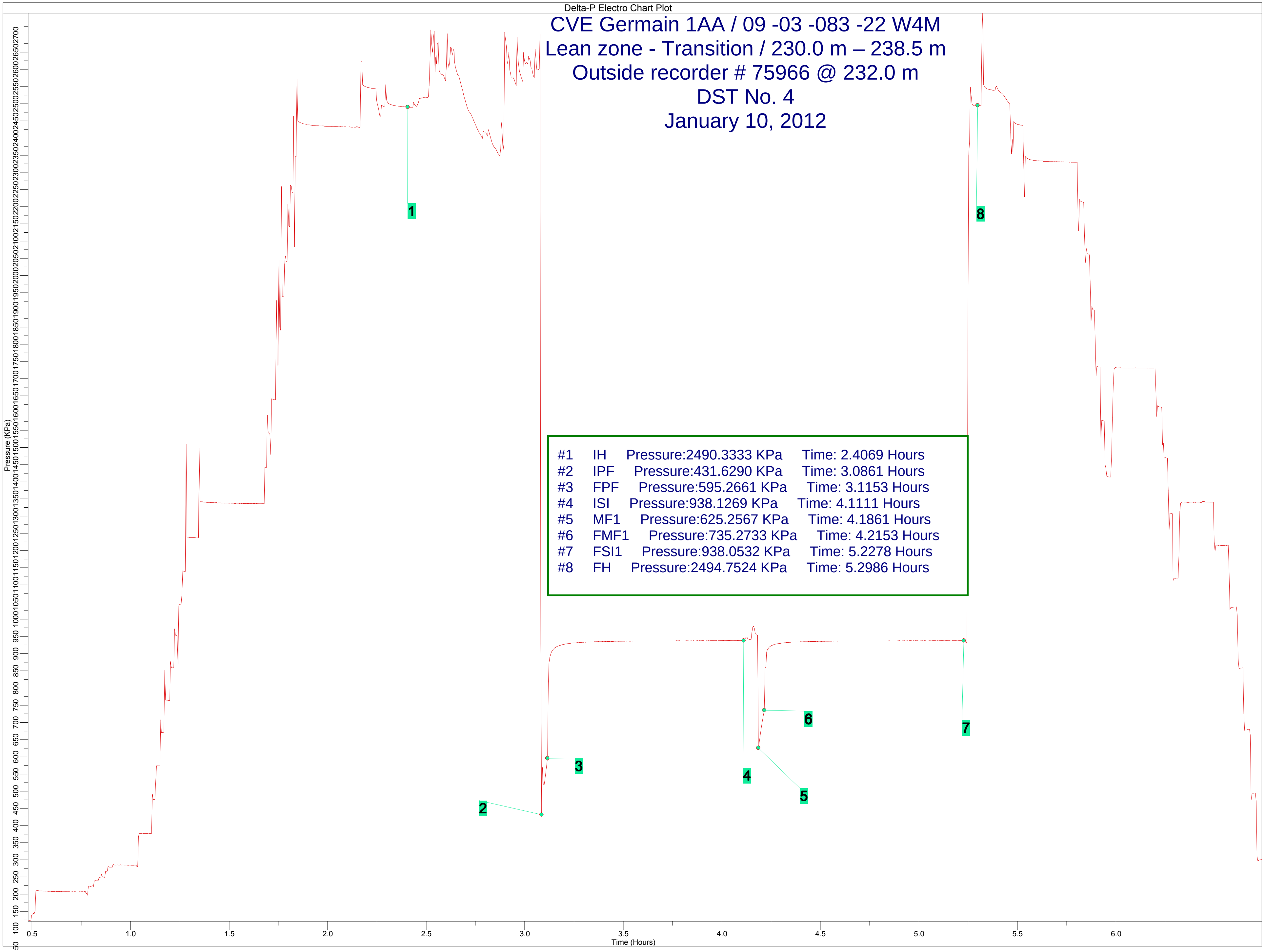


Delta-P Test Corp
CVE Germain 1AA / 09-03-083-22 W4M DST 4
Lean zone - Transition / 230.0 - 238.5 m
Inside recorder # 76132 @ 217.39 m
Fluid recorder #76461 @ 209.96 m
Pressure - Temprature - Fluid influx Plot
Inside recorder # 76132 @ 217.39m Pressure , kPa(a)
Fluid recorder # 76132 @ 209.96 m Pressure , kPa(a)
Inside recorder # 76132 @ 217.39m Temperature , °C
3000
2625
2250
1875
1500
1125
750
375
0
160
140
120
100
80
60
40
20
0
17:00
2013/1/10
18:00
19:00
20:00
Clock Time in Hours
Fast

Delta-P Test Corp



Delta-P Test Corp



APPENDIX 14-1

HUMAN HEALTH MULTI-MEDIA ASSESSMENT

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1 HUMAN HEALTH MULTI-MEDIA ASSESSMENT

This is a revised version of Appendix 68-1 which was provided in the second round of Supplemental Information Requests (SIRs) for the Pelican Lake Grand Rapids Project (the Project); this version contains updates that reflect comments received during the third round of SIRs, dated December 11, 2013. To better understand the potential human health effects associated with exposures to environmental media impacted by the Project, the following three development scenarios were evaluated:

- Baseline Case: exposure to chemical emissions from existing and approved sources;
- Application Case: exposure to cumulative chemical emissions from existing and approved sources and the Project; and
- Planned Development Case (PDC): exposure to cumulative chemical emissions from the Application Case and planned developments.

Additionally, as per Round 3 SIR 24, emissions associated with the Project alone were evaluated. This human health multi-media assessment relied upon the results of the Air Quality Assessment (Volume 3, Section 1), Soil, Vegetation and Fish Baseline Data Collection and Analysis Baseline Report (Volume 3, Appendix 3-VII), Regional Data Analysis Report (Volume 3, Appendix 3-IX), Estimation of Soil Concentrations Report (Volume 3, Appendix 3-XI), and the Water Quality Assessment (Volume 4, Section 5) in the Project Environmental Impact Assessment (EIA). Specifically, the following data were used in the human health multi-media assessment:

- Predicted air concentrations for chemicals for the Baseline Case, Application Case and PDC (Volume 3, Appendix 3-IV). Existing ambient air concentrations in the region are incorporated into the predicted air concentrations;
- Predicted annual air deposition rates for chemicals for the Baseline Case, Application Case and PDC (Volume 3, Appendix 3-XI);
- Predicted chemical concentrations in soil for the Baseline Case, Application Case and PDC (Volume 3, Appendix 3-XI);
- Measured background chemical concentrations in soil, vegetation, water and fish in the region, including the Project Area (Volume 3, Appendix 3-VII and Appendix 3-IX); and
- Results of the Water Quality assessment that predicted no effects of the Project on surface water quality (Volume 4, Section 5.3).

As part of the response to SIRs, air quality re-modelling was conducted and new air concentrations and deposition rates were generated (Round 2 SIR 73). These updated results have been incorporated into the multi-media risk assessment.

2 PROBLEM FORMULATION

The multi-media risk assessment is being carried out in response to Round 2 SIR 68, which requests that a multi-media assessment be carried out for an aboriginal receptor. In order to focus the assessment on the aboriginal receptor that may have the highest exposure, the locations with the highest air concentrations, dry deposition and wet deposition rates among the identified aboriginal residential locations (Wabasca, Wabasca-Desmarais, Wabasca [IRs 166, 166A, 166B, 166C, 166D], Chipewyan Lake, Sandy Lake Settlement, Trout Lake) were identified and modelling was carried out at these locations. Air concentrations and dry deposition rates were predicted to be the highest at Chipewyan Lake and wet deposition rates were predicted to be the highest at Wabasca IR 166C. Therefore, Chipewyan Lake and Wabasca IR 166C were modelled and represent the highest exposure among the aboriginal residential locations.

2.1 EXPOSURE PATHWAYS EVALUATED

The objective of the exposure pathway screening process is to identify potential routes by which aboriginal receptors could be exposed to chemicals and the relative significance of these pathways to total exposure. A chemical represents a potential health risk only if it can reach receptors through an exposure pathway at a concentration that could potentially lead to adverse effects. If there is no pathway for a chemical to reach a receptor, then there cannot be a risk, regardless of the chemical concentration. All potential exposure pathways between chemicals and people were considered. The rationale for selection of exposure pathways for the multi-media risk assessment is provided in Table 1.

Table 1 Exposure Pathways Evaluated in the Human Health Multi-Media Risk Assessment

Exposure Pathway	Evaluated	Special Consideration	Not Evaluated	Rationale
Inhalation of air	✓	–	–	People may be exposed to airborne chemicals released to air from the Project.
Inhalation of dust	✓	–	–	Airborne chemicals may deposit to soil and people may inhale soil dust particulates.
Ingestion of groundwater	–	–	×	Effects to aquifers used for potable water sources (i.e., wells) are considered to be unlikely; therefore, this pathway was not evaluated for Aboriginal receptors.
Ingestion of surface water	–	✓	–	Effects to waterbodies and watercourses as a result of Project emissions are not expected to be measurable (Volume 3, Section 3.3.4.2). However, to be conservative, the Aboriginal receptor was assumed to obtain their drinking water from local surface waters, consequently this pathway was evaluated.
Dermal contact with surface water	–	–	×	If people swim or bathe in potentially affected waterbodies or watercourses, they would not receive significant exposures through this route relative to water ingestion. In addition, effects associated with the Project are considered unlikely to occur (Volume 3, Section 3.3.4.2).
Ingestion of fish	–	✓	–	Although effects to waterbodies and watercourses are considered to be unlikely, ingestion of fish under existing conditions was evaluated in order to understand total exposure.
Ingestion of soil	✓	–	–	Airborne chemicals may deposit to soil and people may incidentally ingest soil.
Dermal contact with soil	✓	–	–	Airborne chemicals may deposit to soil and people may have dermal contact.
Ingestion of plants	✓	–	–	People may consume plants that have received airborne deposition or that have taken up chemicals from the soil. Plants include wild traditional plants and garden produce.
Ingestion of animals	✓	–	–	People may consume animals harvested from areas near the Project. Moose meat is a staple of the diets of Aboriginal people in the region and wild meat can be a significant component of their overall meat intake.

– = Not applicable.
✓ = Pathway was evaluated in the multi-media risk assessment.
× = Pathway was not evaluated in the multi-media risk assessment.

2.2 CHEMICALS EVALUATED

2.2.1 Chemical Screening Process for the Terrestrial Environment (Soil, Plants, Animals)

In order to focus the human health multi-media assessment on Project-related emissions, a comprehensive chemical screening process was applied to identify chemicals of potential concern (COPCs) that are emitted into air and are expected to deposit near the Project and possibly persist or accumulate in the terrestrial environment in sufficient quantities for people to be exposed through secondary pathways.

The steps used in the chemical screening process for the multi-media assessment are as follows:

- Step 1: Identify chemicals that are emitted by the Project by comparing deposition rates between the Application Case and the Baseline Case.
- Step 2: Identify chemicals that are non-volatile by comparing the Henry's Law Constant, vapour pressure and molecular weight for each chemical to the volatility criteria (i.e., those chemicals with Henry's Law Constants less than 1 x 10^{-5} atm-m^3/mol, chemicals with vapour pressure less than 0.001 mm Hg, or molecular weight greater than 200 g/mol). Any chemical with at least two of the three physical-chemical properties indicating non-volatile is considered non-volatile. For chemicals with only one of the three physical-chemical properties indicating non-volatile, further evaluation of their environmental fate was carried out to determine if they should be retained for the multi-media assessment (as per Round 3 SIR 14).
- Step 3: Identify chemicals that are carcinogens.
- Step 4: Identify chemicals that are persistent or bioaccumulative based on the following criteria established by Environment Canada (2006): half-life ≥ 182 days and bioconcentration factor (BCF) ≥ 5,000, as well as log Kow > 3.5 (as per Round 1 SIRs 173 and 174).
- Step 5: Retain all chemicals that meet the above criteria (i.e., emitted by the Project and non-volatile) for the multi-media assessment.

The steps of the screening process, and the chemicals that are retained at each stage, are shown below.

Step 1: Identify Chemicals Emitted by the Project

A comparison of the total deposition rates between the Baseline Case and Application Case is shown in Table 2. The chemicals that are retained in this step have greater deposition rates for the Application Case than the Baseline Case, as shown in bold. All metals identified in this step were retained for the multi-media assessment, as the subsequent screening steps only apply to organic chemicals.

Table 2 Comparison of Total Deposition Rates: Baseline and Application Case

Chemical	Highest Total Deposition Rate[(a)] [kg/ha/yr]		Application Case > Baseline Case
	Application Case	Baseline Case	
Metals			
Aluminum	6.7E-05	6.7E-05	No
Antimony	2.5E-07	2.5E-07	No
Arsenic	2.0E-05	3.9E-06	**Yes**
Barium	4.3E-04	8.1E-05	**Yes**
Beryllium	1.2E-06	2.6E-07	**Yes**
Cadmium	1.2E-04	3.4E-05	**Yes**
Chromium (total)	1.6E-04	4.9E-05	**Yes**
Cobalt	1.2E-05	5.0E-06	**Yes**
Copper	8.7E-05	1.9E-05	**Yes**
Gallium	2.4E-06	2.4E-06	No
Indium	1.4E-05	1.4E-05	No
Iron	2.4E-04	2.4E-04	No
Lead	5.4E-05	1.4E-05	**Yes**
Magnesium	1.3E-05	1.3E-05	No
Manganese	4.8E-05	1.7E-05	**Yes**
Mercury	2.5E-05	4.6E-06	**Yes**
Molybdenum	1.1E-04	2.3E-05	**Yes**
Nickel	2.5E-04	7.8E-05	**Yes**
Palladium	2.4E-06	2.4E-06	No
Phosphorus	1.9E-05	1.9E-05	No
Selenium	1.1E-05	9.1E-06	**Yes**
Silicon	6.6E-04	6.6E-04	No
Silver	2.9E-06	2.9E-06	No
Tin	2.7E-06	2.7E-06	No
Titanium	5.1E-6	5.1E-6	No
Vanadium	2.5E-4	6.6E-5	**Yes**
Zinc	3.0E-3	6.4E-4	**Yes**
Zirconium	2.7E-6	2.7E-6	No
Polycyclic Aromatic Hydrocarbons (PAHs)			
Acenaphthene	3.91E-06	3.85E-06	**Yes**
Acenaphthylene	1.56E-05	1.55E-05	**Yes**
Anthracene	2.06E-06	1.31E-06	**Yes**
Anthracene surrogate	4.13E-07	4.13E-07	No
Benzo(a)anthracene	1.28E-06	7.22E-07	**Yes**
Benzo (a) anthracene surrogate	1.01E-05	5.08E-06	**Yes**
Benzo(a)pyrene	8.41E-07	4.67E-07	**Yes**
Benzo (a) pyrene surrogate	2.04E-06	1.96E-06	**Yes**
Benzo(b)fluoranthene	1.39E-06	1.07E-06	**Yes**
Benzo(g,h,i)perylene	1.37E-06	1.33E-06	**Yes**
Benzo(g,h,i)perylene	1.20E-08	1.20E-08	No
Benzo(k)fluoranthene	1.22E-06	6.61E-07	**Yes**
Biphenyl	4.22E-04	4.22E-04	No
Chlorobenzene surrogate	4.17E-08	4.17E-08	No
Chrysene	2.13E-06	2.08E-06	**Yes**
Dibenzo(a,h)anthracene	9.46E-07	5.72E-07	**Yes**

Table 2 Comparison of Total Deposition Rates: Baseline and Application Case (continued)

Chemical	Highest Total Deposition Rate[a] [kg/ha/yr]		Application Case > Baseline Case
	Application Case	Baseline Case	
Dibenzo(a,h)anthracene surrogate	3.12E-08	3.12E-08	No
Fluoranthene	5.41E-06	5.31E-06	**Yes**
Fluoranthene surrogate	8.71E-07	8.71E-07	No
Fluorene	1.64E-05	1.63E-05	**Yes**
Fluorene surrogate	2.61E-08	2.61E-08	No
Indeno(1,2,3-cd)pyrene	1.17E-06	6.06E-07	**Yes**
Indeno(1,2,3-cd)pyrene surrogate	1.10E-07	1.10E-07	No
Naphthalene	4.69E-04	3.94E-04	**Yes**
Naphthalene surrogate	1.15E-04	1.14E-04	**Yes**
Phenanthrene	3.19E-05	3.14E-05	**Yes**
Phenanthrene surrogate	4.60E-06	4.60E-06	No
Pyrene	7.33E-06	7.15E-06	**Yes**
Pyrene surrogate	1.24E-07	1.24E-07	No

[a] Highest total deposition rate of all receptor locations.

Note: **Bold** text represents chemicals with total deposition rates that are higher for the Application Case than for the Baseline Case.

Step 2: Identify Non-Volatile Chemicals

The volatility screening for volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and acid gases is presented in Table 3. Chemicals retained as non-volatile are those chemicals meeting at least two of the three non-volatile criteria. As per Round 3 SIR 14, further evaluation of those chemicals meeting one of the three non-volatile criteria is presented following Table 3.

Atmospheric concentrations have been estimated for the petroleum hydrocarbon (PHC) groups C_2 to C_6 aliphatic, C_6 to C_8 aliphatic, C_8 to C_{10} aliphatic, C_8 to C_{10} aromatic, C_{10} to C_{12} aliphatic, C_{10} to C_{12} aromatic, C_{12} to C_{16} aliphatic, C_{12} to C_{16} aromatic, C_{16} to C_{21} aliphatic and C_{21} to C_{34} aliphatic for the Baseline Case, Application Case and PDC. There are no Project emissions for any of these petroleum hydrocarbon (PHC) groups except C_2 to C_6 aliphatic, as the Baseline Case and Application Case air concentrations for all the other PHC groups are identical. The chemicals represented by the C_2 to C_6 aliphatic group are: ethyne, ethane, 1-propyne, propene, propane, butane, i-butane, isobutene, butene, cis-2-butene, trans-2-butene, pentene, cyclopentane, 3-methyl-1-butene, 2-methyl-1-butene, trans-2-pentene, pentane, 2,2-dimethylpropane, isopentane, 1-methyl-1-(2-methylene)cyclopentane, 1-methyl-4-(1-methylene)cyclohexane, 1-methyl-4-(methylene)cyclohexene, 2-ethyl-2-hexene, 2-methyl pentane,2,3-dimethylbutane, 2-methyl-1-pentene + 1-hexene, 2-methyl-4-pentene, 2-methylbycyclo[4.4.0]heptane, 4-methyl-1-(1-methylene)cyclohexene, acetylene + ethane, 1,2-butane, 1-butene, 1-

methyl-1-cyclopentene, 1-pentene, 1-pentyne, 2-butanol, 2-butyne, 2-methyl-2-butene, 3-methyl-2-butene, 4-methyl-1-cyclopentene, C6-olefin, cis-2-pentene, cyclopentene, ethene, isobutane, isobutanol, methyl-tert-butyl ether, naphthene, n-butane, n-butanol, n-pentane and n-propanol. The larger chemicals in this group (i.e., those with the highest number of carbons) are expected to be the least volatile. Hexane and cyclohexane have Henry's Law Constants of 1.81 atm-m^3/mol and 0.19 atm-m^3/mol, respectively (Health Canada 2009). Compared to the Henry's Law Constant criteria of greater than 1E-05 atm-m^3/mol for volatility, cyclohexane and hexane are considered volatile, thus it can be considered that all of the C_2 to C_6 chemicals could be considered volatile. Negligible deposition rates are expected for volatile chemicals, thus C_2 to C_6 aliphatic was not retained for the multi-media assessment. Based on the lack of Project contribution to PHCs which may deposit to the terrestrial environment, PHCs were not retained for the multi-media assessment.

Table 3 Screening Against Volatility Criteria

COC	Molecular Weight [g/mol]	Vapour Pressure [mm Hg]	Henry's Law [atm-m^3/mol]	Reference
Volatile Organic Carbons (VOCs)				
1,1,2-trichloroethane	133	242	9.24E-4	Health Canada 2009
1,2-dichloropropane	113	49.7	2.69E-3	Health Canada 2009
1,3-butadiene	54.1	2,110	7.36E-2	Health Canada 2009
1,3-dichloropropene	111	34	1.82E-2	Health Canada 2009
Acrolein	56.1	274	9.71E-5	Health Canada 2009
Aldehydes (surrogate: acetaldehyde)	44.1	910	7.31E-5	Health Canada 2009
Acetone	58.1	231	3.93E-5	Health Canada 2009
carbon tetrachloride	154	114	2.89E-2	Health Canada 2009
chlorobenzene	113	11.9	3.62E-3	Health Canada 2009
chloroethane	64.5	120	1.79E-3	Health Canada 2009
chloroform	119	197	3.76E-3	Health Canada 2009
cumene	120	4.58	1.45E-2	Health Canada 2009
dichlorobenzene (1,4)	147	0.975	2.39E-3	Health Canada 2009
1,1-dichloroethane	99	227	5.86E-3	Health Canada 2009
1,2-dichloroethane	99	79.1	1.20E-3	Health Canada 2010
Ethanol	46.07	59.3	**7.4E-6**	HSDB 2012 and Mackay et al. 2006
Ethylbenzene	106	9.53	8.75E-3	Health Canada 2009
Ethylene	28.05	52,100	2.28E-1	HSDB 2012
ethylene dibromide	187.86	11.2	6.50E-4	HSDB 2012
Formaldehyde	30.03	3,890	**3.37E-7**	HSDB 2012
Hexane	86.2	152	1.81	Health Canada 2009
ketone (surrogate: methyl ethyl ketone)	72.1	90.8	3.59E-5	Health Canada 2009
Methanol	32.04	127	**6.1E-6**	HSDB 2012 and Mackay et al. 2006
methylene chloride	84.9	435	3.68E-3	Health Canada 2009
Phenol	94.1	0.353	**1.5E-6**	HSDB 2012 and Mackay et al. 2006
propylene oxide	58.1	533	8.55E-5	Health Canada 2009
1,1,1,2-tetrachloroethane	168	11.9	2.45E-3	Health Canada 2009

Table 3 Screening Against Volatility Criteria (continued)

COC	Molecular Weight [g/mol]	Vapour Pressure [mm Hg]	Henry's Law [atm-m^3/mol]	Reference
1,1,2,2-tetrachloroethane	168	5.95	4.64E-4	Health Canada 2010
Styrene	104	6.6	3.18E-3	Health Canada 2009
Toluene	92.1	28.5	6.71E-3	Health Canada 2009
1,2,4-trimethylbenzene	120	2.03	5.62E-3	Health Canada 2009
1,3,5-trimethylbenzene	120	2.44	7.71E-3	Health Canada 2010
Xylenes	106	7.99	7.30E-3	Health Canada 2009
vinyl chloride	62.5	2,660	7.92E-2	Health Canada 2009
Acid Gases				
Nitrogen dioxide	46.006	900	nv	HSDB 2012
Sulphur dioxide	64.064	3,000	8.1E-4	HSDB 2012
Carbon monoxide	28.01	1.55E+8	1.04	HSDB 2012
carbonyl sulphide	60.075	9,412	6.1E-1	HSDB 2012
carbon disulphide	76.1	362	1.72E-2	Health Canada 2009
Hydrogen sulphide	34.08	15,600	nv	HSDB 2012
Mercaptans (surrogate: amyl mercaptan)	104.22	13.8	1.2E-2	HSDB 2012
Thiophenes (surrogate: dibenzothiophene)	184.26	4.4E-3	3.4E-5	HSDB 2012 and Mackay et al. 2006
Polycyclic Aromatic Hydrocarbons (PAHs)				
acenaphthene	154	2.00E-03	1.50E-04	Health Canada 2009
acenaphthylene	150	7.00E-03	8.30E-05	Health Canada 2009
anthracene	178	**8.00E-06**	3.90E-05	Health Canada 2009
benz(a)anthracene	**228**	**2.10E-07**	**5.70E-06**	Health Canada 2009
benzo(a)pyrene	**252**	**5.00E-09**	**4.50E-07**	Health Canada 2009
benzo(b)fluoranthene	**252**	**5.00E-07**	1.10E-04	Health Canada 2009
benzo(g,h,i)perylene	**276**	**1.00E-10**	**3.30E-07**	Health Canada 2009
benzo(k)fluoranthene	**252**	**3.90E-10**	**1.60E-07**	Health Canada 2009
chrysene	**228**	**4.30E-09**	**6.40E-07**	Health Canada 2009
dibenzo(a,h)anthracene	**278**	**2.80E-12**	**1.70E-09**	Health Canada 2009
fluoranthene	**202**	**9.23E-06**	**9.40E-06**	Health Canada 2009
fluorene	166	**7.00E-04**	7.80E-05	Health Canada 2009
indeno(1,2,3-cd)pyrene	**276**	**1.25E-10**	**3.50E-07**	Health Canada 2009
naphthalene	128	7.80E-02	4.20E-04	Health Canada 2009
phenanthrene	178	**2.00E-04**	3.20E-05	Health Canada 2009
pyrene	**202**	**5.00E-06**	**9.10E-06**	Health Canada 2009

Note: Bolded and shaded cells indicate chemicals with a molecular weight of >200 g/mol, vapour pressure <0.001 mm Hg or Henry's Law Constant <1E-5 atm m^3/mol; nv = no value.

Ethanol, formaldehyde, methanol, phenol, anthracene, fluorene and phenanthrene satisfied one of the three criteria for non-volatility. In order to evaluate whether these chemicals should be added to the multi-media assessment, a closer evaluation of their environmental fate was required and are discussed below.

Ethanol and methanol have the following properties (HSDB 2012):

- present as a vapour in the atmosphere;
- react with hydroxyl radicals in the atmosphere with an estimated half-life of 36 hours (ethanol) and 17 days (methanol);
- volatilize from dry and moist soil surfaces and water surfaces;
- biodegrade in soil and water with estimated half-lives of a few days; and
- potential for bioconcentration in aquatic organisms is low.

Although the Henry's Law Constants for ethanol and methanol are slightly below the non-volatility criteria (7E-6 and 6E-6 versus 1E-5 atm-m^3/mol), because ethanol and methanol are generally expected to either volatilize or degrade in soil and water, they were not retained for the multi-media assessment.

Formaldehyde has the following properties (HSDB 2012):

- present as a vapour in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 41 hours;
- susceptible to direct photolysis with an estimated half-life of 6 hours in simulated sunlight;
- volatilizes from dry soil surfaces;
- biodegrades in soil and water under both aerobic and anaerobic conditions with estimated half-lives of a few days; and
- potential for bioconcentration in aquatic organisms is low.

Formaldehyde degrades quickly in the atmosphere. The Henry's Law Constant for formaldehyde is low enough that it may be washed out of the atmosphere by precipitation and found in moist soil, and lakes and rivers. However, formaldehyde biodegrades in water and does not bioconcentrate. Therefore, it is not expected to be present in appreciable amounts in vegetation, animal tissue or fish. As formaldehyde does not persist or accumulate in the environment, it was not retained for the multi-media assessment.

Phenol has the following properties (HSDB 2012):

- present as a vapour in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 15 hours;
- reacts with nitrate radicals in the atmosphere at night with an estimated half-life of 12 minutes;
- biodegrades in soil with an estimated half-life of 2 to 5 days, even in subsurface soil;
- mineralizes (i.e., breaks down completely) in water within days; and
- bioaccumulation of phenol in aquatic organisms is unlikely.

Phenol has a short half-life in air, water and soil and is not expected to persist or accumulate in terrestrial or aquatic environments. Therefore, it was not retained for the multi-media assessment.

Anthracene has the following properties (HSDB 2012):

- exists in both the vapor and particulate phases in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 4 hours;
- particulate phase anthracene can be removed from the atmosphere by wet and dry deposition;
- volatilizes from moist soil surfaces and water surfaces, attenuated by adsorption to organic matter;

- biodegrades in soil with estimated half-lives of 50 to 134 days;
- bioconcentration in aquatic organisms is moderate to very high; and
- subject to photolysis in sunlit surface waters with estimated half-lives of less than an hour.

Although atmospheric half-lives for anthracene are short, because it is subject to particle-bound wet and dry deposition and may accumulate in aquatic organisms, it will be evaluated in the multi-media risk assessment.

Fluorene has the following properties (HSDB 2012):

- exists primarily in the vapour phase in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 29 hours;
- particulate phase fluorene can be removed from the atmosphere by wet and dry deposition;
- biodegrades readily in soil and water under aerobic conditions, biodegradation can be slow under anaerobic conditions; and
- estimated half-lives in soil range from 2 to 64 days.

Although atmospheric half-lives for fluorene are short, because it is subject to particle-bound wet and dry deposition and may persist in soil and water depending on the conditions, it will be evaluated in the multi-media risk assessment.

Phenanthrene has the following properties (HSDB 2012):

- exists in both the vapour and particulate phases in the atmosphere;
- reacts with hydroxyl radicals in the atmosphere with an estimated half-life of 2 to 65 days;
- particulate phase phenanthrene can be removed from the atmosphere by wet and dry deposition;
- volatilizes from moist soil surfaces and water surfaces, attenuated by adsorption to organic matter;
- biodegrades in soil with estimated half-lives of 3 to 26 days;
- biodegrades in water with estimated half-lives of 1.3 to 13 days;
- Subject to photolysis with estimated half-lives of 6 to 100 hours during the day;
- bioconcentration in aquatic organisms is high to very high;

Although phenanthrene degrades in air, soil and water, because it is subject to particle-bound wet and dry deposition and may bioconcentrate in aquatic organisms, it will be evaluated in the multi-media risk assessment.

Step 3: Identify Carcinogens

All non-volatile PAHs that have been identified by the Canadian Council of Ministers of the Environment (CCME) as carcinogens (i.e., benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene) were retained for the multi-media assessment. Health Canada provides potency equivalence factors for fluoranthene and phenanthrene, and therefore, they were also evaluated as carcinogens (as per Round 3 SIR 21).

Step 4: Identify Chemicals that are Persistent or Bioaccumulative

Among the original list of organic chemicals, all VOCs and acid gases were screened out because they are volatile, and among the non-volatile PAHs, all of them except for pyrene were identified as carcinogens and retained. Pyrene was originally evaluated for persistence and bioaccumulative properties using the criteria of soil half life greater than 182 days and BCF greater than 5,000. There was evidence of persistence and bioaccumulative properties for pyrene, and thus, it was retained for further assessment. In Round 1 SIR 173, the reviewer requested that log Kow values (i.e., octanol water partition coefficients) are considered when identifying persistent PAHs. The use of log Kow would not change the results of the chemical screening for the multi-media assessment because pyrene would also be retained as COPCs based on its log Kow value being greater than 3.5 (log Kow of 5.18 for pyrene from Health Canada 2009). Overall, pyrene was retained for the multi-media assessment.

Step 5: Final COPC List

The COPC list that results from the above screening steps is shown in Table 4. The COPCs listed in Table 4 were retained for the multi-media assessment.

Table 4 Chemicals of Potential Concern Retained for the Multi-Media Assessment

Metals	PAHs
Arsenic	Anthracene
Barium	Benzo(a)anthracene
Beryllium	Benzo(a)anthracene surrogate
Cadmium	Benzo(a)pyrene
Chromium	Benzo(a)pyrene surrogate
Cobalt	Benzo(g,h,i)perylene
Copper	Benzo(b)fluoranthene
Lead	Benzo(k)fluoranthene
Manganese	Chrysene
Mercury	Dibenzo(a,h)anthracene
Molybdenum	Fluoranthene
Nickel	Fluorene
Selenium	Indeno(1,2,3-cd)pyrene
Vanadium	Phenanthrene
Zinc	Pyrene

2.2.2 Chemical Screening Process for the Aquatic Environment (Surface Water and Fish)

The screening of chemicals potentially released into regional surface water and groundwater was not necessary because effects to the aquatic environment are considered to be unlikely (Volume 4, Section 5). The Project will not release chemicals directly to surface waters (Volume 4, Section 5.3.1).

The Project will employ on-site domestic wastewater treatment. Domestic wastewater will be collected in storage tanks and transferred to an alternative wastewater treatment facility holding an approval under the Alberta *Environmental Protection and Enhancement Act* (EPEA) until a wastewater treatment plant is constructed. When the wastewater treatment plant is constructed, domestic wastewater from the Project will be treated and disposed of in a similar manner to the one used at the Christina Lake Thermal Project, which includes wastewater treatment and release to a subsurface drainage system.

Site runoff will be directed to an industrial runoff control system (including stormwater retention ponds). The water will be tested based on the conditions of the EPEA approval before release to surface waters. Surface runoff collected within the containment berms at well pad sites will also be tested before release to surface waters.

The Project will incorporate design features, management practices and mitigation plans to minimize the potential for spills that might adversely affect surface water quality, as described in Volume 1, Section 8.1. These measures will reduce the potential for spills to reach nearby surface waters. Spills of produced water or other potentially hazardous substances will be cleaned up according to emergency response procedures and regulations (Volume 1, Section 8.1).

2.2.3 Chemicals of Potential Concern

Chemicals of Potential Concern retained for the multi-media assessment are shown in Table 4.

3 HUMAN HEALTH EXPOSURE ASSESSMENT

Exposure assessment is the process of estimating the exposure of a human receptor to a substance under a given exposure scenario. An exposure assessment was conducted for each COPC identified in the problem formulation. For the multi-media assessment, exposure is determined as a dose. This value is called the Estimated Daily Intake (EDI) and is typically expressed as milligram of a chemical per kilogram of body weight per day (mg/kg-day).

The EDI was calculated from site-specific concentrations of substances in each environmental medium (e.g., air, water, soil and food), the amount of time a receptor spends at a location and receptor-specific parameters, such as body weight, ingestion rates and dietary preferences. Exposure assumptions used in calculating the EDI for human receptors are outlined below.

3.1 MEASURED EXPOSURE CONCENTRATIONS

Exposure concentrations based on measured concentrations in the various media are outlined in the following sections. Measured concentrations were available for soil, vegetation, surface water and fish.

3.1.1 Concentrations in Soil

Baseline soil concentrations were presented in Volume 3, Appendix 3-VII. The 95% Upper Confidence Limit of the Mean (UCLM) was calculated for each parameter based on the Project-specific baseline concentrations. The full detection limit was conservatively used in the calculations. For chemicals with >70% non-detects, a UCLM was not calculated and the maximum measured value was conservatively used. For chemicals with 100% non-detects, ½ of the detection limit value was used. The baseline soil concentrations used in the multi-media assessment are provided in Table 5. All of the PAHs were not detected in soil and half of the detection limit (0.005 mg/kg) was used in the multi-media risk assessment.

Table 5 Summary of 95th Upper Confidence Level of the Mean Soil Concentrations

Parameter	95% UCLM Concentration [dry weight mg/kg]	Percent of Results Less than Detection Limit
Arsenic	3.73	0%
Barium	77.27	0%
Beryllium	0.30	45%
Cadmium	0.34	5%
Chromium	8.35	14%
Cobalt	4.10	0%
Copper	8.31	0%
Lead	5.99	0%
Manganese	186.50	0%
Mercury	0.094	41%
Molybdenum	0.90	0%
Nickel	9.32	0%
Selenium	0.75[a]	91%
Vanadium	15.61	0%
Zinc	31.82	14%

[a] UCLM was not calculated, the maximum measured value was used.

3.1.2 Concentrations in Plant Tissues

Baseline plant concentrations were presented in Volume 3, Appendix 3-VII. For Labrador tea, alder (used for moose ingestion only) and berries, the 95% UCLM was calculated for each parameter based on the Project-specific baseline concentrations. The full detection limit was conservatively used in the calculations. For chemicals with >70% non-detects, a UCLM was not calculated and the maximum measured value was conservatively used. For chemicals with 100% non-detects, ½ of the detection limit value was used.

Cattails are generally peeled by Cree/Dene groups in the Athabasca region before consumption. Previous environmental assessments have relied on peeled concentrations for use in the human health risk assessment (e.g., Cenovus FCCL Ltd. Narrows Lake Project EIA, 2010). During baseline data collection for the Project, the analytical laboratory (ALS Laboratory Group [ALS]) was instructed to peel half of the cattail sample and analyze both the unpeeled and peeled portions of the sample separately for metals and PAHs. However, the laboratory instead generated a composite sample (half peeled and half unpeeled) and analyzed the composite for metals and PAHs. In order to utilize concentrations that better reflect potential consumption patterns (i.e., people typically consume peeled cattails), the maximum peeled cattail concentrations from the 2008 Narrows Lake EIA baseline data (Cenovus 2010) were used to represent baseline cattail concentrations for the Project rather than the results from the composite cattail samples from the Project. This was considered appropriate because the regional data analysis (Volume 3,

Appendix 3-IX) indicated that baseline alder, Labrador tea and berry concentrations collected for the Project are similar to available regional data; this suggests that peeled cattail concentrations from the 2008 Narrows Lake EIA baseline data would also be similar to peeled cattail concentrations for the Project.

The baseline Labrador tea, alder, berry and cattail concentrations used in the multi-media assessment are provided in Tables 6 to 9. All of the PAHs were not detected in vegetation and half of the detection limit (0.005 mg/kg) was used in the multi-media assessment.

Table 6 Summary of 95th Upper Confidence Level of the Mean Labrador Tea Concentrations

Parameter	95% UCLM Concentration [dry weight mg/kg]	Percent of Results Less than Detection Limit
Arsenic	0.032	54%
Barium	73.50	0%
Beryllium	0.005[(a)]	100%
Cadmium	0.005[(a)]	100%
Chromium	1.01	0%
Cobalt	0.066	8%
Copper	3.90	0%
Lead	0.035	46%
Manganese	717.80	0%
Mercury	0.006	54%
Molybdenum	0.21	54%
Nickel	1.07	0%
Selenium	0.16[(b)]	92%
Vanadium	0.13	0%
Zinc	24.48	0%

(a) UCLM was not calculated; half of the detection limit value was used.

(b) UCLM was not calculated; the maximum measured value was used.

Table 7 Summary of 95th Upper Confidence Level of the Mean Alder Concentrations

Parameter	5% UCLM Concentration [dry weight mg/kg]	Percent of Results Less than Detection Limit
Arsenic	0.042	30%
Barium	87.53	0%
Beryllium	0.036	70%
Cadmium	0.40	30%
Chromium	0.74	0%
Cobalt	2.20	0%
Copper	12.91	0%
Lead	0.086	0%
Manganese	1,593	0%
Mercury	0.0096	10%
Molybdenum	0.82	10%
Nickel	3.25	0%
Selenium	0.05[a]	100%
Vanadium	0.22	0%
Zinc	217.60	0%

[a] UCLM was not calculated; half of the detection limit value was used.

Table 8 Summary of 95th Upper Confidence Level of the Mean Berry Concentrations

Parameter	95% UCLM Concentration [dry weight mg/kg]	Percent of Results Less than Detection Limit
Arsenic	0.023[a]	80%
Barium	17.54	0%
Beryllium	0.005[b]	100%
Cadmium	0.031	50%
Chromium	0.68	0%
Cobalt	0.043	40%
Copper	4.70	0%
Lead	0.025[a]	80%
Manganese	315.30	0%
Mercury	0.0025[b]	100%
Molybdenum	0.362	0%
Nickel	2.16	0%
Selenium[a]	0.05[b]	100%
Vanadium	0.069	60%
Zinc	13.09	0%

[a] UCLM was not calculated; the maximum measured value was used.

[b] UCLM was not calculated; half of the detection limit value was used.

Table 9 Summary of Cattail Concentrations

Parameter	Maximum Peeled Cattail (Cenovus Narrows Lake Project, 2010)
Arsenic	0.17
Barium	9.19
Beryllium	<0.05
Cadmium	<0.02
Chromium	1.5
Cobalt	0.05
Copper	1.0
Lead	0.11
Manganese	312
Mercury	<0.008
Molybdenum	0.24
Nickel	0.9
Selenium	<0.1
Vanadium	<0.06
Zinc	39.5

3.1.3 Concentrations in Water

Surface water quality data were obtained from several surface waterbodies in the Project Area. Nine waterbodies in the Project Area were available for water quality data (Water Quality Baseline Report, Appendix 4-VI). Horsetail Lake, Kamistikowik Lake and seven unnamed waterbodies were used to compute median concentrations for each season. Median concentrations of metals measured in the Local Study Area waterbodies (Water Quality Baseline Report, Appendix 4-VI) are presented in Table 10. The maximum median concentration for each metal was used in the risk assessment (the shaded values in Table 10). Given that PAHs were primarily not detected in surface water, the concentration of PAHs in surface water was equivalent to one half the detection limit (0.005 µg/L). To be conservative, Aboriginal residents were assumed to obtain their drinking water from surface water.

Table 10 Summary of Water Quality in Waterbodies Within the Local Study Area

Parameter	Units	Summer	Fall	Winter	Spring
		Median	Median	Median	Median
Metals (Total)					
Arsenic	mg/L	0.0006	0.0006	0.001	0.0005
Barium	mg/L	0.013	0.019	0.03	0.014
Beryllium	mg/L	0.000007	<0.00001	<0.001	<0.00001
Cadmium	mg/L	0.00001	<0.000005	<0.000005	<0.000005
Chromium	mg/L	0.0002	0.0002	0.002	<0.0001
Cobalt	mg/L	0.0001	0.00007	<0.0003	0.00006
Copper	mg/L	0.0002	0.0006	0.0007	0.0003
Lead	mg/L	0.0001	0.00009	0.0008	0.0001
Manganese	mg/L	0.146	0.137	0.39	0.058
Mercury	µg/L	0.02	<0.002	<0.001	0.005
Molybdenum	mg/L	0.00005	0.00006	<0.0002	0.00006
Nickel	mg/L	0.0001	0.0002	<0.0005	0.0001
Selenium	mg/L	0.0001	<0.00004	<0.0002	<0.00004
Vanadium	mg/L	0.0042	<0.0002	<0.001	<0.0002
Zinc	mg/L	0.002	0.003	0.011	0.002

Shaded = Maximum value used in multi-media risk assessment.
Source: Volume 4, Appendix 4-VI, Water Quality Baseline Report for Pelican Lake Grand Rapids Project.

3.1.4 Concentrations in Fish

Fish tissue concentrations were presented in Volume 3, Appendix 3-VII. Northern pike was sampled as a representative fish species for human consumption. Fillets were collected and submitted for chemical analysis because this is the portion of the fish typically consumed by people. Maximum northern pike concentrations were used in the risk assessment and are presented in Table 11. PAHs were not detected in northern pike and half of the detection limit was used in the risk assessment (0.005 mg/kg).

Table 11 Concentrations of Metals in Baseline Northern Pike Fillets

Parameter	Northern Pike Maximum Concentration [mg/kg wet weight]
Arsenic	0.026
Barium	0.084
Beryllium	0.001[(a)]
Cadmium	0.001[(a)]
Chromium	0.13
Cobalt	0.002[(a)]
Copper	0.38
Lead	0.047
Manganese	0.81
Mercury	0.027
Molybdenum	0.012
Nickel	0.084
Selenium	0.075
Vanadium	0.002[(a)]
Zinc	7.61

(a) Parameter not detected; half of detection limit value used.

3.2 BIOAVAILABILITY

Bioavailability (also referred to as absorption efficiency) is a measure of the amount of a chemical that is absorbed and retained within the body. Consideration of bioavailability may be important under the following circumstances (Health Canada 1995):

- if the medium of exposure is different than the medium on which the toxicity reference value is based (e.g., exposure is from soil, but the toxicity reference value is based on exposure from water);
- if the route of exposure is different than the route of exposures in the study used to derive the toxicity reference value (e.g., oral route of exposure, but based on an inhalation study); or
- the toxicity reference value derived by the regulatory agency has been adjusted for bioavailability.

In the human health assessment, chemical bioavailability was taken into account by using Relative Absorption Factors (RAFs). Oral and inhalation exposures were assumed to have a relative absorption of 100% (RAF = 1) as pathway specific Toxicity Reference Values (TRVs) were available. As TRVs typically do not exist for the dermal exposure pathway, the dermal exposures are estimated from the oral dose taking into account the relative bioavailability and absorption. For dermal bioavailability, the RAFs were obtained from Health Canada (2010) and the Ontario Ministry of the Environment (2011) and are presented in Table 12 (as per Round 3

SIR 17). A RAF was not available for manganese, and therefore, a RAF of 1 was conservatively adopted.

Table 12 Relative Absorption Factors for Soil Dermal Contact

Chemical	RAF	Reference
Arsenic	0.03	Health Canada 2010, MOE 2011
Barium	0.10	Health Canada 2010, MOE 2011
Beryllium	0.10	MOE 2011
Cadmium	0.01	Health Canada 2010, MOE 2011
Chromium	0.10	Health Canada 2010, MOE 2011
Cobalt	0.01	MOE 2011
Copper	0.06	Health Canada 2010, MOE 2011
Lead	1.0	MOE 2011
Manganese	1	Default
Mercury	0.10	MOE 2011
Molybdenum	0.01	Health Canada 2010, MOE 2011
Nickel	0.20	MOE 2011
Selenium	0.01	Health Canada 2010
Vanadium	0.1	MOE 2011
Zinc	0.10	Health Canada 2010
Anthracene	0.13	MOE 2011
Benzo(a)anthracene	0.13	MOE 2011
Benzo (a) anthracene surrogate	0.13	MOE 2011
Benzo(a)pyrene	0.148	Health Canada 2010
Benzo (a) pyrene surrogate	0.148	Health Canada 2010
Benzo(b)fluoranthene	0.13	MOE 2011
Benzo(g,h,i)perylene	0.13	MOE 2011
Benzo(k)fluoranthene	0.13	MOE 2011
Chrysene	0.13	MOE 2011
Dibenzo(a,h)anthracene	0.13	MOE 2011
Fluoranthene	0.13	MOE 2011
Fluorene	0.13	MOE 2011
Indeno(1,2,3-cd)pyrene	0.13	MOE 2011
Phenanthrene	0.13	MOE 2011
Pyrene	0.148	Health Canada 2010

Previously, for arsenic, a RAF of 0.5 was applied for the ingestion of soil, vegetation, and meat. This assumption was based on lower bioavailability of soil-borne arsenic reported in animal feeding studies that range from less than 10% to 50% (ATSDR 2007). Several factors influence arsenic bioavailability in soil including arsenic speciation, low solubility, and inaccessibility due to the presence of secondary reaction products or insoluble matrix components (ATSDR 2007). This is supported by studies completed with in vitro simulations of the gastric or intestinal fluids

(ATSDR 2007). However, as per Round 3 SIR 18, a RAF of 1 is now applied for arsenic.

The forms of arsenic in fish and shellfish (i.e., arsenobetaine and arsenocholine) have been reported to be essentially non-toxic. However, a small percentage in fish tissue may be in the toxic inorganic form. Therefore, an inorganic arsenic fish content of 10% was previously used in calculations for arsenic exposures via the fish pathway (ATSDR 2007). However, per Round 3 SIR 18, a 100% inorganic arsenic in fish is now applied.

3.3 MODELLED EXPOSURE CONCENTRATIONS

Activities in all three assessment cases (Baseline Case, Application Case and PDC) have the potential to increase concentrations of metals and PAHs in soil and vegetation through deposition of particulate matter. Wildlife that browse vegetation and incidentally ingest soil can then take up substances into tissues, which are then consumed by people. Therefore, concentrations in animal tissues and future concentrations of substances in soil and plants were estimated. The incremental concentrations contributed by activities in the region were calculated using the food chain modelling methods developed by the United States Environmental Protection Agency (U.S. EPA 2005). A description of the methods used to predict concentrations in soil, plants and meat are presented below.

3.3.1 Soil

The method for predicting incremental soil concentrations remains as presented in Volume 3, Appendix 3-XI, but is presented herein for clarity. Incremental soil concentrations (ISCs) contributed by activities in the region for the Application Case and PDC were calculated using the modelling methods developed by the United States Environmental Protection Agency (U.S. EPA 2005). Specifically, the equations presented in Table 13 were used.

Table 13 Equations Used for Predicting Incremental Concentrations in Soil

Equation
Inorganic chemicals: ISC = (100 x (Dyd+Dyw) x tD/(Z_s x BD) Organic chemicals: ISC = [(100 x (Dyd+Dyw) x [1-exp(-Ks x tD]/(Z_s x BD x Ks)]
Where: ISC = incremental soil concentration (mg/kg dw) 100 = units conversion factor (mg-m^2/kg-cm^2) Dyd = dry deposition rate (g/m^2/yr); Project-specific Dyw = wet deposition rate (g/m^2/yr); Project-specific K*s* = soil loss constant (yr^{-1}); chemical-specific (U.S. EPA 2005) tD = deposition time (40 yr); Project-specific Z_s = soil mixing depth; 0.02 m untilled land (U.S. EPA 2005) BD = bulk density; 1.5 g/cm^3 (U.S. EPA 2005)

Source: Equations from U.S. EPA (2005).

Deposition onto soil was assumed to occur throughout the operational phase of the Project (tD) (i.e., a maximum of 40 years was assumed). All chemicals deposited onto soil were assumed to mix within the top 0.02 m of soil (Z_s) (U.S. EPA 2005). Soil was assumed to have a bulk density (BD) of 1,500 kg/m^3 (U.S. EPA 2005). The dry and wet deposition rates (Dyd and Dyw, respectively) were modelled for each receptor location assessed in the multi-media assessment (i.e., Chipewyan Lake and Wabasca IR 166C).

The soil loss constant (K*s*) represents the loss constant due to all processes, including soil erosion, surface runoff, leaching, volatilization and biotic and abiotic degradation. The processes of soil erosion, surface runoff and leaching can transfer chemicals both onto and off the Project Area; thus, loss constants for these processes were set at zero. As part of the screening for the multi-media assessment, only non-volatile chemicals were retained; as such, the volatilization rate for calculating ISCs was set at zero. Setting these loss constants at zero is a conservative approach which may result in an overestimation of ISCs. Loss constants for biotic and abiotic degradation for PAHs have been measured in field studies, and the loss constants recommended in U.S. EPA (2005) were applied in this calculation. The soil loss constant for degradation (K*sg*) for each of the modelled chemicals is shown in Table 14. Since the other loss constants have been set at zero, the soil loss constant (K*s*) is equal to the loss constant for degradation (K*sg*).

Table 14 Degradation Loss Constants for Polycyclic Aromatic Hydrocarbons

Chemical	Degradation Loss Constant (K*sg*) [yr^{-1}]	Reference
Anthracene	0.55	U.S. EPA (2005)
Benzo(a)anthracene	0.37	U.S. EPA (2005)
Benzo(a)pyrene	0.48	U.S. EPA (2005)
Benzo(g,h,i)perylene	0.27	Surrogate dibenzo(a,h)anthracene
Benzo(b)fluoranthene	0.41	U.S. EPA (2005)
Benzo(k)fluoranthene	0.12	U.S. EPA (2005)
Chrysene	0.25	U.S. EPA (2005)
Dibenzo(a,h)anthracene	0.27	U.S. EPA (2005)
Indeno(1,2,3-c,d)pyrene	0.35	U.S. EPA (2005)
Fluoranthene	0.57	U.S. EPA (2005)
Fluorene	4.22	U.S. EPA (2005)
Phenanthrene	1.26	U.S. EPA (2005)
Pyrene	0.13	U.S. EPA (2005)

The incremental increase in soil concentrations due to the Baseline, Application and Planned Development cases was added to measured baseline concentrations.

3.3.2 Plant Tissue

Chemical concentrations in wild plants or garden produce were estimated using the equations presented in Table 15. These equations were used to calculate leaf concentrations, berry or fruit concentrations and root concentrations. Labrador tea was used in the human health assessment as a surrogate for leafy vegetables. Cattails were used in the human health assessment as a surrogate for root vegetables. Berries were used in the human health risk assessment.

Plant concentrations were calculated based on the total exposure from direct deposition onto leaves or berries (incorporating surface area), absorption from gaseous chemicals in the air and uptake from soil. Project-specific bioaccumulation factors (BAFs) were calculated based on measured baseline soil and vegetation concentrations, and are presented in Section 3.4.

Table 15 Equations for Predicting Incremental Concentrations in Plants

Media	Equation
Total plant concentration (for berries/fruit and leaves)	PC = Pd + Pr
	PC = incremental concentration (mg/kg dry wt) Pd = incremental concentrations due to air deposition (mg/kg dry wt) Pr = incremental concentration due to root uptake (mg/kg dry wt)
Plant concentration due to air deposition (for berries/fruit and leaves)	Pd = 1,000 x [D_{yd} + (Fw x D_{wyd})] x Rp [1-exp(-kp x Tp)]/(Y_p x kp)
	Pd = incremental concentration due to air deposition (mg/kg dry wt) D_{yd} = dry particle deposition rate ($g/m^2/y$); Project-specific Fw = Fraction of COPC wet deposition that adheres to plant surface; 0.6 for all plants (U.S. EPA 2005) D_{wyd} = wet deposition rate ($g/m^2/y$); Project-specific Rp = interception fraction; represents portion of chemical deposition intercepted by plants; 0.39 for all plants (U.S. EPA 2005) Y_p = crop yield (kg dry wt/m^2); 2.24 for all plants (U.S. EPA 2005) Tp = length of plant exposure to deposition per harvest; Project-specific, 0.25 for all plants kp = chemical removal from the plant surface by weathering (yr^{-1}); 18 for all plants (U.S. EPA 2005)
Plant concentration due to root uptake (for berries/fruit and leaves)	Pr = SC x BAF
	Pr = incremental concentration due to root uptake (mg/kg dry wt) SC = predicted incremental soil concentration (mg/kg dry wt) BAF = bioaccumulation factor (unitless); Project-specific presented in Section 3.4
Root concentration for cattails	RC = SC x BAF
	RC = incremental root concentration (mg/kg dry wt) SC = predicted incremental soil concentration (mg/kg dry wt) BAF = soil-to-root bioaccumulation factors (unitless); Project-specific presented in Section 3.4

Source: U.S. EPA 2005.

The default values for crop yield (Yp) were used in the prediction of future plant concentrations for the Project (U.S. EPA 2005). The default values for interception fraction (Rp) (U.S. EPA 2005) were determined to be sufficiently conservative for wild plants because the surface areas of fruit (e.g., tomatoes, apples) and leafy vegetables (e.g., lettuce, cabbage) are much greater than berries and Labrador tea leaves. Length of plant exposure (Tp) was estimated to be three months for berry/fruit/vegetable (the length of the growing season in the area) and wild plant leaves because these would either be shed in the fall or they would be covered by snow for most of the winter months.

The incremental increase in plant concentrations due to the Baseline, Application and Planned Development cases was added to measured baseline concentrations.

3.3.3 Animal Tissue

Wildlife may ingest soil, plants and water from the Project Area and accumulate substances into their tissues. Therefore, uptake of metals and PAHs into animals consumed by people or other animals was estimated using food chain modelling.

Muscle tissue concentrations (i.e., meat) were calculated using the equations presented in Table 16. The meat concentrations were calculated based on consumption of plants, soil and water by moose. Moose was chosen because it is a key food source for aboriginal residents in the region.

Table 16 Equations for Predicting Meat Concentrations

Media	Equation
Moose tissue	T_C = ∑EDI x BTF x MF
	T_C = incremental chemical concentration in moose tissue (mg/kg wet wt) ∑EDI = sum of chemical ingestion from all oral pathways (mg/day) BTF = biotransfer factor (day/kg wet wt); chemical-specific (Table 17) MF = metabolism factor; 1 for metals, 0.01 for PAHs (Hofelt et al. 2001)

Source: (U.S. EPA 2005).

Plant and water ingestion rates for moose were estimated based on a body weight of 630 kg (NatureServe 2013) and the allometric equations provided in Sample and Suter (1994). A soil ingestion rate was calculated based on the assumption that the soil ingestion rate is 2% of the food ingestion rate (Beyer et al. 1994). Biotransfer factors for uptake of metals from plants and soil to muscle tissue of animals were applied (Table 17). Biotransfer factors for beef were used for metals since biotransfer factors specifically for moose were not available. A metabolism factor of 0.01 was applied to the final concentration of PAHs in moose tissue to account for the ability of mammals to metabolize and excrete PAHs (Hofelt et al. 2001).

3.4 CHEMICAL-SPECIFIC FACTORS USED IN THE FOOD CHAIN MODEL

The chemical-specific uptake factors used in the food chain model are presented in Table 17. Soil-to-plant uptake factors (BAFs) for metals were calculated using the baseline data for soil and plant tissues. An uptake factor was only calculated if both the co-located plant and soil sample had detectable metal concentrations. A 95^{th} UCLM was calculated where sufficient number of paired detectable concentrations allowed, otherwise a BAF from U.S. EPA (2005) was adopted. For PAHs, given that concentrations were primarily not detected in soil and plant tissues, BAFs from U.S. EPA (2005) were used. All biotransfer factors (BTF) of COPCs to meat tissues were adopted from U.S. EPA (2005).

Table 17 Chemical-Specific Bioaccumulation Factors and Biotransfer Factors

Parameter	Dry weight Bioaccumulation Factor (BAF)				BTF Beef[e]
	Labrador Tea[a]	Berries[b]	Cattails[c]	Alder[d]	
Arsenic	0.054	0.0063	0.81	0.058	0.0020
Barium	1.74	0.30	0.27	1.77	0.00015
Beryllium	0.01	0.0026	0.16	0.010	0.0010
Cadmium	0.36	0.58	0.69	26.32	0.00012
Chromium	0.42	0.087	1.36	0.34	0.0055
Cobalt	0.042	0.025	0.21	2.88	0.0019
Copper	1.99	1.42	0.62	6.96	0.0019
Lead	0.016	0.014	0.12	0.025	0.00030
Manganese	18.67	21.30	2.07	24.04	0.0019
Mercury	0.62	0.018	0.036	0.43	0.0077
Molybdenum	0.17	1.07	1.73	3.05	0.0019
Nickel	0.58	0.43	0.62	2.71	0.0060
Selenium	0.016	0.020	0.022	0.016	0.0023
Vanadium	0.036	0.0098	0.15	0.040	0.0019
Zinc	1.35	0.90	0.42	6.98	0.00009
Anthracene	0.097	0.097	0.15	0.097	3.38
Benzo(a)anthracene	0.020	0.020	0.095	0.020	3.99
Benzo(a)pyrene	0.013	0.013	0.061	0.013	3.76
Benzo(g,h,i)perylene[f]	0.0068	0.0068	0.041	0.0068	3.10
Benzo(b)fluoranthene	0.011	0.011	1.15	0.011	3.62
Benzo(k)fluoranthene	0.012	0.012	0.061	0.012	3.65
Chrysene	0.020	0.020	0.095	0.020	3.99
Dibenzo(a,h)anthracene	0.0068	0.0068	0.041	0.0068	3.10
Indeno(1,2,3-c,d)pyrene	0.0059	0.0059	0.053	0.0059	2.94
Fluoranthene	0.050	0.057	0.15	0.057	3.92
Fluorene	0.15	0.15	0.19	0.15	0.029
Phenanthrene	0.097	0.097	0.18	0.097	3.38
Pyrene	0.057	0.050	0.15	0.050	3.84

(a) Soil to Labrador tea BAFs calculated from baseline data except beryllium, cadmium, selenium and all PAHs, which were adopted from U.S. EPA (2005), Br (plant-soil bioconcentration factor) forage values.

(b) Soil to berry BAFs calculated from baseline data except arsenic, beryllium, lead, selenium and all PAHs, which were adopted from U.S. EPA (2005), Br (plant-soil bioconcentration factor) above-ground produce values and mercury, which was adopted from U.S. EPA (1997).

(c) Soil to cattail BAFs calculated from baseline data except for selenium and all PAHs, which were adopted from U.S. EPA (2005), Br (plant-soil bioconcentration factor) root values and mercury, which was adopted from U.S. EPA (1997).

(d) Soil to alder BAFs calculated from baseline data except beryllium, selenium and all PAHs, which were adopted from U.S. EPA (2005), Br (plant-soil bioconcentration factor) forage values.

(e) Beef Biotransfer factors are from (U.S. EPA 2005).

(f) Literature values were not available for benzo(g,h,i)perylene and surrogate values from dibenzo(a,h)anthracene were adopted.

3.5 RECEPTOR ASSUMPTIONS

The multi-media assessment focuses on an aboriginal resident, which is considered to be an individual that lives on an Indian Reserve (IR) for 365 days per year for a lifetime and consumes plants and animals from the area. Exposure pathways applicable to the aboriginal resident are:

- inhalation of air;
- inhalation of dust;
- ingestion of surface water (as drinking water);
- ingestion of fish;
- incidental ingestion of soil;
- dermal contact with soil;
- ingestion of plants (representative species modelled as Labrador tea, berries and cattail); and
- ingestion of wild game (representative species modelled as moose).

It was assumed that aboriginal residents get 100% of their fish, plant and wild game intake from the locations modelled. As per Round 3 SIR 19, non-carcinogenic risks were calculated for all life stages (infant, toddler, child, adolescent and adult). The toddler was the most sensitive lifestage (i.e., had the highest risks) for all of the PAHs as well as lead, mercury and selenium, and the infant was the most sensitive lifestage for the rest of the metal COPCs. Therefore, non-carcinogenic risks are presented for the infant and toddler. For carcinogenic chemicals, a composite receptor was employed to amortize exposure over the average lifetime expectancy (80 years), consistent with Health Canada guidance (Health Canada 2010). A composite receptor is used to assess risk across all life stages combined over a lifetime. The age categories consist of infants (i.e., 0 to 6 months of age), toddlers (i.e., 7 months to 4 years of age), children (i.e., 5 to 11 years of age), adolescents (i.e., 12 to 19 years of age) and adults (i.e., greater than 20 years of age). Exposure parameters used in the assessment are presented in Table 18.

Table 18 Exposure Parameters Used in the Multi-Media Risk Assessment

Parameter	Infant (0 to 6 months)	Toddler (6 months to 4 years)	Child (5 to 11 years)	Teen (12 to 19 years)	Adult (20+ years)
Aboriginal Resident					
Weight [kg][a]	8.2	16.5	32.9	59.7	70.7
Water ingestion rate [L/day][a]	0.3	0.6	0.8	1.0	1.5
Soil ingestion rate [kg/day][a]	0.00002	0.00008	0.00002	0.00002	0.00002
Air Inhalation rate [m^3/day][a]	2.2	8.3	14.5	15.6	15.6
Exposure Duration [ED; years] [a]	0.5	4.5	7	8	60
Soil loading to exposed skin [hands] [kg/cm^2/event][a]	$1x10^{-7}$	$1x10^{-7}$	$1x10^{-7}$	$1x10^{-7}$	$1x10^{-7}$
Wild game ingestion rate [kg wet wt/day][a]	0	0.085	0.125	0.175	0.270
Fish ingestion rate[kg wet wt/day][b]	0	0.095	0.170	0.200	0.220
Leaf ingestion rate[kg wet wt/day][a]	0.072	0.067	0.098	0.12	0.13
Root ingestion rate [kg wet wt/day][a]	0.083	0.105	0.161	0.227	0.188
Berry ingestion rate [kg wet wt/day][c]	0.00067	0.0037	0.0086	0.0069	0.0097
Exposure Frequency					
Air and soil [days per year]	365	365	365	365	365
Meat [days per year]	0	365	365	365	365
Fish [days per year]	0	365	365	365	365
Plants [days per year]	365	365	365	365	365
Surface water for drinking water [days per year]	365	365	365	365	365

(a) Health Canada 2010. Data for Canadian Aboriginal Populations for wild game ingestion.

(b) Health Canada 2009. Data for Canadian Aboriginal Populations for fish ingestion.

(c) Berry ingestion rates were based on strawberry and blueberry ingestion rates (Health Canada 1994).

3.6 EXPOSURE ASSESSMENT

Exposure assessment is the process of estimating the exposure of a human receptor to a substance under a given exposure scenario. An exposure assessment was conducted for each COPC identified in the problem formulation. For the multi-media risk assessment, exposure is determined as a dose. This value is called the EDI and is typically expressed as mg/kg day. The EDI was calculated from site-specific concentrations of substances in each environmental medium (e.g., air, water, soil and food), the amount of time a receptor spends at a location, and receptor-specific parameters, such as body weight, ingestion rates and dietary preferences. The assessment considered the unique diets and lifestyles of Aboriginal people in the region, including the reliance on wild plants, fish and animals as food sources.

Exposure estimate equations used in the multi-media risk assessment are provided in Table 19. Exposure estimates for each pathway and receptor are provided in Attachment A, Tables A-1 to A-9.

Table 19 Exposure Equations

Pathway	Equation and Equation Parameters
Water Ingestion	$EDI_{water} = \frac{C_w \times IR_w \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$
	EDI_{water} = Estimated Daily Intake due to ingestion of water (mg/kg day) C_w= COPC concentration in water (mg/L) IR_w = Water ingestion rate (L/d) AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless) EF = Exposure frequency (d/yr) ED = Exposure duration (yr) BW = Body weight (kg) AT = Averaging time (yr) CF_1 = Conversion Factor (365 d/yr)
Air Inhalation	$EDI_{air} = \frac{C_a \times IR_a \times AF_{inh} \times EF \times ED}{BW \times AT \times CF_1 \times CF_2}$
	EDI_{air} = Estimated Daily Intake due to inhalation of air (mg/kg day) C_a = COPC concentration in air (µg/m^3) IR_a = Inhalation rate (m^3/d) AF_{inh} = Inhalation absorption factor (unitless) EF = Exposure frequency (d/yr) ED = Exposure duration (yr) BW = Body weight (kg) AT = Averaging time (yr) CF_1 = Conversion factor (365 d/yr) CF_2 = Conversion factor (1000 µg/mg)
Dust Inhalation	$EDI_{dust} = \frac{C_s \times IR_a \times AF_{inh} \times EF \times ED \times C_d}{BW \times AT \times CF_1}$
	EDI_{dust} = Estimated Daily Intake due to inhalation of dust (mg/kg day) C_s = COPC concentration in soil (mg/kg) IR_a = Inhalation rate (m^3/d) AF_{inh} = Inhalation absorption factor (unitless) EF = Exposure frequency (d/yr) ED = Exposure duration (yr) C_d = Dust concentration (kg/m^3) BW = Body weight (kg) AT = Averaging time (yr) CF_1 = Conversion Factor (365 d/yr)
Dermal Absorption from Soil	$EDI_{dermal} = \frac{C_s \times SL_H \times EF \times SA_H \times AF_{skin} \times DE}{BW \times CF_1}$
	EDI_{dermal} = Estimated Daily Intake due to dermal contact with soil (mg/kg day) C_s= COPC concentration in soil (mg/kg) SL_H = Soil loading to exposed skin (kg/cm^2-event) EF = Exposure frequency (d/yr) SA_H = Surface area exposed (cm^2) AF_{skin} = Absorption factor for the skin (unitless) DE = Dermal events (events/d) BW = Body weight (kg) CF_1 = Conversion Factor (365 d/yr)
Incidental Soil Ingestion	$EDI_{soil} = \frac{C_s \times IR_s \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$
	EDI_{soil} = Estimated Daily Intake due to ingestion of soil (mg/kg day) C_s = COPC concentration in soil (mg/kg) IR_s = Soil ingestion rate (kg/d) AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless) EF = Exposure frequency (d/yr) ED = Exposure duration (yr) BW = Body weight (kg) AT = Averaging time (yr) CF_1 = Conversion Factor (365 d/yr)

Pathway	Equation and Equation Parameters
Food Ingestion (i.e., meat, fish and vegetation)	$EDI_{food} = \frac{C_{food} \times IR_{food} \times AF_{GIT} \times EF \times ED}{BW \times AT \times CF_1}$
	EDI_{food} = Estimated Daily Intake due to ingestion of food (i.e., meat, fish or vegetation) (mg/kg day) C_{food} = COPC concentration in food (mg/kg) IR_{food} = Food ingestion rate (kg/d) AF_{GIT} = Absorption factor for the gastrointestinal tract (unitless) ED = Exposure duration (yr) EF = Exposure frequency (d/yr) BW = Body weight (kg) AT = Averaging time (yr) CF_1 = Conversion Factor (365 d/yr)

4 TOXICITY ASSESSMENT

The toxicity assessment provides the basis for evaluating what is an acceptable exposure and what level of exposure may adversely affect people's health. The toxicity assessment for the multi-media risk assessment is based on long-term (chronic) toxicity studies. Toxicity assessment involves determining the amount of a chemical a person may take into his or her body through all applicable exposure pathways without affecting their health. This parameter is called a TRV.

For the multi-media risk assessment, TRVs for non-carcinogenic chemicals are called reference doses (RfDs) for the oral pathway and RfCs for the inhalation pathway. For carcinogenic chemicals, TRVs are called Slope Factors (SF) for the oral pathway and unit risk (UR) for the inhalation pathway. Consistent with Alberta Health and Wellness (2011) guidance, available RfDs, RfCs, SFs and URs were compiled from the following agencies:

- Health Canada (Health Canada 2010);
- U.S. Environmental Protection Agency's (EPA's) Integrated Risk Information System (U.S. EPA 2013); and
- Agency for Toxic Substances and Disease Registry (ATSDR 2013).

If values were not available from any of these agencies, other values were compiled from the literature. Other sources of TRVs were California Environmental Protection Agency (Cal. EPA 2013), British Columbia Ministry of the Environment (2013), RIVM (2001) and Canadian Council of Ministers of the Environment (CCME, 2010). The most conservative of the values was selected for use in the multi-media risk assessment. The selected RfDs and RfCs are presented in Table 20. As per Round 3 SIR 20, the toxicological basis for the TRVs reviewed and the TRV selected are provided in Attachment B.

Table 20 Toxicity Reference Values

	RfD [mg/kg/d]	Reference	RfC [mg/m³]	Reference
Arsenic	0.0003	U.S. EPA IRIS (2013)	1.5E-5	Cal. EPA (2013)
Barium	0.2	U.S. EPA IRIS (2013)	1.0E-3	RIVM (2001)
Beryllium	0.002	U.S. EPA IRIS (2013)	7.0E-6	Cal. EPA (2013)
Cadmium	0.0001	ATSDR (2013)	1.0E-5	ATSDR (2013)
Chromium	1.5	U.S. EPA IRIS (2013)	6.0E-2	RIVM (2001)
Cobalt	0.001	ATSDR (2013)	1.0E-4	ATSDR (2013)
Copper	0.091 (infant and toddler)	Health Canada (2010)	n/a	-
Lead	1.3	B.C. MOE (2013)	n/a	-
Manganese	0.136 (infant and toddler)	Health Canada (2010)	5.0E-5	U.S. EPA IRIS (2013)
Mercury	0.0003	Health Canada (2010)	3.0E-5	Cal. EPA (2013)
Molybdenum	0.005	U.S. EPA IRIS (2013)	1.2E-2	RIVM (2001)
Nickel	0.011	Health Canada (2010)	1.8E-5	Health Canada (2010)
Selenium	0.005	U.S. EPA IRIS (2013)	2.0E-2	Cal. EPA (2013)
Vanadium	0.009	U.S. EPA IRIS (2013)	1.0E-4	ATSDR (2013)
Zinc	0.3	U.S. EPA IRIS (2013)	n/a	-
Anthracene	0.3	U.S. EPA IRIS (2013)	n/a	-
Benzo(a)anthracene	n/a	-	n/a	-
Benzo(a)pyrene	n/a	-	n/a	-
Benzo(g,h,i)perylene[f]	n/a	-	n/a	-
Benzo(b)fluoranthene	n/a	-	n/a	-
Benzo(k)fluoranthene	n/a	-	n/a	-
Chrysene	n/a	-	n/a	-
Dibenzo(a,h)anthracene	n/a	-	n/a	-
Indeno(1,2,3-c,d)pyrene	n/a	-	n/a	-
Fluoranthene	0.04	U.S. EPA IRIS (2013)	n/a	-
Fluorene	0.04	-	n/a	-
Phenanthrene	n/a	-	n/a	-
Pyrene	0.03	Health Canada (2010)	n/a	-

n/a = not available.

4.1 CHEMICAL CLASSIFICATION

Different agencies and jurisdictions will classify chemicals based on their mode of action (i.e., threshold vs. non-threshold substances). The U.S. EPA Integrated Risk Information System (IRIS) database (U.S. EPA 2013), Health Canada (2010) and the International Agency for Research on Carcinogens (IARC 2013) were consulted to classify the COPCs retained; the group definitions for each agency are provided in Table 21. A summary of the results is provided in Table 22.

Table 21 Carcinogenicity Classification Systems

U.S. EPA IRIS Database (2013)		IARC (2013)		Health Canada (2010)	
Group A	Human carcinogen	Group 1	Carcinogenic to humans	Group I	Carcinogenic to humans
Group B1	Probable human carcinogen – based on limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in animals	Group 2A	Probably carcinogenic to humans	Group II	Probably carcinogenic to humans
Group B2	Probable human carcinogen – based on sufficient evidence of carcinogenicity in animals	Group 2B	Possibly carcinogenic to humans	Group III	Possibly carcinogenic to humans
Group C	Possible human carcinogen	Group 3	Not classifiable as to its carcinogenicity to humans	Group IV	Unlikely to be carcinogenic to humans
Group D	Not classifiable as to human carcinogenicity	Group 4	Probably not carcinogenic to humans	Group V	Probably not carcinogenic to humans
Group E	Evidence of non-carcinogenicity for humans			Group VI	Unclassifiable with respect to its carcinogenicity to humans
				Group VA	Inadequate data for evaluation

Table 22 Carcinogenicity Classification of Chemicals of Potential Concern for the Multi-Media Risk Assessment

Chemical	U.S. EPA IRIS Database (2013)	Health Canada (2010)	IARC (2013)	Assessed as a Carcinogen
Arsenic	Group A	Group I	Group 1	Yes (oral, inhalation)
Barium	Group D	Group VA	n/a	No
Beryllium	Group B1	n/a	Group 1	Yes (inhalation)
Cadmium	Group A	Group II	Group 1	Yes (inhalation)
Chromium	Group D (Cr-III)	Group I (total)	Group 3 (Cr-III)	Yes (inhalation)
Cobalt	n/a	n/a	Group 2B	No
Copper	Group D	n/a	n/a	No
Lead	Group B2	n/a	Group 2A	No[(a)]
Manganese	Group D	n/a	n/a	No
Mercury	Group D	n/a	Group 3	No
Molybdenum	n/a	n/a	n/a	No
Nickel	n/a	Group I	Group 1 (nickel compounds); Group 2B (metallic nickel and alloys)	Yes (inhalation)
Selenium	Group D	n/a	Group 3	No
Vanadium	n/a	n/a	Group 2B	No
Zinc	Group D	n/a	n/a	No
Anthracene	Group D	n/a	Group 3	No
Benzo(a)anthracene	Group B2	n/a	Group 2B	Yes (oral, inhalation)
Benzo(a)pyrene	Group B2	Group II	Group 1	Yes (oral, inhalation)
Benzo(g,h,i)perylene	Group D	n/a	Group 3	Yes (oral, inhalation)
Benzo(b)fluoranthene	Group B2	n/a	Group 2B	Yes (oral, inhalation)
Benzo(k)fluoranthene	Group B2	n/a	Group 2B	Yes (oral, inhalation)
Chrysene	Group B2	n/a	Group 2B	Yes (oral, inhalation)
Dibenzo(a,h)anthracene	Group B2	n/a	Group 2A	Yes (oral, inhalation)
Indeno(1,2,3-c,d)pyrene	Group B2	n/a	Group 2B	Yes (oral, inhalation)
Fluoranthene	Group D	n/a	Group 3	Yes[(b)]
Fluorene	Group D	n/a	Group 3	No
Phenanthrene	Group D	n/a	Group 3	Yes[(b)]
Pyrene	Group D	n/a	Group 3	No

(a) No oral slope factors or inhalation unit risks are recommended by Health Canada or U.S. EPA IRIS

(b) Based on potency equivalence factors from Health Canada (as per Round 3 SIR 21)

n/a = Not assessed.

With the exception of arsenic and the carcinogenic PAHs, none of the COPCs for the multi-media risk assessment are carcinogenic via the oral route. However, arsenic, beryllium, cadmium, chromium, nickel and the carcinogenic PAHs are carcinogenic via the inhalation route. For chromium, TRVs provided for total chromium or chromium III were used. Health Canada has an inhalation unit risk for total chromium but not an oral slope factor; therefore, total chromium was evaluated as a carcinogen for the inhalation exposure pathway but not the oral exposure pathway. The selected SFs and URs for the COPCs evaluated as carcinogens are presented in Table 23. For benzo(a)pyrene, the Health Canada (2010) SF was chosen in preference to the U.S. EPA IRIS SF because the Health Canada SF reflects more recent toxicological studies, as it was published in 2010, while the U.S. EPA IRIS SF was published in 1998. Oral SFs for the other carcinogenic PAHs were derived from the benzo(a)pyrene SF using the potency equivalence factors (PEFs) provided in CCME (2010), and as per Round 3 SIR 21, Health Canada (2010). Inhalation URs for carcinogenic PAHs were also derived from the benzo(a)pyrene UR using the PEFs from CCME (2010).

Table 23 Toxicity Reference Values

	Oral Slope Factor $(mg/kg/d)^{-1}$	Reference	Inhalation Unit Risk $[mg/m^3]^{-1}$	Reference
Arsenic	1.8	Health Canada 2010	6.4	Health Canada 2010
Beryllium	n/a	-	2.4	U.S. EPA IRIS 2013
Cadmium	n/a	-	9.8	Health Canada 2010
Chromium	n/a	-	11	Health Canada 2010
Nickel	n/a	-	0.71	Health Canada 2010
Benzo(a)anthracene	0.23 (PEF 0.1)	CCME 2010	0.0031 (PEF 0.1)	CCME 2010
Benzo(a)pyrene	2.3	Health Canada 2010	0.031	Health Canada 2010
Benzo(g,h,i)perylene	0.023 (PEF 0.01)	CCME 2010	0.00031 (PEF 0.01)	CCME 2010
Benzo(b)fluoranthene	0.23 (PEF 0.1)	CCME 2010	0.0031 (PEF 0.1)	CCME 2010
Benzo(k)fluoranthene	0.23 (PEF 0.1)	CCME 2010	0.0031 (PEF 0.1)	CCME 2010
Chrysene	0.023 (PEF 0.01)	CCME 2010	0.00031 (PEF 0.01)	CCME 2010
Dibenzo(a,h)anthracene	2.3 (PEF 1)	CCME 2010	0.031 (PEF 1)	CCME 2010
Indeno(1,2,3-c,d)pyrene	0.23 (PEF 0.1)	CCME 2010	0.0031 (PEF 0.1)	CCME 2010
Fluoranthene	0.0023 (PEF 0.001)	Health Canada 2010	-0.000031 (PEF 0.001)	Health Canada 2010
Phenanthrene	0.0023 (PEF 0.001)	Health Canada 2010	0.000031 (PEF 0.001)	Health Canada 2010

PEF = potency equivalence factor, equivalent to a multiplication factor from the benzo(a)pyrene slope factor
n/a = not evaluated as a carcinogen for this pathway.

5 RISK CHARACTERIZATION

Long-term health effects were evaluated by calculating ERs for both non-carcinogens and carcinogens. An ER is the ratio between the exposure likely to be incurred by the person and the amount of exposure that is considered to be safe. No health risk is predicted if the ER is equal to or less than one.

When the ER is equal to or greater than one, the scenarios pose a potential concern and require further scrutiny. However, ER values greater than one do not necessarily indicate that adverse health effects will occur. A large margin of safety has been included in the ER estimation.

In the risk characterization step, ERs were calculated for non-carcinogenic COPCs by comparing the predicted levels of exposure with their respective exposure limits according to the following equations:

$$ER = \frac{\text{estimated daily intake (mg/kg day)}}{\text{RfD (mg/kg day)}}$$

or

$$ER = \frac{\text{estimated air concentration } (\mu g/m^3)}{\text{RfC } (\mu g/m^3)}$$

An ER less than or equal to one indicates that the estimated exposure is less than the reference dose signifying negligible health effects.

The ERs generated for carcinogens are based on the Incremental Lifetime Cancer Risk (ILCR) which is the additional cancer cases attributed to the incremental exposures to carcinogenic COPCs released by the Project or future developments in the region. Interpretation of these ILCRs was based on comparison of the calculated ILCR values with the “benchmark” of 1 in 100,000 (i.e., one extra cancer case in a population of 100,000 people). Health Canada (2010) considers cancer risks from chemical exposure to be essentially negligible if the ILCR is less than one in 100,000 (1×10^{-5}).

For carcinogenic COPCs, ILCRs were calculated according to the following equations:

ILCR = estimated daily intake (mg/kg BW/day) x SF $(mg/kg\ day)^{-1}$

or

ILCR = estimated air concentrations $(\mu g/m^3)$ x UR $(\mu g/m^3)^{-1}$

ERs were then calculated, as follows:

ER= ILCR x 100,000

For example, an ER less than or equal to one for a carcinogen represents an ILCR above background of less than one in 100,000, which is considered a negligible health effect.

An ER was calculated for each COPC and each relevant exposure pathway; ERs are provided in Attachment A, Tables A-10 to A-18. Pathway-specific ERs were then summed to give a total ER value for multi-media exposure for each COPC.

5.1 CHEMICAL MIXTURES

According to Health Canada (Health Canada 2010), ERs for COPCs that have similar target organs, effects and mechanisms of action should be added together to determine a total ER for a particular toxicological effect. A brief summary of the COPCs for which ERs were summed and the relevant target organs and effects is provided in Table 24. Table 24 has been revised to include endpoints for lead and manganese, as well as lead and nickel, as per Round 3 SIR 23. Fluorene, which was added as a COPC as per Round 3 SIR 14, has been added to the chemical mixture with effects on blood following chronic oral exposure.

Table 24 Potential Additive Interactions of the Chemicals of Potential Concern for the Multi-Media Risk Assessment

Exposure Scenario	Chemicals of Potential Concern		Target Organ	Effects
Chronic Inhalation Exposure	Non-Carcinogens	Chromium, cobalt, nickel, vanadium	Respiratory system	Lesions in lung, nasal epithelium
		Manganese, mercury	Nervous system	Impairment of neurobehavioural function, hand tremor
	Carcinogens	Arsenic, beryllium, cadmium, chromium, nickel	Lung	Cancer
		Carcinogenic PAHs	Stomach	Tumours
Chronic Oral Exposure	Non- Carcinogens	Barium, cadmium, mercury, pyrene	Kidney	Renal toxicant
		Lead, manganese	Brain	Neurotoxicity
		Lead, nickel	Reproductive system	Developmental
		Cobalt, molybdenum, zinc, fluorene	Blood	Polycythemia
	Carcinogens	Carcinogenic PAHs	Stomach	Tumours

5.2 LAYERS OF SAFETY

Uncertainty is associated with risk estimations, depending on the uncertainty and variability associated with the available information. When information is uncertain, it is standard practice in a risk assessment to make assumptions that are biased towards safety, so that even if there is uncertainty, human health will still be protected.

Several layers of safety were applied in this assessment. For example, the risk assessment assumes that a person will live in the Regional Study Area for their entire life. It further assumes that this person is a susceptible child or elder who will be exposed to reasonable worst-case releases from the Project every day that the facility is operating. The assessment also assumes that while living in an Aboriginal community, traditional activities are carried out (e.g., consumption of traditional foods) for 365 days per year over a lifetime. Thus, if the risk assessment indicates that ERs are less than one for these "maximally exposed" people, then it can be concluded that all people will be protected.

Uncertainty is also associated with estimating TRVs. Toxicity reference values are based on toxicity information available from government databases and published scientific literature. Most toxicity information comes from the results of experiments with laboratory animals. Some additional information on human health effects may also be available for some substances where cases of workplace exposures and associated health effects have been documented. There is uncertainty in extrapolating from animal studies and workplace case studies to the possible effects that may result from exposure to releases from the Project. To add a layer of safety, it is standard practice in a risk assessment to assume that people are more sensitive to the toxic effects of a chemical than laboratory animals. Therefore, the toxicity reference values for human health are set much lower than the animal toxicity threshold (typically 100 to 1,000 times lower). This large margin of safety ensures that exceeding these toxicity reference values by small amounts will not measurably increase the risk of adverse health effects.

6 MULTI-MEDIA RISK ASSESSMENT RESULTS

The results of the multi-media risk assessment are provided in Tables 25 to 30. Exposure Ratios (ERs) are greater than one for arsenic, barium and manganese for the infant (Table 25) and arsenic and manganese for the toddler (Table 26) for all project cases (i.e., Baseline, Application and Planned Development cases) at both evaluated receptor locations (i.e., Chipewyan Lake and Wabasca I.R. 166C). Carcinogens that had ER values greater than one were arsenic, benzo(a)anthracene total, benzo(a)pyrene, benzo(a)pyrene surrogate, benzo(a)pyrene total and dibenzo(a,h)anthracene (Table 27).

In regards to additive effects, the sum of ERs for kidney, blood and brain toxicants for the infant (Table 28), kidney and brain toxicants for the toddler (Table 29) and stomach cancer for the composite receptor (Table 30) were greater than one.

For the parameters with ERs greater than one, Table 31 shows the percent change between Application Case and Baseline Case, and between PDC and Baseline Case. Percent change is calculated as the difference between the ER values from each Case divided by the Baseline ER. All of the percent changes for individual chemicals were less than 0.06% and for additive effects were less than 2.3%. This indicates that the contribution of the Project to exposure is negligible. Although these ERs are greater than one, this is reflective of baseline exposure. Overall, it is concluded that the Project contribution to exposure for aboriginal residents is negligible.

Tables 32 to 35 show ERs for the Project only, as per Round 3 SIR 24. All of the ERs, including individual chemicals and mixtures, for carcinogenic and non-carcinogenic effects, were less than 0.01.

Table 25 Exposure Ratios for the Infant – Non-Carcinogenic Evaluation

Chemical	Infant - Chipewyan Lake			Infant - Wabasca IR 166C		
	Baseline	Application	PDC	Baseline	Application	PDC
Arsenic	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**
Barium	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**
Beryllium	0.061	0.061	0.061	0.061	0.061	0.061
Cadmium	0.56	0.57	0.61	0.56	0.57	0.61
Chromium	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055
Cobalt	0.43	0.43	0.43	0.43	0.43	0.43
Copper	0.21	0.21	0.21	0.21	0.21	0.21
Lead	0.00038	0.00038	0.00038	0.00038	0.00038	0.00038
Manganese	**29**	**29**	**29**	**29**	**29**	**29**
Mercury	0.13	0.13	0.13	0.13	0.13	0.13
Molybdenum	0.31	0.31	0.31	0.31	0.31	0.31
Nickel	0.64	0.64	0.64	0.64	0.64	0.64
Selenium	0.16	0.16	0.16	0.16	0.16	0.16
Vanadium	0.093	0.093	0.093	0.093	0.093	0.093
Zinc	0.69	0.69	0.69	0.69	0.69	0.69
Anthracene	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Fluoranthene	0.00086	0.00086	0.00086	0.00086	0.00086	0.00086
Fluorene	0.00086	0.00086	0.00086	0.00086	0.00086	0.00086
Pyrene	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011

Note: ERs in **Bold** are >1.

Table 26 Exposure Ratios for the Toddler – Non-Carcinogenic Evaluation

Chemical	Toddler - Chipewyan Lake			Toddler - Wabasca IR 166C		
	Baseline	Application	PDC	Baseline	Application	PDC
Arsenic	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**
Barium	0.82	0.82	0.82	0.82	0.82	0.82
Beryllium	0.048	0.048	0.048	0.048	0.048	0.048
Cadmium	0.40	0.40	0.43	0.39	0.40	0.43
Chromium	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038
Cobalt	0.27	0.27	0.27	0.27	0.27	0.27
Copper	0.13	0.13	0.13	0.13	0.13	0.13
Lead	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045
Manganese	**15**	**15**	**15**	**15**	**15**	**15**
Mercury	0.61	0.61	0.61	0.61	0.61	0.61
Molybdenum	0.18	0.18	0.19	0.18	0.19	0.19
Nickel	0.42	0.42	0.42	0.42	0.42	0.42
Selenium	0.17	0.17	0.17	0.17	0.17	0.17
Vanadium	0.068	0.068	0.068	0.068	0.068	0.068
Zinc	0.52	0.52	0.52	0.52	0.52	0.52
Anthracene	0.00019	0.00019	0.00019	0.00019	0.00019	0.00019
Fluoranthene	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
Fluorene	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012
Pyrene	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019

Note: ERs in **Bold** are >1.

Table 27 Exposure Ratios for the Composite Receptor – Carcinogenic Evaluation

Chemical	Composite Receptor - Chipewyan Lake			Composite Receptor - Wabasca IR 166C		
	Baseline	Application	PDC	Baseline	Application	PDC
Arsenic	**90**	**90**	**90**	**90**	**90**	**90**
Beryllium	0.000061	0.000065	0.000091	0.000032	0.000038	0.000053
Cadmium	0.052	0.054	0.082	0.022	0.025	0.038
Chromium	0.074	0.076	0.095	0.039	0.042	0.052
Nickel	0.0075	0.0078	0.0092	0.0040	0.0044	0.0052
Benzo(a)anthracene	0.85	0.85	0.85	0.85	0.85	0.85
Benzo(a)anthracene surrogate	0.85	0.85	0.85	0.85	0.85	0.85
Benzo(a)anthracene total	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**
Benzo(a)pyrene	**8.3**	**8.3**	**8.3**	**8.3**	**8.3**	**8.3**
Benzo(a)pyrene surrogate	**8.3**	**8.3**	**8.3**	**8.3**	**8.3**	**8.3**
Benzo(a)pyrene total	**17**	**17**	**17**	**17**	**17**	**17**
Benzo(g,h,i)perylene	0.080	0.080	0.080	0.080	0.080	0.080
Benzo(b)fluoranthene	0.83	0.83	0.83	0.83	0.83	0.83
Benzo(k)fluoranthene	0.83	0.83	0.83	0.83	0.83	0.83
Chrysene	0.085	0.085	0.085	0.085	0.085	0.085
Dibenzo(a,h)anthracene	**8.0**	**8.0**	**8.0**	**8.0**	**8.0**	**8.0**
Fluoranthene	0.0084	0.0084	0.0084	0.0084	0.0084	0.0084
Indeno(1,2,3-cd)pyrene	0.80	0.80	0.80	0.80	0.80	0.80
Phenanthrene	0.0082	0.0082	0.0082	0.0082	0.0082	0.0082

Note: ERs in **Bold** are >1.

Table 28 Exposure Ratios for the Infant – Non-Carcinogenic Additive Effects

Target-Route (Chemicals)	Infant - Chipewyan Lake			Infant - Wabasca IR 166C		
	Baseline	Application	PDC	Baseline	Application	PDC
Kidneys-Oral (barium, cadmium, mercury, pyrene)	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**	**2.4**
Blood-Oral (cobalt, molybdenum, zinc, fluorene)	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**
Respiratory system-Inhalation (chromium, cobalt, nickel, vanadium)	0.0063	0.0066	0.0079	0.0034	0.0037	0.0044
Brain-Oral (lead, manganese)	**29**	**29**	**29**	**29**	**29**	**29**
Reproductive system (lead, nickel)	0.64	0.64	0.64	0.64	0.64	0.64
Nervous system-Inhalation (manganese, mercury)	0.00061	0.00064	0.00084	0.00031	0.00034	0.00045

Note: ERs in **Bold** are >1.

Table 29 Exposure Ratios for the Toddler – Non-Carcinogenic Additive Effects

Target-Route (Chemicals)	Toddler - Chipewyan Lake			Toddler - Wabasca IR 166C		
	Baseline	Application	PDC	Baseline	Application	PDC
Kidneys-Oral (barium, cadmium, mercury, pyrene)	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**
Blood-Oral (cobalt, molybdenum, zinc, fluorene)	0.98	0.98	0.98	0.98	0.98	0.98
Respiratory system-Inhalation (chromium, cobalt, nickel, vanadium)	0.0063	0.0066	0.0079	0.0034	0.0037	0.0044
Brain-Oral (lead, manganese)	**15**	**15**	**15**	**15**	**15**	**15**
Reproductive system (lead, nickel)	0.42	0.42	0.42	0.42	0.42	0.42
Nervous system-Inhalation (manganese, mercury)	0.00061	0.00064	0.00084	0.00031	0.00034	0.00045

Note: ERs in **Bold** are >1.

Table 30 Exposure Ratios for the Composite Receptor – Carcinogenic Additive Effects

Target-Route (Chemicals)	Composite Receptor - Chipewyan Lake			Composite Receptor - Wabasca IR 166C		
	Baseline	Application	PDC	Baseline	Application	PDC
Lung-Inhalation (arsenic, beryllium, cadmium, chromium, nickel)	0.14	0.14	0.19	0.066	0.073	0.098
Stomach-Inhalation and Oral (all carcinogenic PAHs)	**29**	**29**	**29**	**29**	**29**	**29**

Note: ERs in **Bold** are >1.

Table 31 Percent Change Between Project Cases for Parameters with ER > 1

Parameter – Receptor -Endpoint	Chipewyan Lake		Wabasca IR 166C	
	Application % Change from Baseline	PDC % Change from Baseline	Application % Change from Baseline	PDC % Change from Baseline
Arsenic – Infant – Non-Carcinogenic	0.0071	0.037	0.019	0.052
Arsenic – Toddler – Non-Carcinogenic	0.0053	0.028	0.014	0.038
Barium – Infant – Non-Carcinogenic	0.0012	0.0067	0.0031	0.0084
Manganese – Infant – Non-Carcinogenic	0.00011	0.0012	0.00025	0.0012
Manganese – Toddler – Non-Carcinogenic	0.00014	0.0017	0.00030	0.0014
Arsenic – Composite - Carcinogenic	0.0029	0.015	0.0082	0.022
Benzo(a)anthracene total – Composite - Carcinogenic	0.00010	0.0039	0.00025	0.0050
Benzo(a)pyrene total – Composite - Carcinogenic	0.000016	0.00090	0.000039	0.0011
Dibenzo(a,h)anthracene – Composite - Carcinogenic	0.000011	0.00075	0.000027	0.00085
Additive – Infant – Kidneys	0.13	1.8	0.39	2.2
Additive – Infant – Blood	0.010	0.061	0.031	0.091
Additive – Infant - Brain	0.000067	0.00069	0.00020	0.00090
Additive – Toddler - Kidneys	0.10	1.4	0.31	1.7
Additive – Toddler – Brain	0.000066	0.00067	0.00020	0.00087
Additive – Composite – Stomach cancer	0.000020	0.0011	0.000049	0.0013

Table 32 Project Only Exposure Ratios – Non-Carcinogenic Evaluation

Chemical	Infant – Project Only		Toddler – Project Only	
	Chipewyan Lake	Wabasca IR 166C	Chipewyan Lake	Wabasca IR 166C
Arsenic	0.00014	0.00040	0.000097	0.00025
Barium	0.000021	0.000052	0.000014	0.000030
Beryllium	0.0000029	0.0000042	0.0000028	0.0000039
Cadmium	0.0031	0.0090	0.0019	0.0055
Chromium	0.00000043	0.0000012	0.00000027	0.00000074
Cobalt	0.0000062	0.000016	0.0000060	0.000016
Copper	0.000008	0.000023	0.0000027	0.0000082
Lead	0.000000012	0.000000036	0.0000000073	0.000000022
Manganese	0.000031	0.000073	0.000020	0.000041
Mercury	0.00021	0.00060	0.00012	0.00033
Molybdenum	0.000091	0.00027	0.000061	0.00018
Nickel	0.00024	0.00042	0.00022	0.00037
Selenium	0.000000059	0.00000017	0.000000035	0.00000010
Vanadium	0.000047	0.000081	0.000042	0.000067
Zinc	0.000054	0.00016	0.000027	0.000079
Anthracene	0.000000000090	0.00000000022	0.000000000081	0.00000000020
Fluoranthene	0.00000000060	0.0000000017	0.00000000059	0.0000000017
Fluorene	0.0000000010	0.0000000030	0.00000000049	0.0000000014
Pyrene	0.0000000014	0.0000000034	0.0000000014	0.0000000034

Table 33 Project Only Exposure Ratios –Carcinogenic Evaluation

Chemical	Composite Receptor – Project Only		Composite Receptor – PDC Minus Baseline[(a)]	
	Chipewyan Lake	Wabasca IR 166C	Chipewyan Lake	Wabasca IR 166C
Arsenic	0.0026	0.0074	0.013	0.020
Beryllium	0.0000047	0.0000063	0.000031	0.000021
Cadmium	0.0018	0.0023	0.030	0.016
Chromium	0.0025	0.0033	0.021	0.013
Nickel	0.00024	0.00032	0.0017	0.0011
Benzo(a)anthracene	0.00000018	0.00000043	0.0000090	0.000011
Benzo(a)anthracene surrogate	0.0000016	0.0000039	0.000057	0.000074
Benzo(a)anthracene total	0.0000018	0.0000043	0.000066	0.000085
Benzo(a)pyrene	0.0000011	0.0000026	0.000051	0.000062
Benzo(a)pyrene surrogate	0.0000016	0.0000039	0.000099	0.00011
Benzo(a)pyrene total	0.0000027	0.0000064	0.00015	0.00018
Benzo(g,h,i)perylene	0.0000000090	0.000000025	0.00000061	0.00000068
Benzo(b)fluoranthene	0.00000016	0.00000039	0.000017	0.000018
Benzo(k)fluoranthene	0.00000015	0.00000037	0.0000067	0.0000083
Chrysene	0.000000018	0.000000051	0.0000010	0.0000012
Dibenzo(a,h)anthracene	0.00000089	0.0000022	0.000061	0.000068
Fluoranthene	0.0000000038	0.000000011	0.00000075	0.00000076
Indeno(1,2,3-cd)pyrene	0.00000013	0.00000031	0.0000047	0.0000060
Phenanthrene	0.0000000042	0.000000066	0.0000025	0.0000027

(a) This scenario represents future emissions not including background (as per Round 3 SIR 24)

Table 34 Project Only Exposure Ratios – Non-Carcinogenic Additive Effects

Chemical	Infant – Project Only		Toddler – Project Only	
	Chipewyan Lake	Wabasca IR 166C	Chipewyan Lake	Wabasca IR 166C
Kidneys-Oral (barium, cadmium, mercury, pyrene)	0.0032	0.0094	0.0019	0.0056
Blood-Oral (cobalt, molybdenum, zinc, fluorene)	0.00015	0.00045	0.000092	0.00027
Respiratory system-Inhalation (chromium, cobalt, nickel, vanadium)	0.00022	0.00029	0.00022	0.00029
Brain-Oral (lead, manganese)	0.000019	0.000058	0.0000085	0.000025
Reproductive system (lead, nickel)	0.000063	0.00019	0.000046	0.00014
Nervous system-Inhalation (manganese, mercury)	0.000025	0.000033	0.000025	0.000033

Table 35 Project Only Exposure Ratios –Carcinogenic Additive Effects

Chemical	Composite Receptor – Project Only		Composite Receptor – PDC Minus Baseline[(a)]	
	Chipewyan Lake	Wabasca IR 166C	Chipewyan Lake	Wabasca IR 166C
Lung-Inhalation (arsenic, beryllium, cadmium, chromium, nickel)	0.0047	0.0063	0.055	0.031
Stomach-Inhalation and Oral (all carcinogenic PAHs)	0.0000058	0.000014	0.00031	0.00037

(b) This scenario represents future emissions not including background (as per Round 3 SIR 24)

7 MULTI-MEDIA RISK ASSESSMENT DISCUSSION

Non-carcinogenic ERs were greater than one for arsenic, barium and manganese for the infant, and arsenic and manganese for the toddler for all Project cases at both evaluated receptor locations. The contribution of individual exposure pathways to the total risk for these chemicals is shown in Figures 1 to 4 (as per Round 3 SIR 25).

Figure 1: Contribution of Exposure Pathways for the Infant, Application Case, Arsenic and Barium

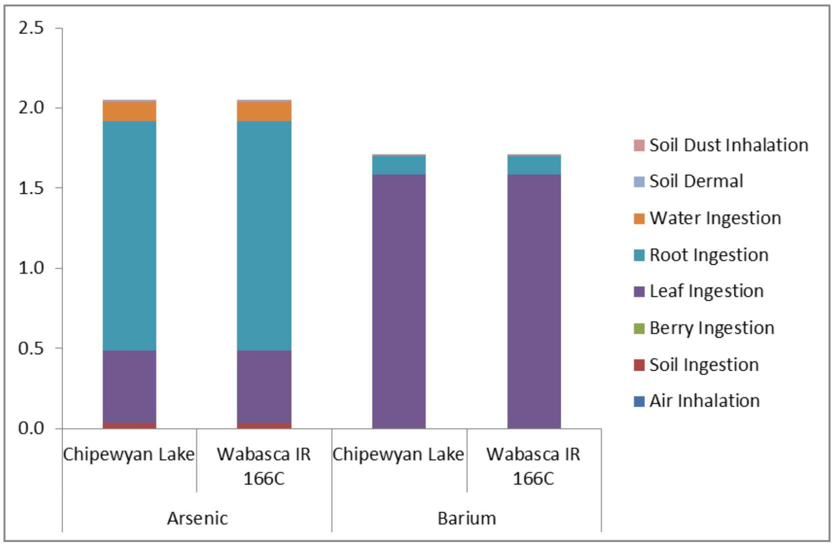


Figure 2: Contribution of Exposure Pathways for the Infant, Application Case, Manganese

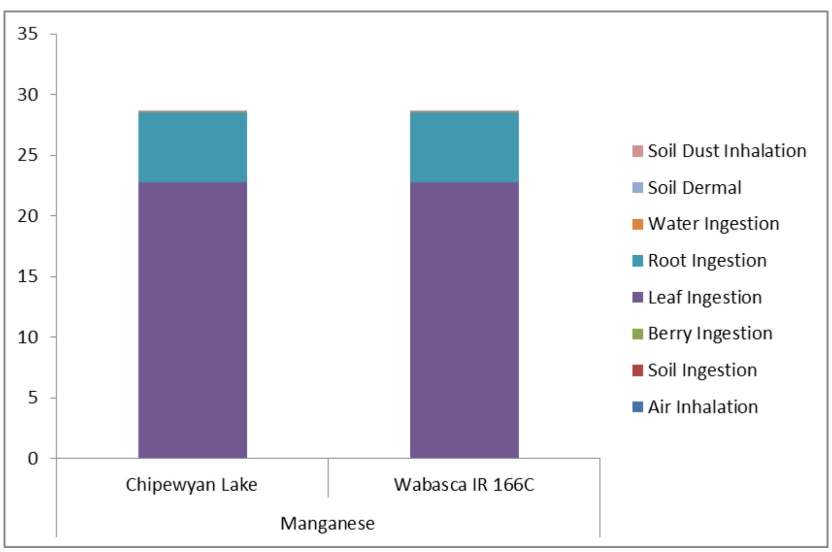


Figure 3: Contribution of Exposure Pathways for the Toddler, Application Case, Arsenic

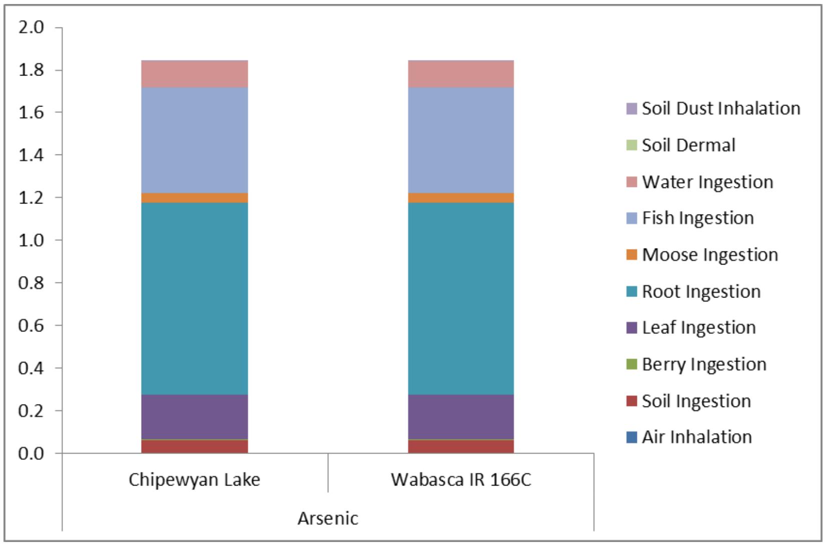
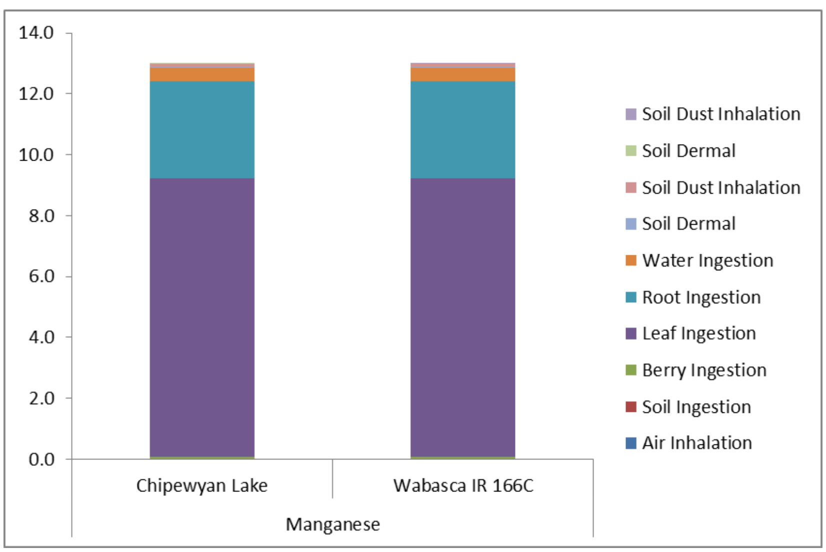


Figure 4: Contribution of Exposure Pathways for the Toddler, Application Case, Manganese



The pathways contributing the greatest exposure were as follows (with percent contribution provided in brackets, percentages for Chipewyan Lake and Wabasca IR 166C being the same):

Arsenic

- Infant - Root ingestion (70%), leaf ingestion (22%)
- Toddler – Root ingestion (49%), fish ingestion (27%), leaf ingestion (11%)

Barium

- Infant – Leaf ingestion (93%), root ingestion (7%)

Manganese

- Infant – Leaf ingestion (79%), root ingestion (20%)
- Toddler – Leaf ingestion (71%), root ingestion (25%)

The air inhalation pathway contributed less than 0.02% of total exposure for the infant and the toddler.

Round 3 SIR 25 requested a discussion of the basis and uncertainty of the TRVs for the non-carcinogens with ERs greater than one. The arsenic RfD of 0.0003 mg/kg/d was adopted from U.S EPA (2013) and ATSDR (2013). The RfD was based on a study of human ingestion of arsenic in drinking water and hyperpigmentation and keratosis. The study derived a No Observed Adverse Effect Level (NOAEL) and a Lowest Observed Adverse Effect Level (LOAEL). An uncertainty factor of three was applied to the NOAEL to account for both the lack of data to preclude reproductive toxicity as a critical effect and to account for some uncertainty in whether the NOAEL of the critical study accounts for all sensitive individuals.

The barium RfD of 0.2 mg/kg/d was adopted from Health Canada (2010), U.S. EPA (2013) and ATSDR (2013). The RfD was based on a two-year drinking water study with mice. The critical effect was nephropathy (renal lesions). The RfD was derived by the benchmark dose approach, with a benchmark response predicted to affect 5% of the population selected as the point of departure. A total uncertainty factor of 300 was applied: 10 for extrapolation for interspecies differences (i.e., laboratory animals to humans), 10 for consideration of intraspecies variation (i.e., differences in human susceptibility) and 3 for deficiencies in the database. The database of oral barium toxicity consists of two human studies, which found no effect on hypertension, and several chronic and subchronic rodent studies. The database is deficient in that neither a two-generation reproductive toxicity study nor an adequate investigation of developmental toxicity has been conducted. The available data indicate that renal toxicity is likely to be the most sensitive endpoint for chronic barium exposure.

Manganese is a ubiquitous element that is essential for normal physiologic functioning in all animal species. Several disease states in humans have been associated with both deficiencies and excess intakes of manganese. The manganese RfD was adopted from Health Canada (2010) and was based on human epidemiological studies of manganese exposure via food and water ingestion. The critical effect was Parkinsonian-like neurotoxicity. The RfD was derived from a NOAEL and no uncertainty factors were deemed necessary. The RfD was adjusted for life stage and body weight so that different RfDs were provided for each life stage.

Round 3 SIR 25 requested a discussion of the level of conservative exposure assumptions and it is provided below for the key exposure pathways. The ingestion rates for infants and toddlers for root vegetables (“root”), other vegetables (“leaf”) and fish were adopted from Health Canada and are based on a Canadian study of exposure factors by Richardson (1997). The ingestion rates are considered conservative. It was assumed that the infant and toddler receive 100% of their vegetable (and fish for the toddler) intake from the study area, which is also a conservative assumption, as likely some portion of their intake would be derived from outside the study area.

Labrador tea was used as a surrogate for leafy vegetables. Concentrations for the Baseline Case were based on the 95^{th} UCLM of the measured Labrador tea concentrations from the study area. This is a conservative assumption, and represents what is likely the highest average concentration to which a resident would be exposed. Cattail was used as a surrogate for root vegetables. As described in Section 3.1.2, the maximum peeled cattail concentrations from the Narrows Lake EIA baseline data were used as the concentrations for the Baseline Case. Use of the maximum concentration is a conservative assumption, as many of the root vegetables in the study area may have lower concentrations. Northern pike was used as a surrogate for all fish that may be ingested by residents and maximum northern pike concentrations were used for all Project cases. The use of a maximum concentration likely results in overestimating the risks to the toddler from fish ingestion.

Leaf and root concentrations for the Application Case were calculated by adding the Baseline Case concentration to the incremental concentration as a result of Project emissions and air deposition and root uptake (equations presented in Table 14). Root uptake relied on 95^{th} UCLM soil-to-plant uptake factors calculated from baseline soil and plant data, which is considered conservative.

The arsenic results presented in this revised version of the mutli-media assessment are considered very conservative, as per Round 3 SIR 18, a RAF of one and an inorganic fish content of 100% was assumed. Literature studies suggest that a RAF of 0.5 and an inorganic fish content of 10% are appropriate.

Round 3 SIR 25 requested the estimated daily intake for Canadians for chemicals with ER values greater than one. Environment Canada and Health Canada (1993) provide estimated average daily intakes for inorganic arsenic by Canadians of 0.1 to 2.6 µg/kg[body weight]/day for infants, 0.3 to 2.4 µg/kg/day for toddlers, 0.2 to 2.1 µg/kg/day for children, 0.1 to 1.3 µg/kg/day for adolescents and 0.1 to 0.7 µg/kg/day for adults. For Canadians living near point sources, maximum daily intakes were estimated to be 14 µg/kg/day for infants, 3.5 µg/kg/day for toddlers, 23 µg/kg/day for children, 11 µg/kg/day for adolescents and 12 µg/kg/day for adults. The primary sources of arsenic are food and water.

The average daily intake of barium has been estimated by Health Canada (1990) to be slightly more than 1 mg/day. Food represents the primary source of barium for non-occupationally exposed Canadians. In cases where barium levels in drinking water are high (e.g., 0.6 mg/L), drinking water may contribute significantly to barium intake (e.g., approximately 50%).

Health Canada (1987) estimated the average daily intake of manganese to be 4.7 mg/day. The greatest source of exposure is from food. Intake from food is substantially higher than intake from drinking water, even in areas where the manganese content of water is high.

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ATTACHMENT A

EXPOSURE ESTIMATES AND EXPOSURE RATIOS

Table A-1 Non-Carcinogenic Exposure Estimates for the Infant - Baseline Case

		Non-Carcinogenic Exposure Estimates for the Infant - Baseline Case									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose[a] Ingestion	Fish[a] Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
arsenic	Chipewyan Lake	8.3E-10	9.1E-06	2.6E-07	1.4E-04	4.3E-04	n/a	n/a	3.7E-05	4.4E-07	7.6E-10
	Wabasca (IR 166C)	4.2E-10	9.1E-06	2.6E-07	1.4E-04	4.3E-04			3.7E-05	4.4E-07	7.6E-10
barium	Chipewyan Lake	1.6E-08	1.9E-04	2.0E-04	3.2E-01	2.3E-02			1.1E-03	3.0E-05	1.6E-08
	Wabasca (IR 166C)	7.9E-09	1.9E-04	2.0E-04	3.2E-01	2.3E-02			1.1E-03	3.0E-05	1.6E-08
beryllium	Chipewyan Lake	6.4E-11	7.3E-07	5.7E-08	2.2E-05	6.3E-05			3.7E-05	1.2E-07	6.1E-11
	Wabasca (IR 166C)	3.3E-11	7.3E-07	5.7E-08	2.2E-05	6.3E-05			3.7E-05	1.2E-07	6.1E-11
cadmium	Chipewyan Lake	1.3E-08	8.3E-07	3.7E-07	2.5E-05	2.9E-05			3.7E-07	1.3E-08	7.0E-11
	Wabasca (IR 166C)	5.8E-09	8.3E-07	3.7E-07	2.5E-05	2.9E-05			3.7E-07	1.3E-08	7.0E-11
chromium	Chipewyan Lake	1.7E-08	2.0E-05	7.7E-06	4.3E-03	3.8E-03			7.3E-05	3.3E-06	1.7E-09
	Wabasca (IR 166C)	8.9E-09	2.0E-05	7.7E-06	4.3E-03	3.8E-03			7.3E-05	3.3E-06	1.7E-09
cobalt	Chipewyan Lake	2.5E-09	1.0E-05	5.0E-07	2.9E-04	1.3E-04			1.1E-05	1.6E-07	8.4E-10
	Wabasca (IR 166C)	1.1E-09	1.0E-05	5.0E-07	2.9E-04	1.3E-04			1.1E-05	1.6E-07	8.4E-10
copper	Chipewyan Lake	5.3E-09	2.0E-05	5.4E-05	1.7E-02	2.5E-03			2.6E-05	1.9E-06	1.7E-09
	Wabasca (IR 166C)	2.5E-09	2.0E-05	5.4E-05	1.7E-02	2.5E-03			2.6E-05	1.9E-06	1.7E-09
lead	Chipewyan Lake	4.5E-09	1.5E-05	2.9E-07	1.5E-04	2.8E-04			2.9E-05	2.3E-05	1.2E-09
	Wabasca (IR 166C)	2.2E-09	1.5E-05	2.9E-07	1.5E-04	2.8E-04			2.9E-05	2.3E-05	1.2E-09
manganese	Chipewyan Lake	6.8E-09	4.5E-04	3.6E-03	3.1E+00	7.9E-01			1.4E-02	7.3E-04	3.8E-08
	Wabasca (IR 166C)	3.5E-09	4.5E-04	3.6E-03	3.1E+00	7.9E-01			1.4E-02	7.3E-04	3.8E-08
mercury	Chipewyan Lake	8.4E-10	2.3E-07	2.9E-08	2.8E-05	1.0E-05			7.3E-07	3.7E-08	1.9E-11
	Wabasca (IR 166C)	4.2E-10	2.3E-07	2.9E-08	2.8E-05	1.0E-05			7.3E-07	3.7E-08	1.9E-11
molybdenum	Chipewyan Lake	5.5E-09	2.2E-06	4.2E-06	9.2E-04	6.1E-04			7.3E-06	3.5E-08	1.8E-10
	Wabasca (IR 166C)	2.8E-09	2.2E-06	4.2E-06	9.2E-04	6.1E-04			7.3E-06	3.5E-08	1.8E-10
nickel	Chipewyan Lake	2.7E-08	2.3E-05	2.5E-05	4.6E-03	2.3E-03			1.8E-05	7.3E-06	1.9E-09
	Wabasca (IR 166C)	1.4E-08	2.3E-05	2.5E-05	4.6E-03	2.3E-03			1.8E-05	7.3E-06	1.9E-09
selenium	Chipewyan Lake	4.2E-09	1.8E-06	5.7E-07	6.9E-04	1.3E-04			7.3E-06	2.9E-08	1.5E-10
	Wabasca (IR 166C)	2.5E-09	1.8E-06	5.7E-07	6.9E-04	1.3E-04			7.3E-06	2.9E-08	1.5E-10
vanadium	Chipewyan Lake	2.0E-08	3.8E-05	7.9E-07	5.6E-04	7.7E-05			1.5E-04	6.1E-06	3.2E-09
	Wabasca (IR 166C)	1.0E-08	3.8E-05	7.9E-07	5.6E-04	7.8E-05			1.5E-04	6.1E-06	3.2E-09
zinc	Chipewyan Lake	1.6E-07	7.8E-05	1.5E-04	1.1E-01	1.0E-01			4.0E-04	1.2E-05	6.5E-09
	Wabasca (IR 166C)	8.1E-08	7.8E-05	1.5E-04	1.1E-01	1.0E-01			4.0E-04	1.2E-05	6.5E-09
anthracene	Chipewyan Lake	3.3E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
	Wabasca (IR 166C)	1.5E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
fluoranthene	Chipewyan Lake	9.4E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
	Wabasca (IR 166C)	4.3E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
fluorene	Chipewyan Lake	1.7E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12

	Wabasca (IR 166C)	8.4E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12
pyrene	Chipewyan Lake	1.3E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.9E-09	1.0E-12
	Wabasca (IR 166C)	5.9E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.9E-09	1.0E-12

(a)

Table A-2 Non-Carcinogenic Exposure Estimates for the Infant - Application Case

		Non-Carcinogenic Exposure Estimates for the Infant - Application Case									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose[(a)] Ingestion	Fish[(a)] Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
arsenic	Chipewyan Lake	9.1E-10	9.1E-06	2.6E-07	1.4E-04	4.3E-04	n/a	n/a	3.7E-05	4.4E-07	7.6E-10
	Wabasca (IR 166C)	5.3E-10	9.1E-06	2.6E-07	1.4E-04	4.3E-04			3.7E-05	4.4E-07	7.6E-10
barium	Chipewyan Lake	1.8E-08	1.9E-04	2.0E-04	3.2E-01	2.3E-02			1.1E-03	3.0E-05	1.6E-08
	Wabasca (IR 166C)	1.0E-08	1.9E-04	2.0E-04	3.2E-01	2.3E-02			1.1E-03	3.0E-05	1.6E-08
beryllium	Chipewyan Lake	6.9E-11	7.3E-07	5.7E-08	2.2E-05	6.3E-05			3.7E-05	1.2E-07	6.1E-11
	Wabasca (IR 166C)	4.0E-11	7.3E-07	5.7E-08	2.2E-05	6.3E-05			3.7E-05	1.2E-07	6.1E-11
cadmium	Chipewyan Lake	1.4E-08	8.4E-07	3.7E-07	2.5E-05	2.9E-05			3.7E-07	1.3E-08	7.0E-11
	Wabasca (IR 166C)	6.4E-09	8.4E-07	3.7E-07	2.5E-05	3.0E-05			3.7E-07	1.3E-08	7.0E-11
chromium	Chipewyan Lake	1.7E-08	2.0E-05	7.7E-06	4.3E-03	3.8E-03			7.3E-05	3.3E-06	1.7E-09
	Wabasca (IR 166C)	9.6E-09	2.0E-05	7.7E-06	4.3E-03	3.8E-03			7.3E-05	3.3E-06	1.7E-09
cobalt	Chipewyan Lake	2.5E-09	1.0E-05	5.0E-07	2.9E-04	1.3E-04			1.1E-05	1.6E-07	8.4E-10
	Wabasca (IR 166C)	1.2E-09	1.0E-05	5.0E-07	2.9E-04	1.3E-04			1.1E-05	1.6E-07	8.4E-10
copper	Chipewyan Lake	5.7E-09	2.0E-05	5.4E-05	1.7E-02	2.5E-03			2.6E-05	1.9E-06	1.7E-09
	Wabasca (IR 166C)	3.0E-09	2.0E-05	5.4E-05	1.7E-02	2.5E-03			2.6E-05	1.9E-06	1.7E-09
lead	Chipewyan Lake	4.7E-09	1.5E-05	2.9E-07	1.5E-04	2.8E-04			2.9E-05	2.3E-05	1.2E-09
	Wabasca (IR 166C)	2.4E-09	1.5E-05	2.9E-07	1.5E-04	2.8E-04			2.9E-05	2.3E-05	1.2E-09
manganese	Chipewyan Lake	6.9E-09	4.5E-04	3.6E-03	3.1E+00	7.9E-01			1.4E-02	7.3E-04	3.8E-08
	Wabasca (IR 166C)	3.7E-09	4.5E-04	3.6E-03	3.1E+00	7.9E-01			1.4E-02	7.3E-04	3.8E-08
mercury	Chipewyan Lake	9.5E-10	2.3E-07	2.9E-08	2.8E-05	1.0E-05			7.3E-07	3.7E-08	1.9E-11
	Wabasca (IR 166C)	5.6E-10	2.3E-07	2.9E-08	2.8E-05	1.0E-05			7.3E-07	3.7E-08	1.9E-11
molybdenum	Chipewyan Lake	5.9E-09	2.2E-06	4.2E-06	9.2E-04	6.1E-04			7.3E-06	3.5E-08	1.8E-10
	Wabasca (IR 166C)	3.4E-09	2.2E-06	4.2E-06	9.2E-04	6.1E-04			7.3E-06	3.5E-08	1.8E-10
nickel	Chipewyan Lake	2.8E-08	2.3E-05	2.5E-05	4.6E-03	2.3E-03			1.8E-05	7.3E-06	1.9E-09
	Wabasca (IR 166C)	1.5E-08	2.3E-05	2.5E-05	4.6E-03	2.3E-03			1.8E-05	7.3E-06	1.9E-09
selenium	Chipewyan Lake	4.2E-09	1.8E-06	5.7E-07	6.9E-04	1.3E-04			7.3E-06	2.9E-08	1.5E-10
	Wabasca (IR 166C)	2.5E-09	1.8E-06	5.7E-07	6.9E-04	1.3E-04			7.3E-06	2.9E-08	1.5E-10
vanadium	Chipewyan Lake	2.1E-08	3.8E-05	7.9E-07	5.6E-04	7.8E-05			1.5E-04	6.1E-06	3.2E-09
	Wabasca (IR 166C)	1.2E-08	3.8E-05	7.9E-07	5.6E-04	7.8E-05			1.5E-04	6.1E-06	3.2E-09
zinc	Chipewyan Lake	1.7E-07	7.8E-05	1.5E-04	1.1E-01	1.0E-01			4.0E-04	1.2E-05	6.5E-09

	Wabasca (IR 166C)	9.7E-08	7.8E-05	1.5E-04	1.1E-01	1.0E-01			4.0E-04	1.2E-05	6.5E-09
anthracene	Chipewyan Lake	3.3E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
	Wabasca (IR 166C)	1.5E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
fluoranthene	Chipewyan Lake	9.4E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
	Wabasca (IR 166C)	4.3E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
fluorene	Chipewyan Lake	1.7E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12
	Wabasca (IR 166C)	8.4E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12
pyrene	Chipewyan Lake	1.3E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.9E-09	1.0E-12
	Wabasca (IR 166C)	5.9E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.9E-09	1.0E-12

(a)

Table A-3 Non-Carcinogenic Exposure Estimates for the Infant – PDC

		Non-Carcinogenic Exposure Estimates for the Infant - PDC									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose[(a)] Ingestion	Fish[(a)] Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
arsenic	Chipewyan Lake	1.4E-09	9.1E-06	2.6E-07	1.4E-04	4.3E-04			3.7E-05	4.4E-07	7.6E-10
	Wabasca (IR 166C)	7.9E-10	9.1E-06	2.6E-07	1.4E-04	4.3E-04			3.7E-05	4.4E-07	7.6E-10
barium	Chipewyan Lake	2.7E-08	1.9E-04	2.0E-04	3.2E-01	2.3E-02			1.1E-03	3.0E-05	1.6E-08
	Wabasca (IR 166C)	1.6E-08	1.9E-04	2.0E-04	3.2E-01	2.3E-02			1.1E-03	3.0E-05	1.6E-08
beryllium	Chipewyan Lake	9.6E-11	7.3E-07	5.7E-08	2.2E-05	6.3E-05			3.7E-05	1.2E-07	6.1E-11
	Wabasca (IR 166C)	5.5E-11	7.3E-07	5.7E-08	2.2E-05	6.3E-05			3.7E-05	1.2E-07	6.1E-11
cadmium	Chipewyan Lake	2.1E-08	8.4E-07	3.8E-07	2.7E-05	3.1E-05			3.7E-07	1.3E-08	7.0E-11
	Wabasca (IR 166C)	9.8E-09	8.4E-07	3.8E-07	2.7E-05	3.2E-05			3.7E-07	1.3E-08	7.0E-11
chromium	Chipewyan Lake	2.2E-08	2.0E-05	7.7E-06	4.3E-03	3.8E-03			7.3E-05	3.3E-06	1.7E-09
	Wabasca (IR 166C)	1.2E-08	2.0E-05	7.7E-06	4.4E-03	3.8E-03			7.3E-05	3.3E-06	1.7E-09
cobalt	Chipewyan Lake	3.6E-09	1.0E-05	5.0E-07	2.9E-04	1.3E-04			1.1E-05	1.6E-07	8.4E-10
	Wabasca (IR 166C)	1.6E-09	1.0E-05	5.0E-07	2.9E-04	1.3E-04	n/a	n/a	1.1E-05	1.6E-07	8.4E-10
copper	Chipewyan Lake	8.4E-09	2.0E-05	5.4E-05	1.7E-02	2.5E-03			2.6E-05	1.9E-06	1.7E-09
	Wabasca (IR 166C)	4.4E-09	2.0E-05	5.4E-05	1.7E-02	2.5E-03			2.6E-05	1.9E-06	1.7E-09
lead	Chipewyan Lake	6.7E-09	1.5E-05	2.9E-07	1.5E-04	2.8E-04			2.9E-05	2.3E-05	1.2E-09
	Wabasca (IR 166C)	3.4E-09	1.5E-05	2.9E-07	1.5E-04	2.8E-04			2.9E-05	2.3E-05	1.2E-09
manganese	Chipewyan Lake	8.8E-09	4.5E-04	3.6E-03	3.1E+00	7.9E-01			1.4E-02	7.3E-04	3.8E-08
	Wabasca (IR 166C)	4.6E-09	4.5E-04	3.6E-03	3.1E+00	7.9E-01			1.4E-02	7.3E-04	3.8E-08
mercury	Chipewyan Lake	1.5E-09	2.3E-07	2.9E-08	2.8E-05	1.0E-05			7.3E-07	3.7E-08	1.9E-11
	Wabasca (IR 166C)	8.9E-10	2.3E-07	2.9E-08	2.8E-05	1.0E-05			7.3E-07	3.7E-08	1.9E-11
molybdenum	Chipewyan Lake	8.4E-09	2.2E-06	4.2E-06	9.2E-04	6.1E-04			7.3E-06	3.5E-08	1.8E-10
	Wabasca (IR 166C)	4.9E-09	2.2E-06	4.2E-06	9.2E-04	6.2E-04			7.3E-06	3.5E-08	1.8E-10
nickel	Chipewyan Lake	3.3E-08	2.3E-05	2.5E-05	4.6E-03	2.3E-03			1.8E-05	7.3E-06	1.9E-09

	Wabasca (IR 166C)	1.8E-08	2.3E-05	2.5E-05	4.6E-03	2.3E-03			1.8E-05	7.3E-06	1.9E-09
selenium	Chipewyan Lake	4.6E-09	1.8E-06	5.7E-07	6.9E-04	1.3E-04			7.3E-06	2.9E-08	1.5E-10
	Wabasca (IR 166C)	2.7E-09	1.8E-06	5.7E-07	6.9E-04	1.3E-04			7.3E-06	2.9E-08	1.5E-10
vanadium	Chipewyan Lake	2.6E-08	3.8E-05	7.9E-07	5.6E-04	7.8E-05			1.5E-04	6.1E-06	3.2E-09
	Wabasca (IR 166C)	1.5E-08	3.8E-05	7.9E-07	5.6E-04	7.8E-05			1.5E-04	6.1E-06	3.2E-09
zinc	Chipewyan Lake	2.4E-07	7.8E-05	1.5E-04	1.1E-01	1.0E-01			4.0E-04	1.2E-05	6.5E-09
	Wabasca (IR 166C)	1.4E-07	7.8E-05	1.5E-04	1.1E-01	1.0E-01			4.0E-04	1.2E-05	6.5E-09
anthracene	Chipewyan Lake	4.5E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
	Wabasca (IR 166C)	2.0E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.5E-09	1.0E-12
fluoranthene	Chipewyan Lake	1.3E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12
	Wabasca (IR 166C)	5.8E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12
fluorene	Chipewyan Lake	2.3E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12
	Wabasca (IR 166C)	1.1E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.6E-09	1.0E-12
pyrene	Chipewyan Lake	1.8E-09	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.9E-09	1.0E-12
	Wabasca (IR 166C)	8.2E-10	1.2E-08	5.7E-08	2.2E-05	1.3E-05			1.8E-07	2.9E-09	1.0E-12

(a)

Table A-4 Non-Carcinogenic Exposure Estimates for the Toddler - Baseline Case

		Non-Carcinogenic Exposure Estimates for the Toddler - Baseline Case									
		Air Inhalation	**Soil Ingestion**	**Berry Ingestion**	**Leaf Ingestion**	**Root Ingestion**	**Moose Ingestion**	**Fish Ingestion**	**Water Ingestion**	**Soil Dermal**	**Soil Dust Inhalation**
arsenic	Chipewyan Lake	1.6E-09	1.8E-05	7.2E-07	6.3E-05	2.7E-04	1.4E-05	1.5E-04	3.6E-05	2.9E-07	1.4E-09
	Wabasca (IR 166C)	7.9E-10	1.8E-05	7.2E-07	6.3E-05	2.7E-04	1.4E-05	1.5E-04	3.6E-05	2.9E-07	1.4E-09
barium	Chipewyan Lake	3.0E-08	3.7E-04	5.5E-04	1.5E-01	1.5E-02	5.6E-04	4.8E-04	1.1E-03	2.0E-05	3.0E-08
	Wabasca (IR 166C)	1.5E-08	3.7E-04	5.5E-04	1.5E-01	1.5E-02	5.6E-04	4.8E-04	1.1E-03	2.0E-05	3.0E-08
beryllium	Chipewyan Lake	1.2E-10	1.5E-06	1.6E-07	9.9E-06	4.0E-05	2.2E-06	5.8E-06	3.6E-05	7.8E-08	1.1E-10
	Wabasca (IR 166C)	6.2E-11	1.5E-06	1.6E-07	9.9E-06	4.0E-05	2.2E-06	5.8E-06	3.6E-05	7.8E-08	1.1E-10
cadmium	Chipewyan Lake	2.5E-08	1.7E-06	1.0E-06	1.2E-05	1.8E-05	4.2E-07	5.8E-06	3.6E-07	8.9E-09	1.3E-10
	Wabasca (IR 166C)	1.1E-08	1.7E-06	1.0E-06	1.2E-05	1.8E-05	4.2E-07	5.8E-06	3.6E-07	8.9E-09	1.3E-10
chromium	Chipewyan Lake	3.2E-08	4.1E-05	2.1E-05	2.0E-03	2.4E-03	3.3E-04	7.7E-04	7.3E-05	2.2E-06	3.2E-09
	Wabasca (IR 166C)	1.7E-08	4.1E-05	2.1E-05	2.0E-03	2.4E-03	3.4E-04	7.7E-04	7.3E-05	2.2E-06	3.2E-09
cobalt	Chipewyan Lake	4.7E-09	2.0E-05	1.4E-06	1.3E-04	8.0E-05	1.5E-05	1.2E-05	1.1E-05	1.1E-07	1.6E-09
	Wabasca (IR 166C)	2.1E-09	2.0E-05	1.4E-06	1.3E-04	8.0E-05	1.5E-05	1.2E-05	1.1E-05	1.1E-07	1.6E-09
copper	Chipewyan Lake	1.0E-08	4.0E-05	1.5E-04	7.8E-03	1.6E-03	3.9E-04	2.2E-03	2.5E-05	1.3E-06	3.2E-09
	Wabasca (IR 166C)	4.8E-09	4.0E-05	1.5E-04	7.8E-03	1.6E-03	3.9E-04	2.2E-03	2.5E-05	1.3E-06	3.2E-09
lead	Chipewyan Lake	8.4E-09	2.9E-05	7.9E-07	7.0E-05	1.8E-04	2.7E-06	2.7E-04	2.9E-05	1.6E-05	2.3E-09
	Wabasca (IR 166C)	4.1E-09	2.9E-05	7.9E-07	7.0E-05	1.8E-04	2.7E-06	2.7E-04	2.9E-05	1.6E-05	2.3E-09
manganese	Chipewyan Lake	1.3E-08	9.0E-04	9.9E-03	1.4E+00	5.0E-01	7.0E-02	4.7E-03	1.4E-02	4.9E-04	7.1E-08

	Wabasca (IR 166C)	6.5E-09	9.0E-04	9.9E-03	1.4E+00	5.0E-01	7.0E-02	4.7E-03	1.4E-02	4.9E-04	7.1E-08
mercury	Chipewyan Lake	1.6E-09	4.6E-07	7.9E-08	1.3E-05	6.4E-06	3.4E-06	1.6E-04	7.3E-07	2.5E-08	3.6E-11
	Wabasca (IR 166C)	7.8E-10	4.6E-07	7.9E-08	1.3E-05	6.4E-06	3.4E-06	1.6E-04	7.3E-07	2.5E-08	3.6E-11
molybdenum	Chipewyan Lake	1.0E-08	4.4E-06	1.1E-05	4.2E-04	3.8E-04	2.3E-05	7.0E-05	7.3E-06	2.3E-08	3.4E-10
	Wabasca (IR 166C)	5.3E-09	4.4E-06	1.1E-05	4.2E-04	3.9E-04	2.3E-05	7.0E-05	7.3E-06	2.3E-08	3.4E-10
nickel	Chipewyan Lake	5.0E-08	4.5E-05	6.8E-05	2.1E-03	1.4E-03	3.8E-04	4.8E-04	1.8E-05	4.9E-06	3.6E-09
	Wabasca (IR 166C)	2.7E-08	4.5E-05	6.8E-05	2.1E-03	1.4E-03	3.8E-04	4.8E-04	1.8E-05	4.9E-06	3.6E-09
selenium	Chipewyan Lake	7.9E-09	3.6E-06	1.6E-06	3.2E-04	8.0E-05	2.0E-05	4.3E-04	7.3E-06	2.0E-08	2.9E-10
	Wabasca (IR 166C)	4.6E-09	3.6E-06	1.6E-06	3.2E-04	8.0E-05	2.0E-05	4.3E-04	7.3E-06	2.0E-08	2.9E-10
vanadium	Chipewyan Lake	3.7E-08	7.6E-05	2.2E-06	2.6E-04	4.9E-05	5.6E-05	1.2E-05	1.5E-04	4.1E-06	6.0E-09
	Wabasca (IR 166C)	1.9E-08	7.6E-05	2.2E-06	2.6E-04	4.9E-05	5.6E-05	1.2E-05	1.5E-04	4.1E-06	6.0E-09
zinc	Chipewyan Lake	3.0E-07	1.5E-04	4.1E-04	4.9E-02	6.3E-02	1.1E-04	4.4E-02	4.0E-04	8.3E-06	1.2E-08
	Wabasca (IR 166C)	1.5E-07	1.5E-04	4.1E-04	4.9E-02	6.3E-02	1.1E-04	4.4E-02	4.0E-04	8.3E-06	1.2E-08
anthracene	Chipewyan Lake	6.1E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	8.7E-06	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	2.8E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	8.7E-06	2.9E-05	1.8E-07	1.7E-09	1.9E-12
fluoranthene	Chipewyan Lake	1.8E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	1.0E-05	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	8.0E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	1.0E-05	2.9E-05	1.8E-07	1.7E-09	1.9E-12
fluorene	Chipewyan Lake	3.2E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	7.6E-08	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	1.6E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	7.6E-08	2.9E-05	1.8E-07	1.7E-09	1.9E-12
pyrene	Chipewyan Lake	2.4E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	9.9E-06	2.9E-05	1.8E-07	1.9E-09	1.9E-12
	Wabasca (IR 166C)	1.1E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	9.9E-06	2.9E-05	1.8E-07	1.9E-09	1.9E-12

Table A-5 Non-Carcinogenic Exposure Estimates for the Toddler - Application Case

		Non-Carcinogenic Exposure Estimates for the Toddler - Application Case									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose Ingestion	Fish Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
arsenic	Chipewyan Lake	1.7E-09	1.8E-05	7.2E-07	6.3E-05	2.7E-04	1.4E-05	1.5E-04	3.6E-05	2.9E-07	1.4E-09
	Wabasca (IR 166C)	1.0E-09	1.8E-05	7.2E-07	6.3E-05	2.7E-04	1.4E-05	1.5E-04	3.6E-05	2.9E-07	1.4E-09
barium	Chipewyan Lake	3.3E-08	3.7E-04	5.5E-04	1.5E-01	1.5E-02	5.6E-04	4.8E-04	1.1E-03	2.0E-05	3.0E-08
	Wabasca (IR 166C)	1.9E-08	3.7E-04	5.5E-04	1.5E-01	1.5E-02	5.6E-04	4.8E-04	1.1E-03	2.0E-05	3.0E-08
beryllium	Chipewyan Lake	1.3E-10	1.5E-06	1.6E-07	9.9E-06	4.0E-05	2.2E-06	5.8E-06	3.6E-05	7.8E-08	1.1E-10
	Wabasca (IR 166C)	7.4E-11	1.5E-06	1.6E-07	9.9E-06	4.0E-05	2.2E-06	5.8E-06	3.6E-05	7.8E-08	1.1E-10
cadmium	Chipewyan Lake	2.6E-08	1.7E-06	1.0E-06	1.2E-05	1.8E-05	4.4E-07	5.8E-06	3.6E-07	8.9E-09	1.3E-10
	Wabasca (IR 166C)	1.2E-08	1.7E-06	1.0E-06	1.2E-05	1.9E-05	4.6E-07	5.8E-06	3.6E-07	8.9E-09	1.3E-10
chromium	Chipewyan Lake	3.3E-08	4.1E-05	2.1E-05	2.0E-03	2.4E-03	3.4E-04	7.7E-04	7.3E-05	2.2E-06	3.2E-09
	Wabasca (IR 166C)	1.8E-08	4.1E-05	2.1E-05	2.0E-03	2.4E-03	3.4E-04	7.7E-04	7.3E-05	2.2E-06	3.2E-09
cobalt	Chipewyan Lake	4.7E-09	2.0E-05	1.4E-06	1.3E-04	8.0E-05	1.5E-05	1.2E-05	1.1E-05	1.1E-07	1.6E-09

	Wabasca (IR 166C)	2.2E-09	2.0E-05	1.4E-06	1.3E-04	8.0E-05	1.5E-05	1.2E-05	1.1E-05	1.1E-07	1.6E-09
copper	Chipewyan Lake	1.1E-08	4.0E-05	1.5E-04	7.8E-03	1.6E-03	3.9E-04	2.2E-03	2.5E-05	1.3E-06	3.2E-09
	Wabasca (IR 166C)	5.6E-09	4.0E-05	1.5E-04	7.8E-03	1.6E-03	3.9E-04	2.2E-03	2.5E-05	1.3E-06	3.2E-09
lead	Chipewyan Lake	8.8E-09	2.9E-05	7.9E-07	7.0E-05	1.8E-04	2.7E-06	2.7E-04	2.9E-05	1.6E-05	2.3E-09
	Wabasca (IR 166C)	4.6E-09	2.9E-05	7.9E-07	7.0E-05	1.8E-04	2.7E-06	2.7E-04	2.9E-05	1.6E-05	2.3E-09
manganese	Chipewyan Lake	1.3E-08	9.0E-04	9.9E-03	1.4E+00	5.0E-01	7.0E-02	4.7E-03	1.4E-02	4.9E-04	7.1E-08
	Wabasca (IR 166C)	6.9E-09	9.0E-04	9.9E-03	1.4E+00	5.0E-01	7.0E-02	4.7E-03	1.4E-02	4.9E-04	7.1E-08
mercury	Chipewyan Lake	1.8E-09	4.6E-07	7.9E-08	1.3E-05	6.4E-06	3.4E-06	1.6E-04	7.3E-07	2.5E-08	3.6E-11
	Wabasca (IR 166C)	1.0E-09	4.6E-07	7.9E-08	1.3E-05	6.4E-06	3.4E-06	1.6E-04	7.3E-07	2.5E-08	3.6E-11
molybdenum	Chipewyan Lake	1.1E-08	4.4E-06	1.1E-05	4.2E-04	3.8E-04	2.3E-05	7.0E-05	7.3E-06	2.3E-08	3.4E-10
	Wabasca (IR 166C)	6.4E-09	4.4E-06	1.1E-05	4.2E-04	3.9E-04	2.3E-05	7.0E-05	7.3E-06	2.3E-08	3.4E-10
nickel	Chipewyan Lake	5.2E-08	4.5E-05	6.8E-05	2.1E-03	1.4E-03	3.8E-04	4.8E-04	1.8E-05	4.9E-06	3.6E-09
	Wabasca (IR 166C)	2.9E-08	4.5E-05	6.8E-05	2.1E-03	1.4E-03	3.8E-04	4.8E-04	1.8E-05	4.9E-06	3.6E-09
selenium	Chipewyan Lake	7.9E-09	3.6E-06	1.6E-06	3.2E-04	8.0E-05	2.0E-05	4.3E-04	7.3E-06	2.0E-08	2.9E-10
	Wabasca (IR 166C)	4.6E-09	3.6E-06	1.6E-06	3.2E-04	8.0E-05	2.0E-05	4.3E-04	7.3E-06	2.0E-08	2.9E-10
vanadium	Chipewyan Lake	3.8E-08	7.6E-05	2.2E-06	2.6E-04	4.9E-05	5.6E-05	1.2E-05	1.5E-04	4.1E-06	6.0E-09
	Wabasca (IR 166C)	2.2E-08	7.6E-05	2.2E-06	2.6E-04	4.9E-05	5.6E-05	1.2E-05	1.5E-04	4.1E-06	6.0E-09
zinc	Chipewyan Lake	3.2E-07	1.5E-04	4.1E-04	4.9E-02	6.3E-02	1.1E-04	4.4E-02	4.0E-04	8.3E-06	1.2E-08
	Wabasca (IR 166C)	1.8E-07	1.5E-04	4.1E-04	4.9E-02	6.3E-02	1.1E-04	4.4E-02	4.0E-04	8.3E-06	1.2E-08
anthracene	Chipewyan Lake	6.1E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	8.7E-06	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	2.8E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	8.7E-06	2.9E-05	1.8E-07	1.7E-09	1.9E-12
fluoranthene	Chipewyan Lake	1.8E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	1.0E-05	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	8.0E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	1.0E-05	2.9E-05	1.8E-07	1.7E-09	1.9E-12
fluorene	Chipewyan Lake	3.2E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	7.6E-08	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	1.6E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	7.6E-08	2.9E-05	1.8E-07	1.7E-09	1.9E-12
pyrene	Chipewyan Lake	2.4E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	9.9E-06	2.9E-05	1.8E-07	1.9E-09	1.9E-12
	Wabasca (IR 166C)	1.1E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	9.9E-06	2.9E-05	1.8E-07	1.9E-09	1.9E-12

Table A-6 Non-Carcinogenic Exposure Estimates for the Toddler – PDC

		Non-Carcinogenic Exposure Estimates for the Toddler - PDC									
		Air	**Soil**	**Berry**	**Leaf**	**Root**	**Moose**	**Fish**	**Water**	**Soil**	**Soil Dust**
		Inhalation	**Ingestion**	**Ingestion**	**Ingestion**	**Ingestion**	**Ingestion**	**Ingestion**	**Ingestion**	**Dermal**	**Inhalation**
arsenic	Chipewyan Lake	2.5E-09	1.8E-05	7.2E-07	6.3E-05	2.7E-04	1.4E-05	1.5E-04	3.6E-05	2.9E-07	1.4E-09
	Wabasca (IR 166C)	1.5E-09	1.8E-05	7.2E-07	6.3E-05	2.7E-04	1.4E-05	1.5E-04	3.6E-05	2.9E-07	1.4E-09
barium	Chipewyan Lake	5.1E-08	3.7E-04	5.5E-04	1.5E-01	1.5E-02	5.6E-04	4.8E-04	1.1E-03	2.0E-05	3.0E-08
	Wabasca (IR 166C)	3.0E-08	3.7E-04	5.5E-04	1.5E-01	1.5E-02	5.6E-04	4.8E-04	1.1E-03	2.0E-05	3.0E-08
beryllium	Chipewyan Lake	1.8E-10	1.5E-06	1.6E-07	9.9E-06	4.0E-05	2.2E-06	5.8E-06	3.6E-05	7.8E-08	1.1E-10

	Wabasca (IR 166C)	1.0E-10	1.5E-06	1.6E-07	9.9E-06	4.0E-05	2.2E-06	5.8E-06	3.6E-05	7.8E-08	1.1E-10
cadmium	Chipewyan Lake	4.0E-08	1.7E-06	1.0E-06	1.3E-05	2.0E-05	6.1E-07	5.8E-06	3.6E-07	9.0E-09	1.3E-10
	Wabasca (IR 166C)	1.8E-08	1.7E-06	1.0E-06	1.3E-05	2.0E-05	6.5E-07	5.8E-06	3.6E-07	9.0E-09	1.3E-10
chromium	Chipewyan Lake	4.1E-08	4.1E-05	2.1E-05	2.0E-03	2.4E-03	3.4E-04	7.7E-04	7.3E-05	2.2E-06	3.2E-09
	Wabasca (IR 166C)	2.2E-08	4.1E-05	2.1E-05	2.0E-03	2.4E-03	3.4E-04	7.7E-04	7.3E-05	2.2E-06	3.2E-09
cobalt	Chipewyan Lake	6.7E-09	2.0E-05	1.4E-06	1.3E-04	8.0E-05	1.5E-05	1.2E-05	1.1E-05	1.1E-07	1.6E-09
	Wabasca (IR 166C)	3.1E-09	2.0E-05	1.4E-06	1.3E-04	8.0E-05	1.5E-05	1.2E-05	1.1E-05	1.1E-07	1.6E-09
copper	Chipewyan Lake	1.6E-08	4.0E-05	1.5E-04	7.8E-03	1.6E-03	3.9E-04	2.2E-03	2.5E-05	1.3E-06	3.2E-09
	Wabasca (IR 166C)	8.3E-09	4.0E-05	1.5E-04	7.8E-03	1.6E-03	3.9E-04	2.2E-03	2.5E-05	1.3E-06	3.2E-09
lead	Chipewyan Lake	1.2E-08	2.9E-05	7.9E-07	7.0E-05	1.8E-04	2.7E-06	2.7E-04	2.9E-05	1.6E-05	2.3E-09
	Wabasca (IR 166C)	6.4E-09	2.9E-05	7.9E-07	7.0E-05	1.8E-04	2.7E-06	2.7E-04	2.9E-05	1.6E-05	2.3E-09
manganese	Chipewyan Lake	1.6E-08	9.0E-04	9.9E-03	1.4E+00	5.0E-01	7.0E-02	4.7E-03	1.4E-02	4.9E-04	7.1E-08
	Wabasca (IR 166C)	8.6E-09	9.0E-04	9.9E-03	1.4E+00	5.0E-01	7.0E-02	4.7E-03	1.4E-02	4.9E-04	7.1E-08
mercury	Chipewyan Lake	2.8E-09	4.6E-07	7.9E-08	1.3E-05	6.4E-06	3.4E-06	1.6E-04	7.3E-07	2.5E-08	3.6E-11
	Wabasca (IR 166C)	1.7E-09	4.6E-07	7.9E-08	1.3E-05	6.4E-06	3.4E-06	1.6E-04	7.3E-07	2.5E-08	3.6E-11
molybdenum	Chipewyan Lake	1.6E-08	4.4E-06	1.1E-05	4.2E-04	3.9E-04	2.3E-05	7.0E-05	7.3E-06	2.3E-08	3.4E-10
	Wabasca (IR 166C)	9.1E-09	4.4E-06	1.1E-05	4.2E-04	3.9E-04	2.3E-05	7.0E-05	7.3E-06	2.4E-08	3.4E-10
nickel	Chipewyan Lake	6.1E-08	4.5E-05	6.8E-05	2.1E-03	1.4E-03	3.8E-04	4.8E-04	1.8E-05	4.9E-06	3.6E-09
	Wabasca (IR 166C)	3.4E-08	4.5E-05	6.8E-05	2.1E-03	1.4E-03	3.8E-04	4.8E-04	1.8E-05	4.9E-06	3.6E-09
selenium	Chipewyan Lake	8.7E-09	3.6E-06	1.6E-06	3.2E-04	8.0E-05	2.0E-05	4.3E-04	7.3E-06	2.0E-08	2.9E-10
	Wabasca (IR 166C)	5.0E-09	3.6E-06	1.6E-06	3.2E-04	8.0E-05	2.0E-05	4.3E-04	7.3E-06	2.0E-08	2.9E-10
vanadium	Chipewyan Lake	4.8E-08	7.6E-05	2.2E-06	2.6E-04	4.9E-05	5.6E-05	1.2E-05	1.5E-04	4.1E-06	6.0E-09
	Wabasca (IR 166C)	2.7E-08	7.6E-05	2.2E-06	2.6E-04	4.9E-05	5.6E-05	1.2E-05	1.5E-04	4.1E-06	6.0E-09
zinc	Chipewyan Lake	4.5E-07	1.5E-04	4.1E-04	4.9E-02	6.3E-02	1.1E-04	4.4E-02	4.0E-04	8.3E-06	1.2E-08
	Wabasca (IR 166C)	2.5E-07	1.5E-04	4.1E-04	4.9E-02	6.3E-02	1.1E-04	4.4E-02	4.0E-04	8.3E-06	1.2E-08
anthracene	Chipewyan Lake	8.4E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	8.7E-06	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	3.8E-10	2.4E-08	1.6E-07	1.0E-05	8.0E-06	8.7E-06	2.9E-05	1.8E-07	1.7E-09	1.9E-12
fluoranthene	Chipewyan Lake	2.5E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	1.0E-05	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	1.1E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	1.0E-05	2.9E-05	1.8E-07	1.7E-09	1.9E-12
fluorene	Chipewyan Lake	4.4E-09	2.5E-08	1.6E-07	1.0E-05	8.0E-06	7.6E-08	2.9E-05	1.8E-07	1.7E-09	1.9E-12
	Wabasca (IR 166C)	2.1E-09	2.5E-08	1.6E-07	1.0E-05	8.0E-06	7.6E-08	2.9E-05	1.8E-07	1.7E-09	1.9E-12
pyrene	Chipewyan Lake	3.4E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	9.9E-06	2.9E-05	1.8E-07	1.9E-09	1.9E-12
	Wabasca (IR 166C)	1.5E-09	2.4E-08	1.6E-07	1.0E-05	8.0E-06	9.9E-06	2.9E-05	1.8E-07	1.9E-09	1.9E-12

Table A-7 Carcinogenic Exposure Estimates for the Composite Receptor - Baseline Case

	Carcinogenic Exposure Estimates for the Composite Receptor - Baseline Case									
	Air	**Soil**	**Berry**	**Leaf**	**Root**	**Moose**	**Fish**	**Water**	**Soil**	**Soil Dust**

		Inhalation	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	Dermal	Inhalation
Benzo(a)anthracene	Chipewyan Lake	1.7E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	7.8E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(a)anthracene surrogate	Chipewyan Lake	1.0E-09	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	5.0E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(a)pyrene	Chipewyan Lake	1.0E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
	Wabasca (IR 166C)	5.0E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
Benzo(a)pyrene surrogate	Chipewyan Lake	1.9E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
	Wabasca (IR 166C)	9.6E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
Benzo(g,h,i)perylene	Chipewyan Lake	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	7.4E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(g)fluoranthene	Chipewyan Lake	3.3E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	1.5E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(k)fluoranthene	Chipewyan Lake	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.4E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	6.9E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.4E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Chrysene	Chipewyan Lake	2.0E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	1.1E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Dibenzo(a,h)anthracene	Chipewyan Lake	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.2E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	6.4E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.2E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Fluoranthene	Chipewyan Lake	9.7E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	4.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Indeno(1,2,3-cd)pyrene	Chipewyan Lake	1.3E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	5.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	6.2E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	5.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Phenanthrene	Chipewyan Lake	3.4E-09	3.2E-09	1.1E-07	5.8E-06	4.3E-06	6.8E-06	1.8E-05	1.2E-07	5.8E-08	1.1E-12
	Wabasca (IR 166C)	1.7E-09	3.2E-09	1.1E-07	5.8E-06	4.3E-06	6.8E-06	1.8E-05	1.2E-07	5.8E-08	1.1E-12
Arsenic	Chipewyan Lake	8.6E-10	2.3E-06	5.2E-07	3.6E-05	1.5E-04	1.1E-05	9.5E-05	2.3E-05	1.8E-04	7.9E-10
	Wabasca (IR 166C)	4.4E-10	2.3E-06	5.2E-07	3.6E-05	1.5E-04	1.1E-05	9.5E-05	2.3E-05	1.8E-04	7.9E-10
Beryllium	Chipewyan Lake	6.6E-11	1.9E-07	1.1E-07	5.7E-06	2.1E-05	1.7E-06	3.7E-06	2.3E-05	4.4E-06	6.3E-11
	Wabasca (IR 166C)	3.4E-11	1.9E-07	1.1E-07	5.7E-06	2.1E-05	1.7E-06	3.7E-06	2.3E-05	4.4E-06	6.3E-11
Chromium	Chipewyan Lake	1.7E-08	2.6E-06	7.6E-06	5.8E-04	6.5E-04	1.3E-04	4.9E-04	4.7E-05	1.2E-04	1.8E-09
	Wabasca (IR 166C)	9.2E-09	2.6E-06	7.6E-06	5.8E-04	6.5E-04	1.3E-04	4.9E-04	4.7E-05	1.2E-04	1.8E-09
Nickel	Chipewyan Lake	2.8E-08	5.8E-06	4.9E-05	1.2E-03	7.8E-04	3.0E-04	3.1E-04	1.2E-05	6.9E-05	2.0E-09
	Wabasca (IR 166C)	1.5E-08	5.8E-06	4.9E-05	1.2E-03	7.8E-04	3.0E-04	3.1E-04	1.2E-05	6.9E-05	2.0E-09

Table A-8 Carcinogenic Exposure Estimates for the Composite Receptor - Application Case

		Carcinogenic Exposure Estimates for the Composite Receptor - Application Case									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose Ingestion	Fish Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
Benzo(a)anthracene	Chipewyan Lake	1.7E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	7.9E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(a)anthracene surrogate	Chipewyan Lake	1.0E-09	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	5.1E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(a)pyrene	Chipewyan Lake	1.0E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
	Wabasca (IR 166C)	5.0E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
Benzo(a)pyrene surrogate	Chipewyan Lake	1.9E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
	Wabasca (IR 166C)	9.7E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
Benzo(g,h,i)perylene	Chipewyan Lake	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	7.4E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(g)fluoranthene	Chipewyan Lake	3.3E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	1.5E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(k)fluoranthene	Chipewyan Lake	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.4E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	7.0E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.4E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Chrysene	Chipewyan Lake	2.0E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	1.1E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Dibenzo(a,h)anthracene	Chipewyan Lake	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.2E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	6.5E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.2E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Fluoranthene	Chipewyan Lake	9.7E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	4.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Indeno(1,2,3-cd)pyrene	Chipewyan Lake	1.3E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	5.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	6.3E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	5.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Phenanthrene	Chipewyan Lake	1.5E-09	3.2E-09	1.1E-07	5.8E-06	4.3E-06	6.8E-06	1.8E-05	1.2E-07	5.8E-08	1.1E-12
	Wabasca (IR 166C)	6.1E-10	3.2E-09	1.1E-07	5.8E-06	4.3E-06	6.8E-06	1.8E-05	1.2E-07	5.8E-08	1.1E-12
Arsenic	Chipewyan Lake	9.4E-10	2.3E-06	5.2E-07	3.6E-05	1.5E-04	1.1E-05	9.5E-05	2.3E-05	1.8E-04	7.9E-10
	Wabasca (IR 166C)	5.5E-10	2.3E-06	5.2E-07	3.6E-05	1.5E-04	1.1E-05	9.5E-05	2.3E-05	1.8E-04	7.9E-10
Beryllium	Chipewyan Lake	7.1E-11	1.9E-07	1.1E-07	5.7E-06	2.1E-05	1.7E-06	3.7E-06	2.3E-05	4.4E-06	6.3E-11
	Wabasca (IR 166C)	4.1E-11	1.9E-07	1.1E-07	5.7E-06	2.1E-05	1.7E-06	3.7E-06	2.3E-05	4.4E-06	6.3E-11
Chromium	Chipewyan Lake	1.8E-08	2.6E-06	7.6E-06	5.8E-04	6.5E-04	1.3E-04	4.9E-04	4.7E-05	1.2E-04	1.8E-09
	Wabasca (IR 166C)	1.0E-08	2.6E-06	7.6E-06	5.8E-04	6.5E-04	1.3E-04	4.9E-04	4.7E-05	1.2E-04	1.8E-09
Nickel	Chipewyan Lake	2.8E-08	5.8E-06	4.9E-05	1.2E-03	7.8E-04	3.0E-04	3.1E-04	1.2E-05	6.9E-05	2.0E-09
	Wabasca (IR 166C)	1.6E-08	5.8E-06	4.9E-05	1.2E-03	7.8E-04	3.0E-04	3.1E-04	1.2E-05	6.9E-05	2.0E-09

Table A-9 Carcinogenic Exposure Estimates for the Composite Receptor – PDC

		Carcinogenic Exposure Estimates for the Composite Receptor - PDC									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose Ingestion	Fish Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
Benzo(a)anthracene	Chipewyan Lake	2.2E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	1.1E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(a)anthracene surrogate	Chipewyan Lake	1.4E-09	3.2E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	6.9E-10	3.2E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(a)pyrene	Chipewyan Lake	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
	Wabasca (IR 166C)	6.8E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
Benzo(a)pyrene surrogate	Chipewyan Lake	2.6E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
	Wabasca (IR 166C)	1.3E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.6E-06	1.8E-05	1.2E-07	5.0E-08	1.1E-12
Benzo(g,h,i)perylene	Chipewyan Lake	1.9E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	9.8E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(g)fluoranthene	Chipewyan Lake	4.5E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	2.0E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.3E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Benzo(k)fluoranthene	Chipewyan Lake	1.9E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.4E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	9.4E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	7.4E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Chrysene	Chipewyan Lake	2.6E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	1.4E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	8.1E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Dibenzo(a,h)anthracene	Chipewyan Lake	1.9E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.2E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	8.9E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	6.2E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Fluoranthene	Chipewyan Lake	1.4E-09	3.2E-09	1.1E-07	5.7E-06	4.3E-06	7.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	6.0E-10	3.2E-09	1.1E-07	5.7E-06	4.3E-06	7.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Indeno(1,2,3-cd)pyrene	Chipewyan Lake	1.7E-10	3.1E-09	1.1E-07	5.7E-06	4.3E-06	5.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
	Wabasca (IR 166C)	8.4E-11	3.1E-09	1.1E-07	5.7E-06	4.3E-06	5.9E-06	1.8E-05	1.2E-07	5.7E-08	1.1E-12
Phenanthrene	Chipewyan Lake	4.4E-09	3.2E-09	1.1E-07	5.8E-06	4.3E-06	6.8E-06	1.8E-05	1.2E-07	5.8E-08	1.1E-12
	Wabasca (IR 166C)	2.2E-09	3.2E-09	1.1E-07	5.8E-06	4.3E-06	6.8E-06	1.8E-05	1.2E-07	5.8E-08	1.1E-12
Arsenic	Chipewyan Lake	1.4E-09	2.3E-06	5.2E-07	3.6E-05	1.5E-04	1.1E-05	9.5E-05	2.3E-05	1.8E-04	7.9E-10
	Wabasca (IR 166C)	8.1E-10	2.3E-06	5.2E-07	3.6E-05	1.5E-04	1.1E-05	9.5E-05	2.3E-05	1.8E-04	7.9E-10
Beryllium	Chipewyan Lake	9.9E-11	1.9E-07	1.1E-07	5.7E-06	2.1E-05	1.7E-06	3.7E-06	2.3E-05	4.4E-06	6.3E-11
	Wabasca (IR 166C)	5.7E-11	1.9E-07	1.1E-07	5.7E-06	2.1E-05	1.7E-06	3.7E-06	2.3E-05	4.4E-06	6.3E-11
Chromium	Chipewyan Lake	2.2E-08	2.6E-06	7.6E-06	5.8E-04	6.5E-04	1.3E-04	4.9E-04	4.7E-05	1.2E-04	1.8E-09

	Wabasca (IR 166C)	1.2E-08	2.6E-06	7.6E-06	5.8E-04	6.5E-04	1.3E-04	4.9E-04	4.7E-05	1.2E-04	1.8E-09
Nickel	Chipewyan Lake	3.4E-08	5.8E-06	4.9E-05	1.2E-03	7.8E-04	3.0E-04	3.1E-04	1.2E-05	6.9E-05	2.0E-09
	Wabasca (IR 166C)	1.9E-08	5.8E-06	4.9E-05	1.2E-03	7.8E-04	3.0E-04	3.1E-04	1.2E-05	6.9E-05	2.0E-09

Table A-10 Non-Carcinogenic Exposure Ratios for the Infant - Baseline Case

		Non-Carcinogenic Exposure Ratios for the Infant - Baseline Case									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose[(a)] Ingestion	Fish[(a)] Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
arsenic	Chipewyan Lake	2.1E-04	3.0E-02	8.8E-04	4.5E-01	1.4E+00			1.2E-01	1.5E-03	2.5E-06
	Wabasca (IR 166C)	1.0E-04	3.0E-02	8.8E-04	4.5E-01	1.4E+00			1.2E-01	1.5E-03	2.5E-06
barium	Chipewyan Lake	5.9E-05	9.4E-04	1.0E-03	1.6E+00	1.2E-01			5.5E-03	1.5E-04	7.9E-08
	Wabasca (IR 166C)	2.9E-05	9.4E-04	1.0E-03	1.6E+00	1.2E-01			5.5E-03	1.5E-04	7.9E-08
beryllium	Chipewyan Lake	3.4E-05	3.7E-04	2.9E-05	1.1E-02	3.2E-02			1.8E-02	5.9E-05	3.1E-08
	Wabasca (IR 166C)	1.8E-05	3.7E-04	2.9E-05	1.1E-02	3.2E-02			1.8E-02	5.9E-05	3.1E-08
cadmium	Chipewyan Lake	5.0E-03	8.3E-03	3.7E-03	2.5E-01	2.9E-01			3.7E-03	1.3E-04	7.0E-07
	Wabasca (IR 166C)	2.1E-03	8.3E-03	3.7E-03	2.5E-01	2.9E-01			3.7E-03	1.3E-04	7.0E-07
chromium	Chipewyan Lake	1.0E-06	1.4E-05	5.1E-06	2.9E-03	2.5E-03			4.9E-05	2.2E-06	1.1E-09
	Wabasca (IR 166C)	5.5E-07	1.4E-05	5.2E-06	2.9E-03	2.5E-03			4.9E-05	2.2E-06	1.1E-09
cobalt	Chipewyan Lake	9.3E-05	1.0E-02	5.0E-04	2.9E-01	1.3E-01			1.1E-02	1.6E-04	8.4E-07
	Wabasca (IR 166C)	4.2E-05	1.0E-02	5.0E-04	2.9E-01	1.3E-01			1.1E-02	1.6E-04	8.4E-07
copper	Chipewyan Lake	—	2.2E-04	5.9E-04	1.8E-01	2.8E-02			2.8E-04	2.1E-05	1.9E-08
	Wabasca (IR 166C)	—	2.2E-04	5.9E-04	1.8E-01	2.8E-02			2.8E-04	2.1E-05	1.9E-08
lead	Chipewyan Lake	—	1.1E-05	2.2E-07	1.2E-04	2.1E-04	n/a	n/a	2.3E-05	1.8E-05	9.4E-10
	Wabasca (IR 166C)	—	1.1E-05	2.2E-07	1.2E-04	2.1E-04			2.3E-05	1.8E-05	9.4E-10
manganese	Chipewyan Lake	5.1E-04	3.3E-03	2.7E-02	2.3E+01	5.8E+00			1.0E-01	5.4E-03	2.8E-07
	Wabasca (IR 166C)	2.6E-04	3.3E-03	2.7E-02	2.3E+01	5.8E+00			1.0E-01	5.4E-03	2.8E-07
mercury	Chipewyan Lake	1.0E-04	7.7E-04	9.5E-05	9.3E-02	3.4E-02			2.4E-03	1.2E-04	6.4E-08
	Wabasca (IR 166C)	5.2E-05	7.7E-04	9.5E-05	9.3E-02	3.4E-02			2.4E-03	1.2E-04	6.4E-08
molybdenum	Chipewyan Lake	1.7E-06	4.4E-04	8.3E-04	1.8E-01	1.2E-01			1.5E-03	7.0E-06	3.7E-08
	Wabasca (IR 166C)	8.8E-07	4.4E-04	8.3E-04	1.8E-01	1.2E-01			1.5E-03	7.0E-06	3.7E-08
nickel	Chipewyan Lake	5.5E-03	2.1E-03	2.2E-03	4.2E-01	2.1E-01			1.7E-03	6.6E-04	1.7E-07
	Wabasca (IR 166C)	3.0E-03	2.1E-03	2.2E-03	4.2E-01	2.1E-01			1.7E-03	6.6E-04	1.7E-07
selenium	Chipewyan Lake	7.9E-07	3.7E-04	1.1E-04	1.4E-01	2.5E-02			1.5E-03	5.9E-06	3.1E-08
	Wabasca (IR 166C)	4.6E-07	3.7E-04	1.1E-04	1.4E-01	2.5E-02			1.5E-03	5.9E-06	3.1E-08
vanadium	Chipewyan Lake	7.3E-04	4.2E-03	8.8E-05	6.2E-02	8.6E-03			1.7E-02	6.8E-04	3.5E-07
	Wabasca (IR 166C)	3.8E-04	4.2E-03	8.8E-05	6.2E-02	8.6E-03			1.7E-02	6.8E-04	3.5E-07
zinc	Chipewyan Lake	—	2.6E-04	5.0E-04	3.5E-01	3.3E-01			1.3E-03	4.1E-05	2.2E-08

	Wabasca (IR 166C)	—	2.6E-04	5.0E-04	3.5E-01	3.3E-01			1.3E-03	4.1E-05	2.2E-08
anthracene	Chipewyan Lake	—	4.1E-08	1.9E-07	7.2E-05	4.2E-05			6.1E-07	8.5E-09	3.4E-12
	Wabasca (IR 166C)	—	4.1E-08	1.9E-07	7.2E-05	4.2E-05			6.1E-07	8.5E-09	3.4E-12
fluoranthene	Chipewyan Lake	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
	Wabasca (IR 166C)	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
fluorene	Chipewyan Lake	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
	Wabasca (IR 166C)	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
pyrene	Chipewyan Lake	—	4.1E-07	1.9E-06	7.2E-04	4.2E-04			6.1E-06	9.7E-08	3.4E-11
	Wabasca (IR 166C)	—	4.1E-07	1.9E-06	7.2E-04	4.2E-04			6.1E-06	9.7E-08	3.4E-11

(a)

Table A-11 Non-Carcinogenic Exposure Ratios for the Infant - Application Case

		Non-Carcinogenic Exposure Ratios for the Infant - Application Case									
		Air Inhalation	**Soil Ingestion**	**Berry Ingestion**	**Leaf Ingestion**	**Root Ingestion**	**Moose[(a)] Ingestion**	**Fish[(a)] Ingestion**	**Water Ingestion**	**Soil Dermal**	**Soil Dust Inhalation**
arsenic	Chipewyan Lake	2.3E-04	3.0E-02	8.8E-04	4.5E-01	1.4E+00			1.2E-01	1.5E-03	2.5E-06
	Wabasca (IR 166C)	1.3E-04	3.0E-02	8.8E-04	4.5E-01	1.4E+00			1.2E-01	1.5E-03	2.5E-06
barium	Chipewyan Lake	6.5E-05	9.4E-04	1.0E-03	1.6E+00	1.2E-01			5.5E-03	1.5E-04	7.9E-08
	Wabasca (IR 166C)	3.8E-05	9.4E-04	1.0E-03	1.6E+00	1.2E-01			5.5E-03	1.5E-04	7.9E-08
beryllium	Chipewyan Lake	3.6E-05	3.7E-04	2.9E-05	1.1E-02	3.2E-02			1.8E-02	5.9E-05	3.1E-08
	Wabasca (IR 166C)	2.1E-05	3.7E-04	2.9E-05	1.1E-02	3.2E-02			1.8E-02	5.9E-05	3.1E-08
cadmium	Chipewyan Lake	5.1E-03	8.4E-03	3.7E-03	2.5E-01	2.9E-01			3.7E-03	1.3E-04	7.0E-07
	Wabasca (IR 166C)	2.4E-03	8.4E-03	3.7E-03	2.5E-01	3.0E-01			3.7E-03	1.3E-04	7.0E-07
chromium	Chipewyan Lake	1.1E-06	1.4E-05	5.2E-06	2.9E-03	2.5E-03			4.9E-05	2.2E-06	1.1E-09
	Wabasca (IR 166C)	6.0E-07	1.4E-05	5.2E-06	2.9E-03	2.5E-03			4.9E-05	2.2E-06	1.1E-09
cobalt	Chipewyan Lake	9.4E-05	1.0E-02	5.0E-04	2.9E-01	1.3E-01			1.1E-02	1.6E-04	8.4E-07
	Wabasca (IR 166C)	4.4E-05	1.0E-02	5.0E-04	2.9E-01	1.3E-01	n/a	n/a	1.1E-02	1.6E-04	8.4E-07
copper	Chipewyan Lake	—	2.2E-04	5.9E-04	1.8E-01	2.8E-02			2.8E-04	2.1E-05	1.9E-08
	Wabasca (IR 166C)	—	2.2E-04	5.9E-04	1.8E-01	2.8E-02			2.8E-04	2.1E-05	1.9E-08
lead	Chipewyan Lake	—	1.1E-05	2.2E-07	1.2E-04	2.1E-04			2.3E-05	1.8E-05	9.4E-10
	Wabasca (IR 166C)	—	1.1E-05	2.2E-07	1.2E-04	2.1E-04			2.3E-05	1.8E-05	9.4E-10
manganese	Chipewyan Lake	5.2E-04	3.3E-03	2.7E-02	2.3E+01	5.8E+00			1.0E-01	5.4E-03	2.8E-07
	Wabasca (IR 166C)	2.7E-04	3.3E-03	2.7E-02	2.3E+01	5.8E+00			1.0E-01	5.4E-03	2.8E-07
mercury	Chipewyan Lake	1.2E-04	7.7E-04	9.5E-05	9.3E-02	3.4E-02			2.4E-03	1.2E-04	6.4E-08
	Wabasca (IR 166C)	6.9E-05	7.7E-04	9.6E-05	9.4E-02	3.4E-02			2.4E-03	1.2E-04	6.4E-08
molybdenum	Chipewyan Lake	1.8E-06	4.4E-04	8.3E-04	1.8E-01	1.2E-01			1.5E-03	7.0E-06	3.7E-08
	Wabasca (IR 166C)	1.1E-06	4.4E-04	8.3E-04	1.8E-01	1.2E-01			1.5E-03	7.0E-06	3.7E-08
nickel	Chipewyan Lake	5.7E-03	2.1E-03	2.2E-03	4.2E-01	2.1E-01			1.7E-03	6.6E-04	1.7E-07

	Wabasca (IR 166C)	3.2E-03	2.1E-03	2.2E-03	4.2E-01	2.1E-01			1.7E-03	6.6E-04	1.7E-07
selenium	Chipewyan Lake	7.9E-07	3.7E-04	1.1E-04	1.4E-01	2.5E-02			1.5E-03	5.9E-06	3.1E-08
	Wabasca (IR 166C)	4.6E-07	3.7E-04	1.1E-04	1.4E-01	2.5E-02			1.5E-03	5.9E-06	3.1E-08
vanadium	Chipewyan Lake	7.6E-04	4.2E-03	8.8E-05	6.2E-02	8.6E-03			1.7E-02	6.8E-04	3.5E-07
	Wabasca (IR 166C)	4.3E-04	4.2E-03	8.8E-05	6.2E-02	8.6E-03			1.7E-02	6.8E-04	3.5E-07
zinc	Chipewyan Lake	—	2.6E-04	5.0E-04	3.5E-01	3.3E-01			1.3E-03	4.1E-05	2.2E-08
	Wabasca (IR 166C)	—	2.6E-04	5.0E-04	3.5E-01	3.3E-01			1.3E-03	4.1E-05	2.2E-08
anthracene	Chipewyan Lake	—	4.1E-08	1.9E-07	7.2E-05	4.2E-05			6.1E-07	8.5E-09	3.4E-12
	Wabasca (IR 166C)	—	4.1E-08	1.9E-07	7.2E-05	4.2E-05			6.1E-07	8.5E-09	3.4E-12
fluoranthene	Chipewyan Lake	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
	Wabasca (IR 166C)	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
fluorene	Chipewyan Lake	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
	Wabasca (IR 166C)	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
pyrene	Chipewyan Lake	—	4.1E-07	1.9E-06	7.2E-04	4.2E-04			6.1E-06	9.7E-08	3.4E-11
	Wabasca (IR 166C)	—	4.1E-07	1.9E-06	7.2E-04	4.2E-04			6.1E-06	9.7E-08	3.4E-11

(a)

Table A-12 Non-Carcinogenic Exposure Ratios for the Infant – PDC

		Non-Carcinogenic Exposure Ratios for the Infant - PDC									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose[(a)] Ingestion	Fish[(a)] Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
arsenic	Chipewyan Lake	3.4E-04	3.0E-02	8.8E-04	4.5E-01	1.4E+00			1.2E-01	1.5E-03	2.5E-06
	Wabasca (IR 166C)	2.0E-04	3.0E-02	8.8E-04	4.5E-01	1.4E+00			1.2E-01	1.5E-03	2.5E-06
barium	Chipewyan Lake	1.0E-04	9.4E-04	1.0E-03	1.6E+00	1.2E-01			5.5E-03	1.5E-04	7.9E-08
	Wabasca (IR 166C)	5.9E-05	9.4E-04	1.0E-03	1.6E+00	1.2E-01			5.5E-03	1.5E-04	7.9E-08
beryllium	Chipewyan Lake	5.1E-05	3.7E-04	2.9E-05	1.1E-02	3.2E-02			1.8E-02	5.9E-05	3.1E-08
	Wabasca (IR 166C)	2.9E-05	3.7E-04	2.9E-05	1.1E-02	3.2E-02			1.8E-02	5.9E-05	3.1E-08
cadmium	Chipewyan Lake	7.9E-03	8.4E-03	3.8E-03	2.7E-01	3.1E-01			3.7E-03	1.3E-04	7.0E-07
	Wabasca (IR 166C)	3.7E-03	8.4E-03	3.8E-03	2.7E-01	3.2E-01			3.7E-03	1.3E-04	7.0E-07
chromium	Chipewyan Lake	1.3E-06	1.4E-05	5.2E-06	2.9E-03	2.5E-03			4.9E-05	2.2E-06	1.1E-09
	Wabasca (IR 166C)	7.4E-07	1.4E-05	5.2E-06	2.9E-03	2.5E-03			4.9E-05	2.2E-06	1.1E-09
cobalt	Chipewyan Lake	1.3E-04	1.0E-02	5.0E-04	2.9E-01	1.3E-01			1.1E-02	1.6E-04	8.4E-07
	Wabasca (IR 166C)	6.1E-05	1.0E-02	5.0E-04	2.9E-01	1.3E-01			1.1E-02	1.6E-04	8.4E-07
copper	Chipewyan Lake	—	2.2E-04	5.9E-04	1.8E-01	2.8E-02			2.8E-04	2.1E-05	1.9E-08
	Wabasca (IR 166C)	—	2.2E-04	5.9E-04	1.8E-01	2.8E-02			2.8E-04	2.1E-05	1.9E-08
lead	Chipewyan Lake	—	1.1E-05	2.2E-07	1.2E-04	2.1E-04			2.3E-05	1.8E-05	9.4E-10
	Wabasca (IR 166C)	—	1.1E-05	2.2E-07	1.2E-04	2.1E-04			2.3E-05	1.8E-05	9.4E-10
manganese	Chipewyan Lake	6.5E-04	3.3E-03	2.7E-02	2.3E+01	5.8E+00			1.0E-01	5.4E-03	2.8E-07

	Wabasca (IR 166C)	3.4E-04	3.3E-03	2.7E-02	2.3E+01	5.8E+00			1.0E-01	5.4E-03	2.8E-07
mercury	Chipewyan Lake	1.9E-04	7.7E-04	9.6E-05	9.4E-02	3.4E-02			2.4E-03	1.2E-04	6.4E-08
	Wabasca (IR 166C)	1.1E-04	7.7E-04	9.6E-05	9.5E-02	3.4E-02			2.4E-03	1.2E-04	6.4E-08
molybdenum	Chipewyan Lake	2.6E-06	4.4E-04	8.3E-04	1.8E-01	1.2E-01			1.5E-03	7.0E-06	3.7E-08
	Wabasca (IR 166C)	1.5E-06	4.4E-04	8.3E-04	1.8E-01	1.2E-01			1.5E-03	7.0E-06	3.7E-08
nickel	Chipewyan Lake	6.8E-03	2.1E-03	2.2E-03	4.2E-01	2.1E-01			1.7E-03	6.6E-04	1.7E-07
	Wabasca (IR 166C)	3.8E-03	2.1E-03	2.2E-03	4.2E-01	2.1E-01			1.7E-03	6.6E-04	1.7E-07
selenium	Chipewyan Lake	8.6E-07	3.7E-04	1.1E-04	1.4E-01	2.5E-02			1.5E-03	5.9E-06	3.1E-08
	Wabasca (IR 166C)	5.0E-07	3.7E-04	1.1E-04	1.4E-01	2.5E-02			1.5E-03	5.9E-06	3.1E-08
vanadium	Chipewyan Lake	9.6E-04	4.2E-03	8.8E-05	6.2E-02	8.6E-03			1.7E-02	6.8E-04	3.5E-07
	Wabasca (IR 166C)	5.4E-04	4.2E-03	8.8E-05	6.2E-02	8.7E-03			1.7E-02	6.8E-04	3.5E-07
zinc	Chipewyan Lake	—	2.6E-04	5.0E-04	3.5E-01	3.3E-01			1.3E-03	4.1E-05	2.2E-08
	Wabasca (IR 166C)	—	2.6E-04	5.0E-04	3.5E-01	3.3E-01			1.3E-03	4.1E-05	2.2E-08
anthracene	Chipewyan Lake	—	4.1E-08	1.9E-07	7.2E-05	4.2E-05			6.1E-07	8.5E-09	3.4E-12
	Wabasca (IR 166C)	—	4.1E-08	1.9E-07	7.2E-05	4.2E-05			6.1E-07	8.5E-09	3.4E-12
fluoranthene	Chipewyan Lake	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
	Wabasca (IR 166C)	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
fluorene	Chipewyan Lake	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
	Wabasca (IR 166C)	—	3.1E-07	1.4E-06	5.4E-04	3.2E-04			4.6E-06	6.4E-08	2.6E-11
pyrene	Chipewyan Lake	—	4.1E-07	1.9E-06	7.2E-04	4.2E-04			6.1E-06	9.7E-08	3.4E-11
	Wabasca (IR 166C)	—	4.1E-07	1.9E-06	7.2E-04	4.2E-04			6.1E-06	9.7E-08	3.4E-11

(a)

Table A-13 Non-Carcinogenic Exposure Ratios for the Toddler - Baseline Case

		Non-Carcinogenic Exposure Ratios for the Toddler - Baseline Case									
		Air Inhalation	**Soil Ingestion**	**Berry Ingestion**	**Leaf Ingestion**	**Root Ingestion**	**Moose Ingestion**	**Fish Ingestion**	**Water Ingestion**	**Soil Dermal**	**Soil Dust Inhalation**
arsenic	Chipewyan Lake	2.1E-04	6.0E-02	2.4E-03	2.1E-01	9.0E-01	4.6E-02	5.0E-01	1.2E-01	9.7E-04	4.8E-06
	Wabasca (IR 166C)	1.0E-04	6.0E-02	2.4E-03	2.1E-01	9.0E-01	4.6E-02	5.0E-01	1.2E-01	9.7E-04	4.8E-06
barium	Chipewyan Lake	5.9E-05	1.9E-03	2.8E-03	7.3E-01	7.3E-02	2.8E-03	2.4E-03	5.5E-03	1.0E-04	1.5E-07
	Wabasca (IR 166C)	2.9E-05	1.9E-03	2.8E-03	7.3E-01	7.3E-02	2.8E-03	2.4E-03	5.5E-03	1.0E-04	1.5E-07
beryllium	Chipewyan Lake	3.4E-05	7.3E-04	7.8E-05	5.0E-03	2.0E-02	1.1E-03	2.9E-03	1.8E-02	3.9E-05	5.7E-08
	Wabasca (IR 166C)	1.8E-05	7.3E-04	7.8E-05	5.0E-03	2.0E-02	1.1E-03	2.9E-03	1.8E-02	3.9E-05	5.7E-08
cadmium	Chipewyan Lake	5.0E-03	1.7E-02	1.0E-02	1.2E-01	1.8E-01	4.2E-03	5.8E-02	3.6E-03	8.9E-05	1.3E-06
	Wabasca (IR 166C)	2.1E-03	1.7E-02	1.0E-02	1.2E-01	1.8E-01	4.2E-03	5.8E-02	3.6E-03	8.9E-05	1.3E-06
chromium	Chipewyan Lake	1.0E-06	2.7E-05	1.4E-05	1.3E-03	1.6E-03	2.2E-04	5.1E-04	4.8E-05	1.5E-06	2.1E-09
	Wabasca (IR 166C)	5.5E-07	2.7E-05	1.4E-05	1.3E-03	1.6E-03	2.2E-04	5.1E-04	4.8E-05	1.5E-06	2.1E-09
cobalt	Chipewyan Lake	9.3E-05	2.0E-02	1.4E-03	1.3E-01	8.0E-02	1.5E-02	1.2E-02	1.1E-02	1.1E-04	1.6E-06

	Wabasca (IR 166C)	4.2E-05	2.0E-02	1.4E-03	1.3E-01	8.0E-02	1.5E-02	1.2E-02	1.1E-02	1.1E-04	1.6E-06
copper	Chipewyan Lake	—	4.4E-04	1.6E-03	8.5E-02	1.7E-02	4.3E-03	2.4E-02	2.8E-04	1.4E-05	3.5E-08
	Wabasca (IR 166C)	—	4.4E-04	1.6E-03	8.5E-02	1.7E-02	4.3E-03	2.4E-02	2.8E-04	1.4E-05	3.5E-08
lead	Chipewyan Lake	—	2.2E-05	6.0E-07	5.4E-05	1.3E-04	2.1E-06	2.1E-04	2.2E-05	1.2E-05	1.8E-09
	Wabasca (IR 166C)	—	2.2E-05	6.0E-07	5.4E-05	1.3E-04	2.1E-06	2.1E-04	2.2E-05	1.2E-05	1.8E-09
manganese	Chipewyan Lake	5.1E-04	6.6E-03	7.3E-02	1.1E+01	3.6E+00	5.1E-01	3.4E-02	1.0E-01	3.6E-03	5.2E-07
	Wabasca (IR 166C)	2.6E-04	6.6E-03	7.3E-02	1.1E+01	3.6E+00	5.1E-01	3.4E-02	1.0E-01	3.6E-03	5.2E-07
mercury	Chipewyan Lake	1.0E-04	1.5E-03	2.6E-04	4.3E-02	2.1E-02	1.1E-02	5.3E-01	2.4E-03	8.2E-05	1.2E-07
	Wabasca (IR 166C)	5.2E-05	1.5E-03	2.6E-04	4.3E-02	2.1E-02	1.1E-02	5.3E-01	2.4E-03	8.2E-05	1.2E-07
molybdenum	Chipewyan Lake	1.7E-06	8.7E-04	2.3E-03	8.5E-02	7.7E-02	4.6E-03	1.4E-02	1.5E-03	4.7E-06	6.9E-08
	Wabasca (IR 166C)	8.8E-07	8.7E-04	2.3E-03	8.5E-02	7.7E-02	4.6E-03	1.4E-02	1.5E-03	4.7E-06	6.9E-08
nickel	Chipewyan Lake	5.5E-03	4.1E-03	6.2E-03	1.9E-01	1.3E-01	3.4E-02	4.4E-02	1.7E-03	4.4E-04	3.2E-07
	Wabasca (IR 166C)	3.0E-03	4.1E-03	6.2E-03	1.9E-01	1.3E-01	3.4E-02	4.4E-02	1.7E-03	4.4E-04	3.2E-07
selenium	Chipewyan Lake	7.9E-07	7.3E-04	3.1E-04	6.4E-02	1.6E-02	4.0E-03	8.6E-02	1.5E-03	3.9E-06	5.7E-08
	Wabasca (IR 166C)	4.6E-07	7.3E-04	3.1E-04	6.4E-02	1.6E-02	4.0E-03	8.6E-02	1.5E-03	3.9E-06	5.7E-08
vanadium	Chipewyan Lake	7.3E-04	8.4E-03	2.4E-04	2.9E-02	5.4E-03	6.2E-03	1.3E-03	1.7E-02	4.5E-04	6.6E-07
	Wabasca (IR 166C)	3.8E-04	8.4E-03	2.4E-04	2.9E-02	5.4E-03	6.2E-03	1.3E-03	1.7E-02	4.5E-04	6.6E-07
zinc	Chipewyan Lake	—	5.1E-04	1.4E-03	1.6E-01	2.1E-01	3.8E-04	1.5E-01	1.3E-03	2.8E-05	4.1E-08
	Wabasca (IR 166C)	—	5.1E-04	1.4E-03	1.6E-01	2.1E-01	3.8E-04	1.5E-01	1.3E-03	2.8E-05	4.1E-08
anthracene	Chipewyan Lake	—	8.1E-08	5.2E-07	3.3E-05	2.7E-05	2.9E-05	9.6E-05	6.1E-07	5.7E-09	6.4E-12
	Wabasca (IR 166C)	—	8.1E-08	5.2E-07	3.3E-05	2.7E-05	2.9E-05	9.6E-05	6.1E-07	5.7E-09	6.4E-12
fluoranthene	Chipewyan Lake	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	2.5E-04	7.2E-04	4.5E-06	4.3E-08	4.8E-11
	Wabasca (IR 166C)	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	2.5E-04	7.2E-04	4.5E-06	4.3E-08	4.8E-11
fluorene	Chipewyan Lake	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	1.9E-06	7.2E-04	4.5E-06	4.3E-08	4.8E-11
	Wabasca (IR 166C)	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	1.9E-06	7.2E-04	4.5E-06	4.3E-08	4.8E-11
pyrene	Chipewyan Lake	—	8.1E-07	5.2E-06	3.3E-04	2.7E-04	3.3E-04	9.6E-04	6.1E-06	6.5E-08	6.4E-11
	Wabasca (IR 166C)	—	8.1E-07	5.2E-06	3.3E-04	2.7E-04	3.3E-04	9.6E-04	6.1E-06	6.5E-08	6.4E-11

Table A-14 Non-Carcinogenic Exposure Ratios for the Toddler - Application Case

		Non-Carcinogenic Exposure Ratios for the Toddler - Application Case									
		Air Inhalation	**Soil Ingestion**	**Berry Ingestion**	**Leaf Ingestion**	**Root Ingestion**	**Moose Ingestion**	**Fish Ingestion**	**Water Ingestion**	**Soil Dermal**	**Soil Dust Inhalation**
arsenic	Chipewyan Lake	2.3E-04	6.0E-02	2.4E-03	2.1E-01	9.0E-01	4.6E-02	5.0E-01	1.2E-01	9.7E-04	4.8E-06
	Wabasca (IR 166C)	1.3E-04	6.0E-02	2.4E-03	2.1E-01	9.0E-01	4.6E-02	5.0E-01	1.2E-01	9.7E-04	4.8E-06
barium	Chipewyan Lake	6.5E-05	1.9E-03	2.8E-03	7.3E-01	7.3E-02	2.8E-03	2.4E-03	5.5E-03	1.0E-04	1.5E-07
	Wabasca (IR 166C)	3.8E-05	1.9E-03	2.8E-03	7.3E-01	7.3E-02	2.8E-03	2.4E-03	5.5E-03	1.0E-04	1.5E-07
beryllium	Chipewyan Lake	3.6E-05	7.3E-04	7.8E-05	5.0E-03	2.0E-02	1.1E-03	2.9E-03	1.8E-02	3.9E-05	5.7E-08

	Wabasca (IR 166C)	2.1E-05	7.3E-04	7.8E-05	5.0E-03	2.0E-02	1.1E-03	2.9E-03	1.8E-02	3.9E-05	5.7E-08
cadmium	Chipewyan Lake	5.1E-03	1.7E-02	1.0E-02	1.2E-01	1.8E-01	4.4E-03	5.8E-02	3.6E-03	8.9E-05	1.3E-06
	Wabasca (IR 166C)	2.4E-03	1.7E-02	1.0E-02	1.2E-01	1.9E-01	4.6E-03	5.8E-02	3.6E-03	8.9E-05	1.3E-06
chromium	Chipewyan Lake	1.1E-06	2.7E-05	1.4E-05	1.3E-03	1.6E-03	2.2E-04	5.1E-04	4.8E-05	1.5E-06	2.1E-09
	Wabasca (IR 166C)	6.0E-07	2.7E-05	1.4E-05	1.3E-03	1.6E-03	2.2E-04	5.1E-04	4.8E-05	1.5E-06	2.1E-09
cobalt	Chipewyan Lake	9.4E-05	2.0E-02	1.4E-03	1.3E-01	8.0E-02	1.5E-02	1.2E-02	1.1E-02	1.1E-04	1.6E-06
	Wabasca (IR 166C)	4.4E-05	2.0E-02	1.4E-03	1.3E-01	8.0E-02	1.5E-02	1.2E-02	1.1E-02	1.1E-04	1.6E-06
copper	Chipewyan Lake	–	4.4E-04	1.6E-03	8.5E-02	1.7E-02	4.3E-03	2.4E-02	2.8E-04	1.4E-05	3.5E-08
	Wabasca (IR 166C)	–	4.4E-04	1.6E-03	8.5E-02	1.7E-02	4.3E-03	2.4E-02	2.8E-04	1.4E-05	3.5E-08
lead	Chipewyan Lake	–	2.2E-05	6.0E-07	5.4E-05	1.3E-04	2.1E-06	2.1E-04	2.2E-05	1.2E-05	1.8E-09
	Wabasca (IR 166C)	–	2.2E-05	6.0E-07	5.4E-05	1.3E-04	2.1E-06	2.1E-04	2.2E-05	1.2E-05	1.8E-09
manganese	Chipewyan Lake	5.2E-04	6.6E-03	7.3E-02	1.1E+01	3.6E+00	5.1E-01	3.4E-02	1.0E-01	3.6E-03	5.2E-07
	Wabasca (IR 166C)	2.7E-04	6.6E-03	7.3E-02	1.1E+01	3.6E+00	5.1E-01	3.4E-02	1.0E-01	3.6E-03	5.2E-07
mercury	Chipewyan Lake	1.2E-04	1.5E-03	2.6E-04	4.3E-02	2.1E-02	1.1E-02	5.3E-01	2.4E-03	8.2E-05	1.2E-07
	Wabasca (IR 166C)	6.9E-05	1.5E-03	2.6E-04	4.3E-02	2.1E-02	1.1E-02	5.3E-01	2.4E-03	8.2E-05	1.2E-07
molybdenum	Chipewyan Lake	1.8E-06	8.7E-04	2.3E-03	8.5E-02	7.7E-02	4.6E-03	1.4E-02	1.5E-03	4.7E-06	6.9E-08
	Wabasca (IR 166C)	1.1E-06	8.7E-04	2.3E-03	8.5E-02	7.7E-02	4.6E-03	1.4E-02	1.5E-03	4.7E-06	6.9E-08
nickel	Chipewyan Lake	5.7E-03	4.1E-03	6.2E-03	1.9E-01	1.3E-01	3.4E-02	4.4E-02	1.7E-03	4.4E-04	3.2E-07
	Wabasca (IR 166C)	3.2E-03	4.1E-03	6.2E-03	1.9E-01	1.3E-01	3.5E-02	4.4E-02	1.7E-03	4.4E-04	3.2E-07
selenium	Chipewyan Lake	7.9E-07	7.3E-04	3.1E-04	6.4E-02	1.6E-02	4.0E-03	8.6E-02	1.5E-03	3.9E-06	5.7E-08
	Wabasca (IR 166C)	4.6E-07	7.3E-04	3.1E-04	6.4E-02	1.6E-02	4.0E-03	8.6E-02	1.5E-03	3.9E-06	5.7E-08
vanadium	Chipewyan Lake	7.6E-04	8.4E-03	2.4E-04	2.9E-02	5.4E-03	6.2E-03	1.3E-03	1.7E-02	4.5E-04	6.6E-07
	Wabasca (IR 166C)	4.3E-04	8.4E-03	2.4E-04	2.9E-02	5.4E-03	6.2E-03	1.3E-03	1.7E-02	4.5E-04	6.6E-07
zinc	Chipewyan Lake	–	5.1E-04	1.4E-03	1.6E-01	2.1E-01	3.8E-04	1.5E-01	1.3E-03	2.8E-05	4.1E-08
	Wabasca (IR 166C)	–	5.1E-04	1.4E-03	1.6E-01	2.1E-01	3.8E-04	1.5E-01	1.3E-03	2.8E-05	4.1E-08
anthracene	Chipewyan Lake	—	8.1E-08	5.2E-07	3.3E-05	2.7E-05	2.9E-05	9.6E-05	6.1E-07	5.7E-09	6.4E-12
	Wabasca (IR 166C)	—	8.1E-08	5.2E-07	3.3E-05	2.7E-05	2.9E-05	9.6E-05	6.1E-07	5.7E-09	6.4E-12
fluoranthene	Chipewyan Lake	–	6.1E-07	3.9E-06	2.5E-04	2.0E-04	2.5E-04	7.2E-04	4.5E-06	4.3E-08	4.8E-11
	Wabasca (IR 166C)	–	6.1E-07	3.9E-06	2.5E-04	2.0E-04	2.5E-04	7.2E-04	4.5E-06	4.3E-08	4.8E-11
fluorene	Chipewyan Lake	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	1.9E-06	7.2E-04	4.5E-06	4.3E-08	4.8E-11
	Wabasca (IR 166C)	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	1.9E-06	7.2E-04	4.5E-06	4.3E-08	4.8E-11
pyrene	Chipewyan Lake	–	8.1E-07	5.2E-06	3.3E-04	2.7E-04	3.3E-04	9.6E-04	6.1E-06	6.5E-08	6.4E-11
	Wabasca (IR 166C)	–	8.1E-07	5.2E-06	3.3E-04	2.7E-04	3.3E-04	9.6E-04	6.1E-06	6.5E-08	6.4E-11

Table A-15 Non-Carcinogenic Exposure Ratios for the Toddler – PDC

	Non-Carcinogenic Exposure Ratios for the Toddler - PDC									
	Air	Soil	Berry	Leaf	Root	Moose	Fish	Water	Soil	Soil Dust

		Inhalation	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	Ingestion	Dermal	Inhalation
arsenic	Chipewyan Lake	3.4E-04	6.0E-02	2.4E-03	2.1E-01	9.0E-01	4.6E-02	5.0E-01	1.2E-01	9.7E-04	4.8E-06
	Wabasca (IR 166C)	2.0E-04	6.0E-02	2.4E-03	2.1E-01	9.0E-01	4.6E-02	5.0E-01	1.2E-01	9.7E-04	4.8E-06
barium	Chipewyan Lake	1.0E-04	1.9E-03	2.8E-03	7.3E-01	7.3E-02	2.8E-03	2.4E-03	5.5E-03	1.0E-04	1.5E-07
	Wabasca (IR 166C)	5.9E-05	1.9E-03	2.8E-03	7.3E-01	7.3E-02	2.8E-03	2.4E-03	5.5E-03	1.0E-04	1.5E-07
beryllium	Chipewyan Lake	5.1E-05	7.3E-04	7.8E-05	5.0E-03	2.0E-02	1.1E-03	2.9E-03	1.8E-02	3.9E-05	5.7E-08
	Wabasca (IR 166C)	2.9E-05	7.3E-04	7.8E-05	5.0E-03	2.0E-02	1.1E-03	2.9E-03	1.8E-02	3.9E-05	5.7E-08
cadmium	Chipewyan Lake	7.9E-03	1.7E-02	1.0E-02	1.3E-01	2.0E-01	6.1E-03	5.8E-02	3.6E-03	9.0E-05	1.3E-06
	Wabasca (IR 166C)	3.7E-03	1.7E-02	1.0E-02	1.3E-01	2.0E-01	6.5E-03	5.8E-02	3.6E-03	9.0E-05	1.3E-06
chromium	Chipewyan Lake	1.3E-06	2.7E-05	1.4E-05	1.3E-03	1.6E-03	2.2E-04	5.1E-04	4.8E-05	1.5E-06	2.1E-09
	Wabasca (IR 166C)	7.4E-07	2.7E-05	1.4E-05	1.3E-03	1.6E-03	2.2E-04	5.1E-04	4.8E-05	1.5E-06	2.1E-09
cobalt	Chipewyan Lake	1.3E-04	2.0E-02	1.4E-03	1.3E-01	8.0E-02	1.5E-02	1.2E-02	1.1E-02	1.1E-04	1.6E-06
	Wabasca (IR 166C)	6.1E-05	2.0E-02	1.4E-03	1.3E-01	8.0E-02	1.5E-02	1.2E-02	1.1E-02	1.1E-04	1.6E-06
copper	Chipewyan Lake	–	4.4E-04	1.6E-03	8.5E-02	1.7E-02	4.3E-03	2.4E-02	2.8E-04	1.4E-05	3.5E-08
	Wabasca (IR 166C)	–	4.4E-04	1.6E-03	8.5E-02	1.8E-02	4.3E-03	2.4E-02	2.8E-04	1.4E-05	3.5E-08
lead	Chipewyan Lake	–	2.2E-05	6.0E-07	5.4E-05	1.3E-04	2.1E-06	2.1E-04	2.2E-05	1.2E-05	1.8E-09
	Wabasca (IR 166C)	–	2.2E-05	6.0E-07	5.4E-05	1.3E-04	2.1E-06	2.1E-04	2.2E-05	1.2E-05	1.8E-09
manganese	Chipewyan Lake	6.5E-04	6.6E-03	7.3E-02	1.1E+01	3.6E+00	5.1E-01	3.4E-02	1.0E-01	3.6E-03	5.2E-07
	Wabasca (IR 166C)	3.4E-04	6.6E-03	7.3E-02	1.1E+01	3.6E+00	5.1E-01	3.4E-02	1.0E-01	3.6E-03	5.2E-07
mercury	Chipewyan Lake	1.9E-04	1.5E-03	2.6E-04	4.3E-02	2.1E-02	1.1E-02	5.3E-01	2.4E-03	8.2E-05	1.2E-07
	Wabasca (IR 166C)	1.1E-04	1.5E-03	2.6E-04	4.4E-02	2.1E-02	1.1E-02	5.3E-01	2.4E-03	8.2E-05	1.2E-07
molybdenum	Chipewyan Lake	2.6E-06	8.7E-04	2.3E-03	8.5E-02	7.7E-02	4.6E-03	1.4E-02	1.5E-03	4.7E-06	6.9E-08
	Wabasca (IR 166C)	1.5E-06	8.7E-04	2.3E-03	8.5E-02	7.7E-02	4.6E-03	1.4E-02	1.5E-03	4.7E-06	6.9E-08
nickel	Chipewyan Lake	6.8E-03	4.1E-03	6.2E-03	1.9E-01	1.3E-01	3.4E-02	4.4E-02	1.7E-03	4.4E-04	3.2E-07
	Wabasca (IR 166C)	3.8E-03	4.1E-03	6.2E-03	1.9E-01	1.3E-01	3.5E-02	4.4E-02	1.7E-03	4.4E-04	3.2E-07
selenium	Chipewyan Lake	8.6E-07	7.3E-04	3.1E-04	6.4E-02	1.6E-02	4.0E-03	8.6E-02	1.5E-03	3.9E-06	5.7E-08
	Wabasca (IR 166C)	5.0E-07	7.3E-04	3.1E-04	6.4E-02	1.6E-02	4.0E-03	8.6E-02	1.5E-03	3.9E-06	5.7E-08
vanadium	Chipewyan Lake	9.6E-04	8.4E-03	2.4E-04	2.9E-02	5.4E-03	6.2E-03	1.3E-03	1.7E-02	4.5E-04	6.6E-07
	Wabasca (IR 166C)	5.4E-04	8.4E-03	2.4E-04	2.9E-02	5.5E-03	6.2E-03	1.3E-03	1.7E-02	4.5E-04	6.6E-07
zinc	Chipewyan Lake	–	5.1E-04	1.4E-03	1.6E-01	2.1E-01	3.8E-04	1.5E-01	1.3E-03	2.8E-05	4.1E-08
	Wabasca (IR 166C)	–	5.2E-04	1.4E-03	1.6E-01	2.1E-01	3.8E-04	1.5E-01	1.3E-03	2.8E-05	4.1E-08
anthracene	Chipewyan Lake	—	8.1E-08	5.2E-07	3.3E-05	2.7E-05	2.9E-05	9.6E-05	6.1E-07	5.7E-09	6.4E-12
	Wabasca (IR 166C)	—	8.1E-08	5.2E-07	3.3E-05	2.7E-05	2.9E-05	9.6E-05	6.1E-07	5.7E-09	6.4E-12
fluoranthene	Chipewyan Lake	–	6.1E-07	3.9E-06	2.5E-04	2.0E-04	2.5E-04	7.2E-04	4.5E-06	4.3E-08	4.8E-11
	Wabasca (IR 166C)	–	6.1E-07	3.9E-06	2.5E-04	2.0E-04	2.5E-04	7.2E-04	4.5E-06	4.3E-08	4.8E-11
fluorene	Chipewyan Lake	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	1.9E-06	7.2E-04	4.5E-06	4.3E-08	4.8E-11
	Wabasca (IR 166C)	—	6.1E-07	3.9E-06	2.5E-04	2.0E-04	1.9E-06	7.2E-04	4.5E-06	4.3E-08	4.8E-11
pyrene	Chipewyan Lake	–	8.2E-07	5.2E-06	3.3E-04	2.7E-04	3.3E-04	9.6E-04	6.1E-06	6.5E-08	6.4E-11
	Wabasca (IR 166C)	–	8.2E-07	5.2E-06	3.3E-04	2.7E-04	3.3E-04	9.6E-04	6.1E-06	6.5E-08	6.4E-11

Table A-16 Carcinogenic Exposure Ratios for the Composite Receptor - Baseline Case

		Carcinogenic Exposure Ratios for the Composite Receptor - Baseline Case									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose Ingestion	Fish Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
Benzo(a)anthracene	Chipewyan Lake	2.0E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	9.3E-08	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(a)anthracene surrogate	Chipewyan Lake	1.2E-06	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	6.0E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(a)pyrene	Chipewyan Lake	1.2E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
	Wabasca (IR 166C)	5.9E-07	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
Benzo(a)pyrene surrogate	Chipewyan Lake	2.2E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
	Wabasca (IR 166C)	1.1E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
Benzo(g,h,i)perylene	Chipewyan Lake	1.7E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.4E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
	Wabasca (IR 166C)	8.8E-09	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.4E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
Benzo(g)fluoranthene	Chipewyan Lake	3.9E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	1.8E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(k)fluoranthene	Chipewyan Lake	1.7E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	8.2E-08	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Chrysene	Chipewyan Lake	2.4E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.9E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
	Wabasca (IR 166C)	1.3E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.9E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
Dibenzo(a,h)anthracene	Chipewyan Lake	1.7E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.4E+00	4.2E+00	2.7E-02	1.3E-02	2.4E-07
	Wabasca (IR 166C)	7.7E-07	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.4E+00	4.2E+00	2.7E-02	1.3E-02	2.4E-07
Fluoranthene	Chipewyan Lake	1.2E-08	7.2E-07	2.6E-05	1.3E-03	9.9E-04	1.8E-03	4.2E-03	2.7E-05	1.3E-05	2.4E-10
	Wabasca (IR 166C)	5.2E-09	7.2E-07	2.6E-05	1.3E-03	9.9E-04	1.8E-03	4.2E-03	2.7E-05	1.3E-05	2.4E-10
Indeno(1,2,3-cd)pyrene	Chipewyan Lake	1.5E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.4E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	7.4E-08	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.4E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Phenanthrene	Chipewyan Lake	4.1E-08	7.3E-07	2.6E-05	1.3E-03	9.9E-04	1.6E-03	4.2E-03	2.7E-05	1.3E-05	2.5E-10
	Wabasca (IR 166C)	2.1E-08	7.3E-07	2.6E-05	1.3E-03	9.9E-04	1.6E-03	4.2E-03	2.7E-05	1.3E-05	2.5E-10
Arsenic	Chipewyan Lake	2.1E-03	4.2E-01	9.3E-02	6.5E+00	2.6E+01	1.9E+00	1.7E+01	4.2E+00	3.3E+01	1.4E-04
	Wabasca (IR 166C)	1.1E-03	4.2E-01	9.3E-02	6.5E+00	2.6E+01	1.9E+00	1.7E+01	4.2E+00	3.3E+01	1.4E-04
Beryllium	Chipewyan Lake	6.1E-05	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	3.2E-05	–	–	–	–	–	–	–	–	–
Chromium	Chipewyan Lake	7.4E-02	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	3.9E-02	–	–	–	–	–	–	–	–	–
Nickel	Chipewyan Lake	7.5E-03	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	4.0E-03	–	–	–	–	–	–	–	–	–

Table A-17 Carcinogenic Exposure Ratios for the Composite Receptor - Application Case

		Carcinogenic Exposure Ratios for the Composite Receptor - Application Case									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose Ingestion	Fish Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
Benzo(a)anthracene	Chipewyan Lake	2.0E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	9.5E-08	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(a)anthracene surrogate	Chipewyan Lake	1.2E-06	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	6.1E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(a)pyrene	Chipewyan Lake	1.2E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
	Wabasca (IR 166C)	6.0E-07	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
Benzo(a)pyrene surrogate	Chipewyan Lake	2.2E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
	Wabasca (IR 166C)	1.2E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
Benzo(g,h,i)perylene	Chipewyan Lake	1.7E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.4E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
	Wabasca (IR 166C)	8.9E-09	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.4E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
Benzo(g)fluoranthene	Chipewyan Lake	3.9E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	1.8E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(k)fluoranthene	Chipewyan Lake	1.7E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	8.3E-08	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Chrysene	Chipewyan Lake	2.4E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.9E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
	Wabasca (IR 166C)	1.3E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.9E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
Dibenzo(a,h)anthracene	Chipewyan Lake	1.7E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.4E+00	4.2E+00	2.7E-02	1.3E-02	2.4E-07
	Wabasca (IR 166C)	7.7E-07	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.4E+00	4.2E+00	2.7E-02	1.3E-02	2.4E-07
Fluoranthene	Chipewyan Lake	1.2E-08	7.2E-07	2.6E-05	1.3E-03	9.9E-04	1.8E-03	4.2E-03	2.7E-05	1.3E-05	2.4E-10
	Wabasca (IR 166C)	5.3E-09	7.2E-07	2.6E-05	1.3E-03	9.9E-04	1.8E-03	4.2E-03	2.7E-05	1.3E-05	2.4E-10
Indeno(1,2,3-cd)pyrene	Chipewyan Lake	1.5E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.4E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	7.5E-08	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.4E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Phenanthrene	Chipewyan Lake	1.7E-08	7.3E-07	2.6E-05	1.3E-03	9.9E-04	1.6E-03	4.2E-03	2.7E-05	1.3E-05	2.5E-10
	Wabasca (IR 166C)	7.3E-09	7.3E-07	2.6E-05	1.3E-03	9.9E-04	1.6E-03	4.2E-03	2.7E-05	1.3E-05	2.5E-10
Arsenic	Chipewyan Lake	2.3E-03	4.2E-01	9.3E-02	6.5E+00	2.6E+01	1.9E+00	1.7E+01	4.2E+00	3.3E+01	1.4E-04
	Wabasca (IR 166C)	1.4E-03	4.2E-01	9.3E-02	6.5E+00	2.6E+01	1.9E+00	1.7E+01	4.2E+00	3.3E+01	1.4E-04
Beryllium	Chipewyan Lake	6.5E-05	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	3.8E-05	–	–	–	–	–	–	–	–	–
Chromium	Chipewyan Lake	7.6E-02	–	–	–	–	–	–	–	–	–

	Wabasca (IR 166C)	4.2E-02	–	–	–	–	–	–	–	–	–
Nickel	Chipewyan Lake	7.8E-03	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	4.4E-03	–	–	–	–	–	–	–	–	–

Table A-18 Carcinogenic Exposure Ratios for the Composite Receptor – PDC

		Carcinogenic Exposure Ratios for the Composite Receptor - PDC									
		Air Inhalation	Soil Ingestion	Berry Ingestion	Leaf Ingestion	Root Ingestion	Moose Ingestion	Fish Ingestion	Water Ingestion	Soil Dermal	Soil Dust Inhalation
Benzo(a)anthracene	Chipewyan Lake	2.7E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	1.3E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(a)anthracene surrogate	Chipewyan Lake	1.6E-06	7.3E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	8.3E-07	7.3E-05	2.6E-03	1.3E-01	9.9E-02	1.9E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(a)pyrene	Chipewyan Lake	1.7E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
	Wabasca (IR 166C)	8.1E-07	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
Benzo(a)pyrene surrogate	Chipewyan Lake	3.1E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
	Wabasca (IR 166C)	1.6E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.7E+00	4.2E+00	2.7E-02	1.1E-02	2.4E-07
Benzo(g,h,i)perylene	Chipewyan Lake	2.3E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.4E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
	Wabasca (IR 166C)	1.2E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.4E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
Benzo(g)fluoranthene	Chipewyan Lake	5.4E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	2.4E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Benzo(k)fluoranthene	Chipewyan Lake	2.3E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	1.1E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.7E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Chrysene	Chipewyan Lake	3.1E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.9E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
	Wabasca (IR 166C)	1.6E-08	7.2E-06	2.6E-04	1.3E-02	9.9E-03	1.9E-02	4.2E-02	2.7E-04	1.3E-04	2.4E-09
Dibenzo(a,h)anthracene	Chipewyan Lake	2.3E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.4E+00	4.2E+00	2.7E-02	1.3E-02	2.4E-07
	Wabasca (IR 166C)	1.1E-06	7.2E-04	2.6E-02	1.3E+00	9.9E-01	1.4E+00	4.2E+00	2.7E-02	1.3E-02	2.4E-07
Fluoranthene	Chipewyan Lake	1.6E-08	7.2E-07	2.6E-05	1.3E-03	9.9E-04	1.8E-03	4.2E-03	2.7E-05	1.3E-05	2.4E-10
	Wabasca (IR 166C)	7.2E-09	7.2E-07	2.6E-05	1.3E-03	9.9E-04	1.8E-03	4.2E-03	2.7E-05	1.3E-05	2.4E-10
Indeno(1,2,3-cd)pyrene	Chipewyan Lake	2.0E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.4E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
	Wabasca (IR 166C)	1.0E-07	7.2E-05	2.6E-03	1.3E-01	9.9E-02	1.4E-01	4.2E-01	2.7E-03	1.3E-03	2.4E-08
Phenanthrene	Chipewyan Lake	5.2E-08	7.4E-07	2.6E-05	1.3E-03	9.9E-04	1.6E-03	4.2E-03	2.7E-05	1.3E-05	2.5E-10
	Wabasca (IR 166C)	2.6E-08	7.4E-07	2.6E-05	1.3E-03	9.9E-04	1.6E-03	4.2E-03	2.7E-05	1.3E-05	2.5E-10
Arsenic	Chipewyan Lake	3.4E-03	4.2E-01	9.3E-02	6.5E+00	2.6E+01	1.9E+00	1.7E+01	4.2E+00	3.3E+01	1.4E-04
	Wabasca (IR 166C)	2.0E-03	4.2E-01	9.3E-02	6.5E+00	2.6E+01	1.9E+00	1.7E+01	4.2E+00	3.3E+01	1.4E-04

Beryllium	Chipewyan Lake	9.1E-05	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	5.3E-05	–	–	–	–	–	–	–	–	–
Chromium	Chipewyan Lake	9.5E-02	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	5.2E-02	–	–	–	–	–	–	–	–	–
Nickel	Chipewyan Lake	9.2E-03	–	–	–	–	–	–	–	–	–
	Wabasca (IR 166C)	5.2E-03	–	–	–	–	–	–	–	–	–

ATTACHMENT B

TOXICOLOGICAL PROFILES

Table B-1 Anthracene Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	**0.3**	Based on a subchronic toxicity study with mice (U.S. EPA, 1989). No treatment-related effects were noted. The RfD was derived from the NOAEL by applying an uncertainty factor of 10 to account for interspecies extrapolation, 10 for intraspecies variability and 30 for both the use of a subchronic study for chronic RfD derivation and for lack of reproductive / developmental data and adequate toxicity data in a second species.
ATSDR	-	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	-	-
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-2 Arsenic Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	-	-

U.S. EPA IRIS	**0.0003**	Based on data reported in Tseng (1968) and Tseng (1977) that showed increased incidence of blackfoot disease (hyperpigmentation and keratosis) in Taiwanese farmers with increases in arsenic dose. Arsenic dose was estimated based on arsenic concentrations in drinking well water and average water consumption rates. U.S. EPA IRIS identified a NOAEL and LOAEL from the studies and used the NOAEL to derive the RfD. An uncertainty factor of 3 was applied to account for both the lack of data to preclude reproductive toxicity as a critical effect and to account for uncertainty in whether the NOAEL of the critical study accounts for all sensitive individuals.
ATSDR	**0.0003**	ATSDR also relied on the Tseng (1968) and Tseng (1977) studies and applied an uncertainty factor of 3 to the NOAEL.
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**1.5E-5**	Based on studies of 10 year-old children exposed to arsenic in drinking water over the course of a year (Wasserman et al. 2004 and Tsai et al. 2003). The critical effects were decrease in intellectual function and adverse effects on neurobehavioural development. A NOAEL was not observed, the RfC was derived from the LOAEL. An uncertainty factor of 3 was applied to account for use of a LOAEL and an uncertainty factor of 10 was applied to account for interindividual variation.
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**1.8**	Based on human exposure to arsenic in drinking water (Morales et al. 2000, Chen et al. 1985, Wu et al. 1989). Critical effects were bladder, lung and liver cancer. Slope factor based on upper end of range of mean unit risks.
U.S. EPA IRIS	1.5	Based on the Tseng (1968) and Tseng (1977) studies on Taiwanese farmers ingesting arsenic in drinking water, with skin cancer as the critical endpoint. The maximum likelihood estimate of skin cancer risk was calculated.
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**6.4**	Based on humans occupationally exposed to arsenic in the air, with lung cancer as the critical end point (Higgins et al. 1986). The unit risk was calculated using a relative risk model.
U.S. EPA IRIS	4.3	Based on males occupationally exposed to arsenic in the air, with lung cancer as the critical endpoint (Brown and Chu 1983, Lee-Feldstein 1983, Higgins 1983 and Enterline and Marsh 1983).

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-3 Barium Toxicological Profile

Oral Reference Doses		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**0.2**	Based on a chronic study with rats and mice, exposure to barium chloride in drinking water and a critical effect of renal lesions (U.S. EPA 2005). An uncertainty factor of 10 was applied for intraspecies variation, 10 for interspecies variation and 3 for database deficiencies.
U.S. EPA IRIS	**0.2**	Based on a 2-year drinking water study in mice with nephropathy as the critical effect (NTP 1994). An uncertainty factor of 10 was applied for intraspecies variation, 10 for interspecies variation and 3 for database deficiencies.
ATSDR	**0.2**	ATSDR also relied on the NTP (1994) study with the application of the same uncertainty factors as U.S. EPA IRIS.
Inhalation Reference Concentrations		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**-**	-
RIVM	**0.001**	Based on inhalation of barium carbonate in rats (IPCS 1990). No effects were observed. The RfC was derived from a NOAEC with the application of an uncertainty factor of 10 for intraspecies variation and 10 for interspecies variation.
Oral Slope Factors		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
Inhalation Unit Risks		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-4 Beryllium Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**-**	**-**
U.S. EPA IRIS	**0.002**	Based on a dog dietary study with a critical effect of small intestinal lesions (Morgareidge et al. 1976). An uncertainty factor of 10 for interspecies differences, 10 for intraspecies variation and 3 for database deficiencies was applied to the benchmark dose.
ATSDR	**0.002**	The ATSDR also relied on the Morgareidge et al. (1976) study and applied the same uncertainty factors as U.S. EPA IRIS.
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	2E-5	Based on a worker exposure via inhalation with a critical effect of beryllium sensitization and progression to chronic beryllium disease (Eisenbud et al. 1949). An uncertainty factor of 10 was applied to account for the sensitive nature of the subclinical endpoint and database deficiencies.
ATSDR	-	-
Cal. EPA	**7E-6**	Based on worker exposure via inhalation with a critical effect of beryllium sensitization and chronic beryllium disease (Kreiss et al. 1996). An uncertainty factor of 10 was applied for use of a LOAEL and and an uncertainty factor of 3 was applied for intraspecies variability.
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	**2.4**	Based on a study of human males occupationally exposed to beryllium via inhalation with a critical effect of lung cancer (Wagoner et al. 1980).

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-5 Cadmium Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	0.001	Based on human occupational exposure to cadmium with the critical effect of renal tubular dysfunction (WHO 1972, Friberg et al. 1971). An uncertainty factor was not applied.
U.S. EPA IRIS	0.001	A toxicokinetic model was used to calculate the food ingestion dose associated with the highest cadmium concentration in the renal cortex not associated with significant proteinuria (U.S. EPA, 1985). An uncertainty factor was not applied.
ATSDR	**0.0001**	ATSDR carried out a meta-analysis of 8 human dose-response studies that measured urinary cadmium as an indicator of internal dose and identified low molecular weight proteinuria as the critical endpoint. An uncertainty factor of 3 was applied to account for human variability.
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	**1E-5**	ATSDR carried out a meta-analysis of 11 human dose-response studies that measured urinary cadmium as an indicator of internal dose and identified low molecular weight proteinuria as the critical endpoint. An uncertainty factor of 3 was applied to account for human variability and the possible increased sensitivity of diabetics and a modifying factor of 3 was used to account for the lack of adequate human data, which could be used to compare the relative sensitivities of the respiratory tract and kidneys.
Cal. EPA	2E-5	Based on a mice inhalation study with the critical effect of ovarian atrophy (NTP 1993). The RfC was derived from the LOAEL with the application of an interspecies uncertainty factor of 3 and an intraspecies uncertainty factor of 10.
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**9.8**	Based on a study of rat inhalation of cadmium chloride aerosols and development of lung cancer (Takenaka et al. 1983, Oldiges et al. 1984). A multistage model was used to calculate the UR.
U.S. EPA IRIS	1.8	Based on inhalation of cadmium in the workplace by human males and lung, trachea and bronchus cancer deaths (Thun et al. 1985).

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-6 Carcinogenic PAHs Toxicological Profile

ORAL REFERENCE DOSES		
*Among the carcinogenic PAHs, an RfD is only available for **fluoranthene**, which is described below. This RfD was only applied for fluoranthene. Oral non-carcinogenic endpoints were not evaluated for the other carcinogenic PAHs.		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**-**	**-**
U.S. EPA IRIS	**0.04**	Based on a 13-week mouse oral subchronic study with critical effects of nephropathy, increased liver weights, hematological alterations and clinical effects (U.S. EPA 1988). The RfD was derived from the NOAEL with an uncertainty factor of 10 for interspecies conversion, 10 for intraspecies variability and 30 for use of a subchronic study for chronic RfD derivation and for lack of supporting reproductive/developmental toxicity data and toxicity data in a second species.
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
*Among the carcinogenic PAHs, no RfCs were available		
ORAL SLOPE FACTORS		
***Oral slope factors have been derived for **benzo(a)pyrene**, slope factors for other PAHs are calculated by using potency equivalency factors.		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**2.3**	Based on a subchronic mouse study with exposure through the diet and a critical endpoint of gastric tumours (Neal and Rigdon 1967). Linear extrapolation and surface-area correction were used to calculate the SF. Health Canada carried out a comprehensive review and recommended this SF in 2010, thus it was applied in preference to the U.S. EPA value that was established prior to 1998.
U.S. EPA IRIS	7.3	The geometric mean of four slope factors obtained by different modelling procedures. Derived from the combination of multiple data sets from two different reports (Neal and Rigdon 1967 and Rabstein et al. 1973). Both are mice studies with exposure through the diet and gastric tumours as the critical endpoint. The U.S. EPA IRIS last revised the toxicological profile for benzo(a)pyrene in 1998.
INHALATION UNIT RISKS		
***Inhalation unit risks have been derived for **benzo(a)pyrene**, unit risks for other PAHs are calculated by using potency equivalency factors.		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health	**0.031**	An inhalation study with hamsters and a critical effect of

Canada		respiratory tract tumours (Thysson et al. 1981). Multistage modeling was used to derive the UR.
U.S. EPA IRIS	-	-

POTENCY EQUIVALENCE FACTORS		
*Potency equivalence factors are multiplied by the benzo(a)pyrene oral slope factor or inhalation unit risk		
Chemical	**Health Canada PEF**	**CCME PEF**
Benzo(a)anthracene	0.1	0.1
Benzo(g,h,i)perylene	0.01	0.01
Benzo(b)fluoranthene	0.1	0.1
Benzo(k)fluoranthene	0.1	0.1
Chrysene	0.01	0.01
Dibenzo(a,h)anthracene	1	1
Indeno(1,2,3-c,d)pyrene	0.1	0.1
Fluoranthene	0.001	-
Phenanthrene	0.001	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-7 Chromium Toxicological Profile

Toxicity Reference Values for total chromium or chromium III were used.

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**-**	**-**
U.S. EPA IRIS	**1.5 (Cr III)**	Based on a chronic rat feeding study (Ivankovic and Preussman 1975). No effects were observed. The RfD was derived from the NOAEL with the application of an uncertainty factor of 10 to account for interspecies variability and 10 to account for intraspecies variability and a modifying factor of 10 to reflect database deficiencies.
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m³)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**-**	-
RIVM	**0.06 (Cr III)**	Based on a human inhalation exposure study (Triebag et al. 1987). The RfC was derived from a NOAEC with the application of an uncertainty factor of 10 for intraspecies extrapolation.

ORAL SLOPE FACTORS		
Agency	**SF (mg/kg/d)$^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR (mg/m^3)$^{-1}$**	**Description**
Health Canada	**11 (total Cr)**	Based on human occupational studies with exposure via inhalation and lung cancer as the critical effect (Mancuso 1975).
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-8 Cobalt Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**-**	**-**
U.S. EPA IRIS	**-**	-
ATSDR	**0.001**	An intermediate duration RfD was derived by ATSDR based on a LOAEL for polycythemia in a study of human male exposure to cobalt chloride (Davis and Fields 1958). An uncertainty factor of 10 was applied for use of a LOAEL and 10 for human variability. In addition, consistent with the approach used in MOE (2011), the intermediate duration RfD was converted to a chronic duration by dividing by 10.
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	**-**
U.S. EPA IRIS	-	-
ATSDR	0.0001	Based on a study of diamond polishers who were occupationally exposed to cobalt and had respiratory effects (Nemery et al. 1992). The RfC was derived from the NOAEL with the application of an uncertainty factor of 10 to account for human variability.
Cal. EPA	**-**	-
ORAL SLOPE FACTORS		
Agency	**SF (mg/kg/d)$^{-1}$**	**Description**

Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR (mg/m^3)$^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-9 Copper Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	Infant and toddler: **0.091**, child: **0.11**, adolescent: **0.126**, adult: **0.141**	Based on human clinical studies of ingestion of copper gluconate tablets, with critical effects of hepatotoxicity and gastrointestinal effects (Pratt et al. 1985, O'Donohue et al. 1993). The RfDs were derived from NOAELs and adjusted for age group and body weight.
U.S. EPA IRIS	**-**	-
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**-**	-
ORAL SLOPE FACTORS		
Agency	**SF (mg/kg/d)$^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR (mg/m^3)$^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-10 Fluorene Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**-**	**-**
U.S. EPA IRIS	**0.04**	Based on a mouse oral subchronic study with a critical effect of decreased red blood cell count, packed cell volume and hemoglobin (U.S. EPA 1989). The RfD was derived from the NOAEL with the application of an uncertainty factor of 10 for use of a subchronic study for chronic RfD derivation, 10 each for inter- and intraspecies variability and 3 for lack of adequate toxicity data in a second species and reproductive / developmental data.
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**-**	-
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-11 Lead Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**-**	**-**
U.S. EPA IRIS	**-**	-
ATSDR	**-**	-
B.C. MOE	**1.3**	B.C. MOE 2013 does not provide study details and the primary reference could not be accessed, as it was a document submitted to the B.C. MOE by SNC Lavalin.
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**-**	-
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-12 Manganese Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	Infant and toddler: **0.136**; child: **0.122**; adolescent: **0.142**; adult: **0.156**	Based on a human epidemiology study with exposure via food and water and a critical effect of Parkinsonian-like neurotoxicity (Greger 1999). An uncertainty factor was not deemed necessary. The NOEL was adjusted for life stage and body weight.

U.S. EPA IRIS	0.14	Based on chronic human ingestion data and central nervous system effects from a composite of studies (NRC 1989, Freeland-Graves et al. 1987, WHO 1973). An uncertainty factor was not deemed necessary.
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	**5E-5**	Based on human occupational exposure to manganese dioxide and impairment of neuro-behavioural function (Roels et al. 1992). The RfD was derived from the LOAEL with the application of an uncertainty factor of 10 for use of a LOAEL, 10 to protect sensitive individuals and 10 for database limitations.
ATSDR	3E-4	ATSDR also relied on the Roels et al. (1992) study with the application of an uncertainty factor of 10 for human variability and 10 for limitations in the database.
Cal. EPA	9E-5	Cal. EPA also relied on the Roels et al. (1992) study with the application of an uncertainty factor of 3 for use of subchronic data and 100 for intraspecies variability (greater absorption and lung deposition in children and greater susceptibility of children to neurotoxicity).
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-13 Mercury Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**0.0003**	Based on rat studies with nephrotoxicity as the critical effect (Druet et al. 1978, Bernaudin et al. 1981, Andres 1984). An uncertainty factor of 10 was applied for use of subchronic studies,

		10 for interspecies variability and 10 for use of a LOAEL.
U.S. EPA IRIS	-	-
ATSDR	-	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	0.0003	Based on human occupational inhalation studies with critical effects including hand tremor, increases in memory disturbance and slight subjective and objective evidence of autonomic dysfunction (Fawer et al. 1983, Piikivi and Tolonen 1989, Pikkivi and Hanninen 1989, Piikivi 1989, Ngim et al. 1992, Liang et al. 1993). An uncertainty factor of 10 was used for the protection of sensitive human subpopulations together with the use of a LOAEL and an uncertainty factor of 3 was used for database deficiencies.
ATSDR	0.0002	Based on a study of hand tremors in mercury-exposed workers (Fawer et al. 1983). An uncertainty factor of 10 was applied to account for variability in sensitivity to mercury within the human population and 3 for use of a minimal-effect LOAEL.
Cal. EPA	**0.00003**	Based on human occupational inhalation studies with neurotoxicity effects (Piikivi and Hanninen 1989; Fawer et al. 1983, Piikivi and Tolonen 1989, Piikivi 1989, Ngim et al. 1992). An uncertainty factor of 10 was applied for use of a LOAEL and 100 for intraspecies variability (to account for inter-individual variability and the greater susceptibility of children and their developing nervous systems).
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-14 Molybdenum Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	Infant, toddler and child: 0.023;	Based on a subchronic rat study with exposure via drinking water and reproductive effects (Fungwe et al.

	adolescent: 0.027; adult: 0.028	1990). The RfD was derived from the NOAEL with an uncertainty factor of 10 applied for interspecies variability and 3 for intraspecies variability. The RfD was adjusted for age group and body weight.
U.S. EPA IRIS	**0.005**	Based on a human 6-year dietary exposure study with a critical effect of increased uric acid levels (Koval'skiy et al. 1961). An uncertainty factor of 3 was used for protection of sensitive human populations and a factor of 10 for the use of a LOAEL.
ATSDR	-	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	-	-
RIVM	**0.012**	Based on an inhalation study with rats and mice (NTP 1997). No effects were observed. An uncertainty factor of 10 was applied for interspecies variation, 10 for intraspecies variation and 10 for extrapolation from semichronic to chronic.
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-15 Nickel Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**0.011**	Based on a two-generation reproductive study for exposure to soluble nickel in drinking water by rats with a critical effect of post-implantation perinatal lethality (SL1 2000). An uncertainty factor of

		10 was applied for intraspecies variability and 10 for interspecies variability.
U.S. EPA IRIS	0.02	Based on decreased body and organ weights in a rat chronic oral study (Ambrose et al. 1976). An uncertainty factor of 10 was used for interspecies extrapolation and 10 to protect sensitive populations, an additional uncertainty factor of 3 was used to account for inadequacies in the reproductive studies.
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	**0.000018**	Based on a subchronic inhalation study on rats and mice and respiratory effects from exposure to nickel subsulphide (Benson et al. 1990, Dunnick et al. 1989). An uncertainty factor of 10 was applied for intraspecies variation, 10 for interspecies variation and 10 for less than a chronic study.
U.S. EPA IRIS	**-**	-
ATSDR	0.00009	Based on a rat inhalation study with respiratory effects (NTP 1996). An uncertainty factor of 3 was applied for species extrapolation and 10 for human variability.
Cal. EPA	0.000014	Based on a rat inhalation study with respiratory effects (NTP 1994). An uncertainty factor of 3 was applied for interspecies variability and 30 for intraspecies variability.
ORAL SLOPE FACTORS		
Agency	**SF ($(mg/kg/d)^{-1}$)**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR ($(mg/m^3)^{-1}$)**	**Description**
Health Canada	**0.71**	Based on a human occupational study with exposure via inhalation of soluble nickel and carcinogenic effects including lung and nasal cancer, kidney, prostrate and mouth cavity cancers (Doll et al. 1990).
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-16 Pyrene Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**0.03**	Based on a subchronic mice study with a nephrotoxic critical endpoint, specifically renal tubular pathology and decreased kidney weights (U.S. EPA 1989). The RfD is based on the NOAEL with the application of an uncertainty factor of 10 for intraspecies variability, 10 for interspecies variability, 10 for less than a chronic study and 3 for the lack of toxicity studies in a second species and developmental / reproductive studies.
U.S. EPA IRIS	**0.03**	The U.S. EPA IRIS relied on the same study and applied the same uncertainty factors as Health Canada.
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**-**	-
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-17 Selenium Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	Infant: 0.0055, toddler: 0.0062, child: 0.0063, adolescent: 0.0062, adult: 0.0057	Based on human studies with exposure to selenium in the diet and the development of selenosis (Yang and Zhou 1994, Shearer and Hadjimarkos 1975). An uncertainty factor of 2 was applied for the severity of irreversible

		results. The NOAEL was adjusted for age group and body weight.
U.S. EPA IRIS	**0.005**	Based on the development of clinical selenosis in people living in China following exposure to environmental selenium (Yang et al. 1989). An uncertainty factor of 3 was applied to the NOAEL to account for sensitive individuals.
ATSDR	**0.005**	Based on a human study with exposure to selenium in the diet and the development of selenosis (Yang and Zhou 1994). An uncertainty factor of 3 was applied for human variability.
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**0.02**	Based on the development of clinical selenosis in people living in China following exposure to environmental selenium (Yang et al. 1989). Extrapolated from an oral reference exposure level. An uncertainty factor of 3 was applied for intraspecies variation.
ORAL SLOPE FACTORS		
Agency	**SF ($(mg/kg/d)^{-1}$)**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR ($(mg/m^3)^{-1}$)**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-18 Vanadium Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	**-**	**-**

U.S. EPA IRIS	**0.009**	Based on a rat chronic oral study for exposure to vanadium pentoxide and decreased hair cysteine (Stokinger et al. 1953). An uncertainty factor of 10 was applied for interspecies extrapolation and 10 to provide added protection for unusually sensitive individuals.
ATSDR	**-**	-
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	**0.0001**	Based on two-year rat and mouse studies for inhaled vanadium pentoxide and respiratory effects (NTP 2002). An uncertainty factor of 3 was applied for animal to human extrapolation and 10 for human variability.
Cal. EPA	**-**	-
ORAL SLOPE FACTORS		
Agency	**SF $(mg/kg/d)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR $(mg/m^3)^{-1}$**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.

Table B-19 Zinc Toxicological Profile

ORAL REFERENCE DOSES		
Agency	**RfD (mg/kg/d)**	**Description**
Health Canada	Infant: 0.49; toddler and child: 0.48; adolescent: 0.54; adult: 0.57	Based on subchronic dietary supplement trials with adults (Yadrick et al. 1989), infants and children (Walravens and Hambridge 1976) with critical effects of reduced iron and copper status and increased infant growth (length, weight and head circumference). An uncertainty factor of 1.5 was applied to the adult study to account for intraspecies variability and extrapolation of a LOAEL to a NOAEL. No uncertainty factors were applied to the infant/children study.

U.S. EPA IRIS	**0.3**	Based on decreases in copper and zinc superoxide dismutase activity in healthy adult volunteers (Yadrick et al. 1989, Fischer et al. 1984, Davis et al. 2000, Milne et al. 2001). An uncertainty factor of 3 was applied to account for variability in susceptibility in human populations.
ATSDR	**0.3**	Based on a study of subclinical changes in copper status and iron status in women exposed to zinc through nutritional supplements (Yadrick et al. 1989). An uncertainty factor of 3 was applied to account for intrahuman variability.
INHALATION REFERENCE CONCENTRATIONS		
Agency	**RfC (mg/m^3)**	**Description**
Health Canada	-	-
U.S. EPA IRIS	-	-
ATSDR	-	-
Cal. EPA	**-**	-
ORAL SLOPE FACTORS		
Agency	**SF ($(mg/kg/d)^{-1}$)**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-
INHALATION UNIT RISKS		
Agency	**UR ($(mg/m^3)^{-1}$)**	**Description**
Health Canada	**-**	-
U.S. EPA IRIS	-	-

Note: Values in **bold** were used in the assessment, unless otherwise noted they are the most conservative (i.e. lowest RfD/RfC and highest SF/UR)
- = No data available.