Colomac Mine Remediation Project - “Post-Reclamation Monitoring and Residual Hydrocarbon Remediation Management Plan”:

Under Part G: Item 5 of Water Licence W2009L8-0003

prepared by:

Aboriginal Affairs and Northern Development Canada - Contaminants and Remediation Directorate

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TABLE OF CONTENTS

1.0 Introduction and Background ................................................................. 1
  1.1 Site History ............................................................................................. 1
  1.2 Review of Site Remediation ..................................................................... 1
  1.3 Remediation Status Summary (as per 2004 Colomac RAP) .................... 4
2.0 Monitoring Overview............................................................................... 7
  2.1 Drivers for Site Monitoring ..................................................................... 7
  2.2 Risk Based Monitoring .......................................................................... 7
  2.3 Expected Outcomes ................................................................................ 8
  2.4 Monitoring End Points ........................................................................... 8
  2.5 Residual Liabilities ................................................................................ 8
3.0 Colomac Site Status ............................................................................... 8
4.0 Monitoring Program - Aspects and Components ..................................... 9
  4.1 Terrestrial Monitoring ........................................................................... 9
    4.1.1 Status ............................................................................................... 9
    4.1.2 Future Monitoring .......................................................................... 10
  4.2 Aquatic Monitoring ............................................................................... 10
    4.2.1 Status ............................................................................................. 10
    4.2.2 Future Monitoring .......................................................................... 11
  4.3 Water Quality Monitoring ..................................................................... 11
    4.3.1 Status ............................................................................................. 11
    4.3.2 Future Monitoring .......................................................................... 11
  4.4 Hydrology Monitoring .......................................................................... 11
    4.4.1 Status ............................................................................................. 11
    4.4.2 Future Monitoring .......................................................................... 12
  4.5 Adaptive Hydrocarbon Monitoring Program .......................................... 12
    4.5.1 Status ............................................................................................. 13
    4.5.2 Future Monitoring .......................................................................... 19
  4.6 Geotechnical and Post-Construction Monitoring .................................... 20
    4.6.1 Status ............................................................................................. 20
    4.6.2 Future Monitoring .......................................................................... 22
5.0 Monitoring Schedule ................................................................................ 23
6.0 Reporting Requirements .......................................................................... 26
7.0 Plan Revisions ....................................................................................... 26
8.0 Conclusions ............................................................................................. 26
APPENDICES

Figure 1 - Colomac Site Map 1
Figure 2 – Colomac Site Map 2
Figure 3 – Colomac Site Map 3
Figure 4 - Colomac SNP Map
Figure 5 - Colomac Hydrology Map 1
Figure 6 - Colomac Hydrology Map 2
Figure 7 – Colomac AHMP Map
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEC</td>
<td>Areas of Environmental Concern</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
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<tr>
<td>BTEX</td>
<td>Benzene, Toluene, Ethyl-benzene and Xylenes</td>
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<td>CARD</td>
<td>Contaminants and Remediation Directorate</td>
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<tr>
<td>CCME</td>
<td>Canadian Council of Ministers of the Environment</td>
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<tr>
<td>CFU</td>
<td>Colony Forming Units (for bacterial counts)</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetres</td>
</tr>
<tr>
<td>cm/s</td>
<td>Centimetres per second</td>
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<tr>
<td>CoCs</td>
<td>Contaminants of Concern</td>
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<tr>
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<td>Enhanced Free-product Recovery</td>
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<td>Environmental Quality Guidelines</td>
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<td>HAZWOPER</td>
<td>Hazardous Waste Operations and Emergency Response</td>
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<tr>
<td>HDPE</td>
<td>High Density Poly-Ethylene</td>
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<tr>
<td>GNWT</td>
<td>Government of the Northwest Territories</td>
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<td>GPR</td>
<td>Ground Penetrating Radar</td>
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<tr>
<td>kg</td>
<td>Kilograms</td>
</tr>
<tr>
<td>L</td>
<td>Litres</td>
</tr>
<tr>
<td>LEL</td>
<td>Lower Explosive Limit</td>
</tr>
<tr>
<td>LNAPL</td>
<td>Light Non-Aqueous Phase Liquid</td>
</tr>
<tr>
<td>LTS</td>
<td>Liquid Treatment System</td>
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<tr>
<td>LTU</td>
<td>Land Treatment Unit</td>
</tr>
<tr>
<td>m</td>
<td>Metres</td>
</tr>
<tr>
<td>m²</td>
<td>Squared Metres (area measurement)</td>
</tr>
<tr>
<td>m³</td>
<td>Cubic Metres (volume measurement)</td>
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<tr>
<td>MAAT</td>
<td>Mean Annual Air Temperature</td>
</tr>
<tr>
<td>MAGT</td>
<td>Mean Annual Ground Temperature</td>
</tr>
<tr>
<td>MAP</td>
<td>Mono-Ammonium Phosphate (fertilizer)</td>
</tr>
<tr>
<td>mg/kg</td>
<td>Milligrams per kilogram (equivalent to parts per million)</td>
</tr>
<tr>
<td>mm</td>
<td>Millimetres</td>
</tr>
<tr>
<td>MPE</td>
<td>Multi-Phase Extraction</td>
</tr>
<tr>
<td>MW</td>
<td>Monitoring Well (also known as a recovery well (RW))</td>
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<tr>
<td>NIOSH</td>
<td>National Institute for Occupational Safety and Health</td>
</tr>
<tr>
<td>NT</td>
<td>Northwest Territories</td>
</tr>
<tr>
<td>ORC</td>
<td>Oxygen Release Compound</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration</td>
</tr>
<tr>
<td>PAHs</td>
<td>Polycyclic Aromatic Hydrocarbons</td>
</tr>
<tr>
<td>PCB</td>
<td>Poly-Chlorinated Biphenyl</td>
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<tr>
<td>PEL</td>
<td>Probable Effects Limits</td>
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<tr>
<td>PHC</td>
<td>Petroleum Hydrocarbon</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts per Million</td>
</tr>
<tr>
<td>PWGSC</td>
<td>Public Works and Government Services Canada</td>
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<td>Quality Assurance/Quality Control</td>
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DEFINITIONS

**Aqueous Phase:** Liquid that is homogeneous, has a density consistent with that of water, and that may or may not have dissolved contaminants.

**Clean Soil:** Soil that has been sampled, analyzed, and determined to contain concentrations of contaminants lower than the criteria applicable to the Colomac site.

**Contact Wastewater:** Water that has been in physical contact with known hydrocarbon contaminated soil, hydrocarbon contaminated soil excavations or stockpiled or windrowed hydrocarbon contaminated soil.

**Extracted Liquid:** The liquid product extracted from the MPE that is a mixture of aqueous phase and non-aqueous phase that requires treatment in the LTS.

**Free Product:** Non-aqueous petroleum hydrocarbon phase in association with, but physically unmixed from, surface water, ground water or soil.

**Hydrocarbon Contaminated Soil:** Soil containing petroleum hydrocarbons at concentrations exceeding at criteria for the Colomac site. Hydrocarbon Contaminated Soil does not require blasting or rock breaking to excavate.

**Land Treatment Unit:** The bermed site area where hydrocarbon contaminated soil is stored.

**Liquid Treatment System:** The system that separates the aqueous and non-aqueous phase liquids into separate streams, and that treats aqueous liquid to remove dissolved contaminants to allow for discharge to the environment.

**Light Non-Aqueous Phase Liquid:** A homogeneous liquid that has a lower density than water, and therefore is typically present as a separate layer sitting on top of water. LNAPLs may also be present as a separate phase liquid present as distinct globules within an aqueous phase. Most fuels and solvents are LNAPLs.

**Mono-Ammonium Phosphate:** A fertilizer used for the bio-treatment of impacted soil.

**Multi Phase Extraction System:** Also called “Bioslurping.” MPE is defined as a system that utilizes a vacuum to extract multiple phases of liquids in the subsurface: gas phase, aqueous phase, and non-aqueous phase liquids.

**Petroleum Hydrocarbons:** Hydrocarbon products described by laboratory analyses as BTEX, lubricating oil and grease, fuel oil, diesel and/or gasoline.

**Treated Soil:** Soil, previously classified as hydrocarbon contaminated soil, which has been treated, sampled, analyzed, and determined to contain concentrations of Petroleum Hydrocarbons lower than the applicable criteria identified above for surficial soils.

**Volatile Organic Compounds:** Health Canada classes Volatile Organic Compounds as organic compounds that have boiling points roughly in the range of 50 to 250°C.

**Waste Oil Lay-down Area:** An area southeast of the Mill building, between the camp and Zone 2 pit, previously used for the storage of waste oil drums.
1.0 INTRODUCTION AND BACKGROUND

The document entitled “Colomac Mine Remediation Project Post-Reclamation Monitoring Plan” is intended to satisfy the requirements of Part G; Item 5 of Water Licence W2009L8-0003 issued by the Wek’eezhii Land and Water Board to Aboriginal Affairs and Northern Development Canada - Contaminants and Remediation Directorate (AANDC-CARD) on February 25, 2010.

The document also reflects the spirit and intent of the 2004 Colomac Remediation Plan (RAP), which was developed through extensive consultation with key stakeholders including the Tlicho Executive, Elders and Authorities Having Jurisdiction and has guided remediation of the site since its approval. The RAP establishes the framework for long term monitoring under the post-reclamation phase of the project.

1.1 Site History

The Colomac Mine is a former gold mine located approximately 220 km north of Yellowknife, NT. The mine site consisted of a main mine facilities area on the eastern shore of Steeves Lake, three open pits, north and south waste rock dumps, tailings containment area (TCA), airstrip, and various access roads, including the Kim-Cass Road connecting Colomac to satellite deposits. The mine was commissioned in 1990 with sporadic production until late 1997, when the mine’s last owner, Royal Oak Mines Inc., placed the mine into care and maintenance. In April 1999, Royal Oak went into receivership and the site reverted to AANDC. Colomac’s relatively short mine life left a significant scar on the local landscape.

At abandonment, the site presented significant legacy issues including: cyanide contaminated tailings water and solids, hydrocarbon impacted soil, bedrock and lake sediments, extensive inventories of waste POL and hazardous chemicals, abandoned mine infrastructure, open pits, waste rock dumps and quarries. The most pressing issue was the management of contaminated tailings water which, by the end of 1998, was threatening to overtop the main water retention structure, Dam 1. Due to poor construction and absence of as-built drawings the effective elevation of the dam was confirmed at mine closure to be (1) metre less than the freeboard limit specified in the Water Licence. This coupled with the rapid rise in Tailings Lake water levels in 1998, made water management critical and emergency measures were invoked under the NWT Waters Act. The measures allowed for the transfer of millions of cubic metres of contaminated tailings from Tailings Lake to the Zone 2.0 Pit for storage and treatment. Added to this was the fact that Dam 1 had been constructed on a major fault and seepage rates began to increase dramatically towards mine closure, to approximately 250 US GPM. The seepage contained elevated concentrations of cyanide and ammonia which required continuous pump back to Tailings Lake to prevent adverse impacts to downstream environments.

1.2 Review of Site Remediation

In support of RAP development in 2004, and subsequent to it approval in 2005, additional investigation, assessment and pilot scale testing work was completed in support of developing detailed remedial designs for each of the components and progressive remediation was taken to address the most significant risks. Through the Enhanced Natural Removal process (simple addition of phosphorus via fertilizer) water treatment in Tailings Lake and Zone 2.0 Pit was completed by 2006 and 2007 respectively. With water management and treatment under control, the remedial focus shifted to hydrocarbon remediation in 2005, with the
demolition of the bulk tank farm, excavation and treatment of contaminated soils, construction of a bio-remediation facility and recovery of free product from bedrock.

Efforts then shifted to remediation of the TCA which was accomplished under a major civil works contract (2006-2007) and included the placement of a 0.8m thick rock cap on all exposed tailings, construction of a new dam (Dam 1B), spillway in Dyke 7 and discharge channel at Dam 2. With the TCA effectively remediated, the Diversion Ditch program (perimeter ditches and deep sumps around Tailings Lake perimeter) was discontinued and the 8km long caribou fence was decommissioned in 2008. In 2009, the area between Dam 1 and Dam 2 was in-filled with clean water and frozen in, effectively cutting off residual seepage flow into the Dam 1 valley. The seepage pumpback system was then decommissioned along with the diversion ditches and sumps.

In 2010, final remediation of the Colomac site commenced and included: decontamination and demolition of buildings, Steeves Lake shoreline restoration, Truck Lake Channel construction, PHC contaminated soil excavation and treatment, hazardous and non-hazardous waste disposal, drainage restoration, general re-grading and installation of site access controls. The original schedule for work completion was estimated to require two full years of construction; however, an accelerated schedule allowed for the remediation to be substantially complete by March 2011 with final remediation was completed in October 2011.

All remaining buildings, with the exception of the “Big Blue” warehouse (which was left standing for future use by the Tlicho Government at their request), were decontaminated and demolished in 2010, including:

- Primary Crusher and Conveyor Access Portal
- Take up Tower and #1 Conveyor
- Underground Conveyor Gallery
- Secondary Crusher (including three conveyors)
- Mill Building (including powerhouse, day tank and exhaust stacks)
- Twelve Leach Tanks and Five Carbon-In-Solution (CIS) Tanks
- Thickener Tank, Process Water Tank and Pumphouse
- Maintenance Building
- Three G-Tanks and Pumphouse
- Tailings Lake Caribou Fence Posts
- Steeves Lake Dock and Equipment Shed
- Radio Tower, Wooden Shacks, Transformer Stand and Electrical Junction Box
- Airstrip Facilities and bridge at Kim-Cass Road and
- Camp Facilities (including sewage vault)

Decontamination of the mill structures followed a comprehensive plan developed in consultation with a certified industrial hygienist. Decontamination included the removal of mill process wastes to the Spruce Lake Disposal Cell (SLDCC) which had been had been left open when the surrounding tailings were covered in 2006. Contaminated waste from decontamination activities was disposed of in the cell in 2010 and once all wastes had been placed, the cell was capped and contoured into existing TCA cap.

Building demolition followed a stepwise plan and involved removal of the building’s internal sub-structure, weakening of the building support structures, building collapse, structure dismantling, and disposal of all non-hazardous debris in the engineered landfill constructed in
Zone 2.5 Pit. The non hazardous landfill was constructed by placing wastes in alternating layers of fill, and a buttress at the southern face of the landfill was constructed to stabilize the wastes and provide granular cover on the south edge of the landfill. The final granular cover of the landfill was compacted and graded to limit erosion and allow for positive drainage.

Hazardous waste, which included mercury containing light bulbs and thermostats, batteries, refrigerants/coolants, and waste oil products, was containerized and stored at the hazardous materials storage area (HMSA) established at the Land Treatment Unit (LTU) – a lined berm facility that had previously been established at the site. There were a number of barrels of variable origin on-site. Empty drums were cleaned and disposed of in the non-hazardous waste facility. Drums with contents (primarily waste oil, lubricants, glycol and oily water) were collected and their contents sampled for characterization. No drum contents were incinerated on-site; the contents were consolidated where appropriate and transported off-site for disposal in an approved facility in 2011.

General site grading was completed in several areas to provide positive drainage and eliminate physical hazards. All remaining concrete slabs in the mine facilities area were covered with a layer of fill and graded. The pilot trench (excavated in 2008), directly north of the former tank farm, was backfilled and contoured to surrounding topography. Berms were constructed at potential access points to the open pits and waste rock dumps to prevent caribou passage through these areas, and rock barriers were installed around the Tailings Lake at potential access points to prevent snowmobile access at site closure. Other areas of disturbance such as the LTU, camp pond, G-Tanks pad and explosives storage pad were also decommissioned and re-contoured.

Surface debris was collected from the entire site, including concentrated areas in and surrounding the mine facilities and scattered debris within 25 m of roadways, 10 m of shorelines, and/or 2 m of open water. Scattered debris outside of these areas was identified by aerial reconnaissance provided by the Crown and accessed by ATVs. Debris was disposed of in Zone 2.5 Pit. Buried debris (from previous mining operations) was identified at four locations within the Boneyard. The debris was considered a low potential environmental risk and geotechnically stable, so the debris was covered in place with a granular cap, with the exception of one small area at the crest of a steep slope that required excavation due to its unstable slope.

Historical petroleum hydrocarbon (PHC) spills throughout the mine facilities area in the vicinity of the former bulk fuel storage facility, maintenance building, waste oil laydown area, former land treatment unit and mill powerhouse, had impacted local soils as well as nearshore sediments in Steeves Lake. A sediment cap was designed and constructed overlying the impacted sediments downgradient of the mill, maintenance building, former tank farm, and camp. The cap area is approximately 750 metres (m) long and between 20 and 35 m wide and includes a perimeter containment berm with a vegetated surface trench forming the new shoreline, an attenuation cap of low-permeability silty sand material overlain by a layer of peat, and a peat trench along the former shoreline with regularly spaced monitoring and recovery wells. Re-vegetation of the sediment cap was initiated in the fall of 2010 and continued in 2011. Sediment control and fish salvage measures were implemented during construction in accordance with the conditions of the Fisheries Authorization.

Site-specific remedial objectives were developed for the PHC impacted soil, and were applied for the identification of contaminated soil delineation and for the remedial objectives that soil treatment must achieve. Contaminated soil was transported to the landfarm, established at the former Waste Oil Laydown Area (WOLA), for treatment. Areas of surficial PHC staining at the
WOLA, around the camp and mill complex areas, and the shoreline were scarified and re-graded as required. PHC contaminated soil excavations were carried out at locations of chronic seepage towards Steeves Lake, immediately north and south of the former fuel tank facility. Product and impacted water were observed discharging from bedrock fractures in the excavations and as a result, seepage collection systems were installed immediately below these zones to intercept and collect the discharging impacts prior to their migration onto the new sediment cap. Soil treatment was conducted within the soil treatment facility, with soils being spread out in lifts of approximately 0.4 m depth, and aerated by flipping the soil with heavy equipment. Water and nutrients were added to improve the rate of bioremediation. Most of the soil was successfully remediated by the winter of 2010; the remaining plots were aerated further in 2011 until composite sample testing confirmed that remedial objectives had been achieved. The landfarm area was reshaped, leaving all the treated soil in place.

Throughout the mine complex area, free hydrocarbon product residuals were present within the subsurface fractured bedrock and groundwater. In addition to pre-existing monitoring and collection wells at the site, additional wells were installed in two drilling phases during the final remedial contract: Phase 1 in the spring of 2010 to determine the northern extent of free product in the camp area; and Phase 2 in the winter of 2011 to install additional wells in the historic seepage areas and improve product recovery. Overburden wells were installed within the Steeves Lake sediment cap shoreline peat trench to monitor product migration into the attenuation area. Numerous monitoring wells were decommissioned during 2010 site activities; some were re-cased or replaced and others were not based on individual evaluation of the well. A multi-phase extraction system was commissioned in 2012 to remove free product and minimize product migration towards Steeves Lake. An estimated 2,500 L has been removed to date.

Spilled mill tailings were present in several locations at the mine facilities area: in the leach tank pad, under the conveyors between the secondary crusher and mill, and surrounding the thickener tank. The tailings were scraped up and/or excavated and disposed of in SLDC.

Drainage rehabilitation work was undertaken at seven areas of the mine site: Truck Lake to Steeves Lake, Spot Pond to Truck Lake, the sewage lagoon to Duck Lake, Duck Pond to Cone Pond, Tailings Lake to the Indin River watershed (Tailings Lake Discharge Channel), and the Cranston and Apex crossings on the Kim-Cass road. Much of this work was completed as habitat compensation for the Steeves Lake shoreline work under the FA. Erosion and sediment control, fish salvage and re-vegetation were completed in conjunction with these works.

1.3 Remediation Status Summary (as per 2004 Colomac RAP)

With the completion of the final remediation contract, all remediation components identified in the 2004 Remedial Plan have been effectively addressed. Post-remediation site conditions are summarized below, consistent with the components identified in the 2004 Remedial Action Plan.

Tailings Lake Water

The water in Tailings Lake meets the discharge criteria established in the Water Licence. The lake remains a physical hazard due to variable ice conditions in winter; ice hazard signs and waste rock barriers have been placed at potential snowmobile access points to the lake to warn hunters and trappers in the area at post closure.
Exposed Tailings

Tailings remain at Spruce Lake and part of Tailings Lake, but all have been capped with a 0.8 m waste rock cap, removing the environmental exposure risk. The Spruce Lake cap is monitored for erosion and settlement.

Zone 2.0 Pit

Zone 2.0 Pit contains tailings water previously transferred from Tailings Lake and during final remediation, the Leach and Thickener Tanks. The water in Zone 2.0 Pit meets the discharge criteria established in the Water Licence.

Tailings Lake Discharge

Dam 1 has been stabilized with the construction of Dam 1B. Thermo-siphons and monitoring instrumentation remain at Dam 1B and Tailings Lake is discharging to the receiving environment at its north end through the Discharge Channel located at the former Dam 2.

Open Pits

Access has been cut off to all open pits with the placement of barriers and open pit warning signs have been placed around the perimeter.

Waste Rock Dumps

Access to waste rock piles has been fully cut-off to caribou with the placement of waste rock berms (caribou berms) at anticipated access points. Waste rock slopes sit at their angle of repose.

Quarries and Soil Borrow Areas

Large boulders have been placed at the upper edge of all steep quarry faces to form a physical and visual barrier. Brush piles have been broken up and spread out over quarry floors to promote re-vegetation. Slopes of quarries and soil borrow areas have been re-contoured to provide stable configurations and positive drainage.

Hazardous Waste

All hazardous waste has been removed from site and disposal certificates have been obtained from the Contractor’s hazardous waste disposal facility.

Roads and Yards

All culverts have been removed from the site. Surface drainage has been restored along the TCA haul road and the Kim-Cass Road. The bridge was removed at the Steeves Lake to Grizzly Lake stream and boulders were placed on either side across the former road. A new channel was built connecting Truck to Steeves Lake. An extension was built to Spot Pond. The north and west shoreline of Truck Lake were reshaped and re-vegetated. The overall mine facilities area was re-contoured to promote positive drainage.
Airstrip

Airstrip facilities were removed and the airstrip has been listed as “abandoned” with Transport Canada. Large white “X’s” were placed across each end of the airstrip to alert pilots of potentially unsafe strip conditions.

Sewage Lagoon

The sewage lagoon contents were left in place to naturally attenuate. The retaining dyke has been contoured to natural topography and lowered to allow surface water drainage and gradual decanting from the lagoon as water levels rise.

Buildings and Equipment

All buildings have been demolished with the exception of the Big Blue warehouse which will be used by the Tlicho Government for storage. The Manitowac crane also remains on site for use by a third party. The following describes remaining sub-grade features:

- Primary Crusher: all sub-grade features remain but have been sealed off with steel (engineered design) and back filled with granular and rock fill. The conveyor access portal at the base has been closed and covered with fill.
- Conveyor 1 Ore Feed Bin: concrete bin remains in place and has been covered with fill.
- Secondary Crusher: concrete foundation slab remains and has been covered with fill.
- Mill and Powerhouse: concrete slab remains in place and has been covered with fill.
- Thickener Tank: concrete base remains in place and has been covered with fill.
- Leach Tank pad: concrete pad remains in place, with the exception of one small area. The pad has been covered with fill.
- Camp Sewage Vault: top of the vault was broken and liquid contents were removed to the Sewage Lagoon; residual sludge contents were capped and the vault backfilled.

Hydrocarbon Contamination

PHC impacted soils were excavated and treated, with the exception of a small volume of material remaining under the powerhouse slab which was backfilled and graded. The impacts are not deemed a risk to surface receptors and a present a low risk for migration. Monitoring wells have been placed in the overburden downgradient of the area to monitor for any migration. Treated PHC soils were re-contoured in place at the WOLA. Small areas of heavier fraction PHC impacted soils within the WOLA were capped with 0.5 m of clean fill and small stains were scarified. Impacted lake sediments at Steeves Lake have been capped with low permeability fill along the shoreline downgradient of the mine facilities.

Residual free-phase hydrocarbon product and contaminated groundwater remain in the fractured bedrock in the mine facilities area. The volume of product remaining is unknown; however, the Colomac Hydrocarbon Expert Panel has estimated residual volumes to be less than 5,000 L.
monitoring field has over a hundred monitoring/collection wells to monitor for product levels and natural attenuation post-remediation. A passive seepage collection system was installed at the two primary seepage zones where the product was migrating towards Steeves Lake. An interceptor trench with regularly spaced monitoring wells was also installed along the former shoreline extending throughout the mine facilities area to attenuate any impacts migrating from on land, and as noted above, the shoreline is now off-set from its original location by 10-20 m of low-permeability fill. Based on these factors, the residual free-phase hydrocarbons are considered a low-risk to the environment. The Adaptive Hydrocarbon Management Program forms part of the overall monitoring program.

**Spilled Tailings**

All spilled surficial tailings have been excavated and consolidated within the SLDC at the TCA.

**Non-Hazardous Waste**

Non-hazardous waste from remedial activities has been buried in an engineered landfill facility at Zone 2.5 Pit. Existing buried waste at the Boneyard has been capped and stabilized. All wastes have been effectively isolated from the environment.

**2.0 MONITORING OVERVIEW**

The long term monitoring program at Colomac is intended to ensure that the remedial efforts implemented over the project’s twelve year history remain effective and that site conditions do not deteriorate over time. While much of the monitoring will require expert scientific and engineering leads, there will be a gradual shift towards community-based monitoring as the program evolves. Tlicho community members will be actively involved in all aspects of long term monitoring and this approach was launched in 2011 with Tlicho job shadows participating in the Adaptive Hydrocarbon Management Program. This continued in 2012 and was expanded to include involvement with geotechnical and re-vegetation monitoring. A secondary objective of the long term monitoring at Colomac will be to support ongoing research in the fields of hydrology and hydro-geology (open pit lakes), bio-engineering (re-vegetation) and contaminant fate and transport (residual hydrocarbons).

**2.1 Drivers for Site Monitoring**

As previously noted in this document, monitoring recommendations were established in the 2004 Colomac RAP and developed through consultation with the Tlicho and AANDC’s Project Closure Guidelines also provides guidance on long term monitoring programs. Regulatory drivers include ensuring continued compliance with the Mackenzie Valley Resource Management Act, NWT Waters Act, Territorial Lands Act, Fisheries Act and the Canadian Environmental Protection Act.

**2.2 Risk Based Monitoring**

After the three (3) year intensive phase, monitoring data will be assessed to determine residual risks and the long term monitoring plan will be refined. Monitoring stations and frequency will be adjusted accordingly as the data indicates.
2.3 Expected Outcomes

With remediation activities completed as of 2011, it’s anticipated that the site will gradually achieve steady state conditions within 3-5 years. The monitoring program will be generally based on an intensive, three (3) year monitoring phase between 2012 and 2015 and will determine the effectiveness of the remediation and site progression towards steady state.

2.4 Monitoring End Points

Specific monitoring end points are being developed for each monitoring component but generally speaking, monitoring will continue until the effectiveness of remediation efforts can be confirmed and site conditions have reached steady state.

2.5 Residual Liabilities

Through the ENR process, Tailings Lake water met the discharge quality established in the Water Licence by 2006. Residual contaminant loading from the lake bed is ameliorated by seasonal stratification of the lake during summer months. Biological activity in the uppermost strata is driven by remnant ENR nutrient mass resulting in the breakdown of residual contaminants brought to the active layer each fall, when cooler surface waters cool and sink and cause mixing or lake over turn. This annual cycling of the upper and lower strata ensures continued bio-remediation of residual contaminant releases from the lake bed. Long term monitoring will ensure that water quality in the lake continues to improve through this cycling process.

As with Tailings Lake, Zone 2.0 Pit water met discharge limits in 2007. Deep water monitoring has confirmed that Zone 2.0 Pit (unlike Tailings Lake) is weakly meromictic; that is, the pit does not undergo complete circulation and is not completely mixed. The deep aeration programs in 2006 and 2007 effectively reduced the mass of key contaminants of concern (ammonia and thiocyanate) to the extent that in 2010, a small volume (relative to overall pit volume) of remnant leach tank water was transferred into the pit without adverse impacts to pit water quality. There is potential for a gradual strengthening of the chemocline (pit may become more strongly meromictic) over time with subsequent isolation of the deep pit water and reduced mixing. Zooplankton hatch outs in 2011 and 2012 within the pit are being assessed by subject matter experts to determine any links between the hatch out and potential changes in pit limnology or water quality. Long term monitoring will ensure that water quality in the pit remains stable.

As previously noted, residual free-phase hydrocarbon product and contaminated groundwater remain in the fractured bedrock in the mine facilities area. The volume of product remaining has been difficult to quantify; however, the Colomac Hydrocarbon Expert Panel has estimated residual volumes to be less than 5,000 L. Product recovery will continue through 2012 and 2013 and a risk assessment for the residual free product is scheduled for this fiscal year, based on recovery from the 2012 program and predicted recovery during 2013.

3.0 COLOMAC SITE STATUS

The Colomac site fell under the care and control of AANDC in 1999 and over that time, the site has been managed under a number of project management phases. From 1999-2002 the site was under active care and maintenance; from 2003-2004 the site underwent progressive clean up and pilot scale testing while remediation planning was undertaken; full scale remediation commenced in 2004-05. With the removal of mine infrastructure from the main mine complex and ancillary
areas, civil earthworks in the TCA (tailings cap, Dam 1B, spillway and discharge channel) and main mine complex area (Steeves Lake shoreline and Truck Lake Channel) as well as overall site excavation, backfilling and re-grading, previously existing surface hydraulic and sub-surface thermal regimes have changed. With these activities/disturbances complete in 2011 it is anticipated that the site as whole will gradually achieve steady state conditions within 3-5 years. Maps of the current Colomac site are provided in Figures 1-3.

4.0 MONITORING PROGRAM - ASPECTS AND COMPONENTS

The Colomac site is expansive with numerous remediated areas that will require vigilant monitoring to ensure the effectiveness of the remediation. The Tlicho have consistently expressed concern over water quality at the Colomac site and downstream receiving environments and AANDC recognizes the need to protect fish, wildlife and plant life in and around the Colomac area. The partnership between AANDC and the Tlicho, struck during the early days of site assessment and remediation planning, will continue through the post closure and monitoring phase through the involvement of the Tlicho in community-based monitoring programs.

Like the remediation approaches, the monitoring program will be based on risk. The areas that present the highest risk potential (engineered structures, Zone 2.0Pit, Landfill, main site complex and Steeves Lake shoreline) or hold greatest ecological/habitat value (downstream TCA receiving environment, local site lakes) will require the greatest monitoring effort while other areas such as stream crossings, waste rock slopes, general site grading and drainage will require less effort. Monitoring locations and frequency will be based on these risks with the ultimate intent of achieving steady state conditions at the Colomac site.

All aspects of the long term monitoring program will be carried out in such a manner so as to ensure worker safety and protection of the environment. Monitoring contractors are required to prepare a Site Specific Health and Safety Plan (SSHASP) for the specific tasks and activities that will be completed on site. The SSHASP must meet AANDC EHS management system requirements and satisfy all Authorities Having Authority.

The Colomac monitoring program will focus on the following aspects of the Colomac site: terrestrial, aquatic, water quality, hydrology, hydrocarbons and geotechnical.

4.1 Terrestrial Monitoring

4.1.1 Status

As part of the 2004 RAP, terrestrial monitoring recommendations were set out in the supporting document entitled “Conceptual Plan for Monitoring the Terrestrial Environment at the Colomac Mine Site, NWT” and included the following three monitoring components:

- Chemical monitoring, including: soil contamination – especially in the tailings area, dust contamination in the tailings area, mammal and bird surveys, plant and berry surveys, plants in wetland surveys
- Biological monitoring, including: vegetation growth and monitoring, large mammal health, small mammal and bird health
- Physical monitoring, including: soil quality, dust quantity, physical hazards
Re-vegetation of disturbed areas at the Colomac site was required as part of the final site remediation contract and the Fisheries Authorization. The objective of the re-vegetation effort was to allow for the natural restoration of five (5) areas of the Colomac Mine Site altered or impacted by final remediation and as compensation under the Fisheries Authorization. These areas included: Steeves Lake Shoreline; Truck Lake Wetland; Truck Lake Channel; Dam 2 Drainage Channel; Spot-Truck Lake Channel.

The re-vegetation approach (based in part on the emerging field of bio-engineering) was designed to mimic and encourage natural processes to restore indigenous vegetation at the site. The use of bio-engineering approaches, aligned with the natural succession processes, will improve soil nutrient, lessen the potential for soil erosion and establish vegetation that is indigenous to the area creating an environment that will encourage other native species to grow. The intended result is an increase in plant biodiversity and subsequent enhanced habitats.

4.1.2 Future Monitoring

A review of the aquatic and terrestrial monitoring work done to date at Colomac is currently being undertaken by the originator of the reports, Collin MacDonald (Northern Environmental Consulting). The objective of the review is to assess the monitoring completed at Colomac since the 2004 RAP and identify long term monitoring requirements; for terrestrial flora and fauna the focus will be on key indicator species such as caribou and lichens. A final report will available at the end of November 2012 and will be submitted to the Board as an addendum to this document.

For the re-vegetation work, following the three (3) year intensive, on the ground, monitoring approach, more passive monitoring strategies will be developed. This may include the use of aerial reconnaissance coupled with GIS applications to map out areas of re-growth and macro-changes in site landscape.

4.2 Aquatic Monitoring

4.2.1 Status

As part of the 2004 Colomac RAP, the supporting document entitled, “Conceptual Plan for Monitoring the Aquatic Environment at the Colomac Mine Site, NWT” included the following monitoring components:

- Water quality testing including: testing for the concentrations of contaminants of concern and general water quality parameter
- Contaminants in fish including: testing a small number of fish for the concentrations of contaminants of concern
- Contaminants in zooplankton including: testing zooplankton for the concentrations of contaminants of concerns
- Sediments – testing lake sediments for the concentrations of cyanide, metals and other contaminants of interest
- Biological sampling, including: fish abundance, health and reproductive status
- Zooplankton abundance and health
- Benthos sampling
- Physical environment, including: limnology of major lakes, littoral zone assessment for habitat quality and quantity
4.2.2 Future Monitoring

As noted above, a review of the aquatic and terrestrial monitoring work done to date is currently being undertaken by Collin MacDonald (Northern Environmental Consulting). The objective of the review is to assess the monitoring completed at Colomac since the 2004 RAP and identify long term monitoring requirements; for aquatic and terrestrial flora and fauna the focus will be on key indicator species such as lake trout and benthos. A final report will available at the end of November 2012 and will be submitted to the Board as an addendum to this document.

4.3 Water Quality Monitoring

4.3.1 Status

Water quality monitoring at Colomac has been conducted in local and downstream receiving environments under the Surveillance Network Program (SNP), which has existed under various Water Licences held by the previous mine operators during mine operations and AANDC during care and maintenance site remediation phases. Current SNP monitoring has been complemented with ENR monitoring as well as deep water monitoring (“physical stability”) in the Zone 2.0 Pit and ground and surface water quality monitoring under the Adaptive Hydrocarbon Monitoring Program. Current SNP monitoring and analysis is conducted monthly during the open water season at each of the sites and once during the under ice, with annual summary reports submitted to the Board. The twenty four (24) SNP stations are illustrated in Figure 4.

4.3.2 Future Monitoring

As remediation has progressed, some SNP stations have become obsolete are no longer active. Monitoring stations and frequency will continue to be pared down supported by empirical data and the next request for de-activation will include SNP 1563-1 (water intake) and 1563-11 (sewage lagoon).

4.4 Hydrology Monitoring

4.4.1 Status

The objective of the Colomac Hydrologic Monitoring Program is to collect and report on lake-level data obtained from water-level monitoring stations located at Steeves Lake, Baton Lake, Zone-2 Pit, Tailings Lake, and L-Shape Lake, together with additional level data obtained from new monitoring stations(installed in 2010) at Duck Lake, Spot Lake, and Truck Lake. Two additional monitoring stations were installed at Zone-2.5 Pit and Zone-3 Pit in 2011. Figure 5 shows the Colomac area watersheds; Figure 6 indicates current station locations for the ten (10) active water-level stations. Current hydrology surveys are conducted twice annually; once during peak flow in June and once during low flow in September.

Zone 2.0 Pit has gradually been filling with local surface runoff and groundwater inflow, with water levels equalizing with Baton Lake in November 2010. As of September 2011, Pit levels were 0.36 m above Baton Lake.
4.4.2 Future Monitoring

The ultimate water level of Zone 2 Pit is not yet clear and is currently being assessed by a subject matter expert. Over the past 2-3 years, pit water levels in Zone 2.5 and 3.0 pits have also been rising and additional survey stations are being installed in October 2012 to better track rates of rise in these pits and determine overall hydrological conditions in the immediate area.

Natural surface water flow from Baton Lake-Spot-Truck-Steeves lakes is being monitored to ensure the French drain between Baton and Spot lakes continues to function as designed. Spot and Truck channels will be monitored for flow and erosion and to ensure that the channels function as per the remedial objectives set out in the 2004 RAP. Water crossings at Duck Lake, Steeves Lake south and the Kim-Cass road will also be monitored for flow and erosion.

4.5 Adaptive Hydrocarbon Monitoring Program

Hydrocarbon remediation at Colomac has been in place since 2000 through free product recovery, tank farm decommissioning, and contaminated soil excavation and treatment. Despite the significant effort, it has not been possible to recover and treat all of the free product or impacted soils. A residual volume of free product remains in the bedrock and seasonal groundwater and limited areas of impacted soil (mill and powerhouse areas) was caped in place. The residuals have the potential of impacting the surrounding environment and in order to better quantify that risk, sub-surface, the sub-surface conditions have been analysed over the last several years.

The Colomac subsurface environment is dynamic and complex due to the interaction of ice/liquid groundwater and free-phase/aqueous phase hydrocarbon within the bedrock fracture network. This fracture network is complex, with three intersecting fracture sets but also with areas where the rock is competent up to the overburden/bedrock contact. In general, the majority of the bedrock fractures are in the upper 5 m, below which the rock is more competent. This fracture zone is responsible for the majority of the contaminant flux (free and aqueous phase) due to the expected low primary porosity in the underlying bedrock matrix.

Product movement is highly variable due to the seasonal effects of freezing and thawing fronts, generated by the air temperature at surface. For the purpose of modeling the site, the subsurface environment can be divided into three main segments: the active zone of groundwater flow, the impermeable zone and the areas of talik. The active zone extends from the ground surface to the impermeable bedrock at depth. The active zone is either thawed or frozen, depending on the time year. The impermeable zone is below the active zone. The talik is associated with heat sources on site (such as Steeves Lake) and remains thawed year-round.

Starting in spring each year (approximately May) air temperatures are consistently above 0°C and a thawing front begins to travel downward through the subsurface. The hydrocarbon contaminants are largely contained within the shallow fractured bedrock and do not migrate below the impermeable surface. By October each year, the air temperatures drop consistently below 0°C and a freezing front begins to travel downward through the subsurface. This creates a situation where the liquid groundwater is flowing at depth between two 0°C isotherms, one at the Autumn freezing front and one at the Spring thawing front, which is still descending. This thawing front does not reach its maximum depth until December/January. Between December and February, the thawing front has reached its maximum depth.
4.5.1 Status

The Adaptive Hydrocarbon Management Program (AHMP) commenced in 2011 to continue free product recovery and monitoring and includes collection, analysis and determination of groundwater, surface water, ground temperature and meteorological data. The objective of the AHMP is to determine fate and transport of residual hydrocarbons potential impacts on the surrounding environment. The AHMP consists of the following tasks:

- Task I/II - Operation and Maintenance of the Multi-Phase Extraction (MPE) Unit and the Enhanced Free-Product Recovery (EFR) Unit
- Task III - Collection, Storage and Disposal of Free-Product/Impacted Water/Spent Peat/Spent Carbon
- Task IV – Set-up and Operation of Field Equipment and Instrumentation
- Task V - Recovery of Data from the Colomac Monitoring Well Network
- Task VI - Monitoring of Steeves Lake Shoreline
- Task VII – Special Response for Steeves Lake Shoreline
- Task VIII - Monitoring of Surface Water Quality
- Task IX – Collection of Thermistor Data
- Task X - Collection of Meteorological Data
- Task XI – Establishment of On-site Health and Safety
- Task XII – Maintenance of On-site Equipment
- Task XIII – Installation, Operation and Maintenance of Camp and Logistics
- Task XIV – Organization of the Colomac Hydrocarbon Advisory Group (CHAG)
- Task XV – Co-ordination of Teleconferences
- Task XVI – Execution of the Implementation Plan
- Task XVII – Co-ordination of the Crown Data Review
- Task XVIII – Completion of Annual Reporting
- Task XIX – Creation of a Colomac Database
- Task XX – Reporting on the Data Compilation and Review

The AHMP will form the basis of long-term hydrocarbon monitoring at Colomac. The program will provide a scientifically defensible model of the sub-surface conditions and fate and transport at Colomac and once established, many of the above noted tasks will continue to be required to confirm long-term plume stability and to verify model assumptions.

Tasks I/II - Operation and Maintenance of the MPE Unit and the EFR Unit

The objective of the operation and maintenance of product recovery equipment is to maximize free product (LNAPL) removal in order to minimize product migration towards Steeves Lake. This task has involved both the Multi-Phase Extraction system (MPE) and Enhanced Free-Product Recovery unit (EFR).

The MPE system is a fully contained product extraction system capable of extracting free phase hydrocarbon from the sub-surface at multiple well sites using a vacuum extraction process. The extraction system was built complete with an oil/water separator and activated carbon for extracted water treatment. The EFR unit is a mobile vacuum extraction unit generally used on a single well. It is capable of vacuum extraction of the free phase hydrocarbon, but does not have water treatment capabilities. The MPE system was situated between the former tank farm area...
and the former trench (near Seepage Area A) at the completion of final remediation in 2010 and from this location, was able to access many suitable wells within the former trench, former tank farm and Seepage Area A using a network of piping. Use of the MPE was discontinued for the 2012 AHMP season and the system is being decommissioned in favour of the more cost effective EFR unit. All future product recovery for the AHMP will be completed with the EFR unit.

Task III - Collection, Storage and Disposal of Free-Product/Impacted Water/Spent Peat/Spent Carbon

The objective of this task was to collect, store and dispose of:

- Free-product recovered from the wells, sumps and seepages
- Impacted water resulting from the operation of the MPE/EFR
- Spent carbon from the operation of the MPE
- Spent peat from the peat trench.

Free-product recovered from the wells, sumps and seepages using the EFR Unit was manually decanted from the Air Liquid Separator units on the EFR and MPE systems into drums and stored until it was shipped offsite for disposal. Containerization of the free product will continue as long as product is collected from the indicated sources. A small amount of water resulting from the operation of the MPE/EFR units was drained off manually into drums which were stored separately from the free product. Containerization of the impacted water from all sources will continue during subsequent AHMP visits. The water treatment portion of the MPE system was never used on Site, since there was not enough water generated during operation of the MPE to require its use. The carbon in the MPE system resulted from final remediation and is considered spent and will require disposal. Removal and offsite disposal of the spent carbon will occur during the 2013 AHMP season.

There has been no collection and disposal of spent peat from the peat trench. The Peat Absorption Study in early 2012 concluded that the peat in the peat trench would act as a good sorbent of the petroleum in both free phase and dissolved phase, but the capacity of the peat could not be determined without additional testing. As there is no additional peat on the site, it was determined that shoreline monitoring would be the most efficient way to determine when additional action for the peat trench would be necessary.

Task IV - Set-up and Operation of Field Equipment and Instrumentation

The objective of the field equipment and instrumentation is to allow for continuous monitoring of water and product levels, temperature and meteorological data. Continuous monitoring of water and product levels in selected monitoring wells aids in the establishment of baseline conditions (post-closure) and captures climatic events such as heavy rainfalls. This is achieved using a system of leveloggers, a barologger and meteorological station, which automatically collect water level, barometric pressure and meteorological data, respectively. These instruments were installed in select wells and rain gauges were installed in three locations to record precipitation data. A staff gauge was installed along the Steeves Lake shoreline to provide a visual indicator of water level. To tie in all the location/elevation of these instruments, a site survey was completed in 2011 for the leveloggers, thermistors, meteorological station and staff gauge.

Meteorological factors such as ambient temperature, precipitation, relative humidity, wind speed and wind direction have varying degrees of influence on groundwater flow characteristics and
these parameters were measured with a meteorological station. Rain gauges were also installed to allow for the measurement of precipitation at three locations on site. A staff gauge was installed along the Steeves Lake shoreline, west of the former camp area, to provide a visual indicator of water level. Staff gauge measurement will be taken during surface water sampling and the elevation corrected to allow for comparison of lake level to groundwater levels in sumps and monitoring wells.

Task V - Recovery of Data from the Colomac Monitoring Well Network

The objective of the monitoring well network is to track fluctuations in the free product and groundwater levels that can affect the transport of free product towards Steeves Lake. Additionally, monitoring of hydrocarbon concentrations in the groundwater permits analysis of the changes in the distribution of the petroleum plume. Groundwater measurements are collected during each site visit, approximately every three weeks during the AHMP. Parameters documented during each site visits include:

- Depth to product
- Depth to water
- Depth to end of hole (or depth to ice plug)
- Condition of each monitoring well

Product levels, water levels, and depth of hole were measured in each of the groundwater monitoring well and seepage collection sum using an interface probe. In addition to these manual measurements, data is also collected with the level loggers. Product and water levels are measured prior to groundwater sampling or product recovery activities, since these activities alter the static equilibrium of groundwater and impact the ability to accurately measure seasonal fluctuations in the water table. The condition of each monitoring well was recorded in order to identify necessary maintenance or to explain anomalous data. Observations included, but were not limited to cracked or broken casings/PVC monitoring pipes, disturbed seals and missing caps.

Sample wells are chosen based on:

- Presence or absence of product in the well
- Potential to sample for groundwater during the spring and fall
- Volume of groundwater in the well
- Location of the well (wells spaced appropriately across the site, so the results were representative of full site conditions).

Groundwater samples are collected to assess the dissolved phase concentrations. Low flow sampling techniques are used where applicable as they reduce the amount of purge water, reduced turbidity and disturbance in the water column during sampling and reduced the potential for free phase product to enter the well that could cause a bias in the analytical results. Since 2011, groundwater samples are collected using manual sampling techniques (bailer). Purge water is discharged directly to the well field. Field measurements of pH, conductivity, oxidation-reduction potential (ORP) and temperature are obtained with sample collection. Samples collected for metals analysis are preserved and field filtered using a 0.45 micron filter. Water samples to be analyzed for volatile compounds are collected with no head space.
Task VI - Monitoring of Steeves Lake Shoreline

The purpose objective of Steeves Lake shoreline monitoring is to verify that visible signs of petroleum impact (free product or surface water sheens) are not apparent anywhere along the shoreline. This was especially important in the areas of historical product seepage. A visual inspection of the Steeves Lake shoreline, seepage zones and shoreline cap/peat trench was completed during each site visit. Information documented will include the presence/absence of:

- Hydrocarbon free-product (location and approximate amount of product to be noted, and area photographed)
- Erosion or ground settlement (location and areal extent noted, and area photographed)
- Hydrocarbon sheen on Steeves Lake or on the shoreline cap (location and extent noted, and area photographed)
- Other features, such as but not limited to vegetation stress, debris, staining and/or ponded water (location and extent noted, and area photographed).

Task VII - Special Response for Steeves Lake Shoreline

The objective of this task is to prepare for containment and recovery of any hydrocarbon breakout along the Steeves Lake shoreline cap. Prior to the final remediation in 2010, a lake boom was deployed every summer to protect Steeves Lake from up gradient hydrocarbon impacts. It is not yet known whether the remedial actions were sufficient to eliminate the seepage or whether the work changed sub-surface conditions such that seepage may be re-established over time. In the latter case, action will be required to protect the constructed shoreline protection. No control measures have been required to date.

Task VIII - Monitoring of Surface Water Quality

The objective of surface water monitoring is to evaluate potential impacts on Steeves Lake originating from the hydrocarbon impacted areas. Samples were collected on a semi-annual basis and included inlet and outlet to Steeves Lake, Seepage Area A, and Seepage Area B/C. Sample locations were selected to provide background (inlet), source (seepage areas) and down-gradient (outlet).

Task IX - Collection of Thermistor Data

The objective of collecting thermistor data is to monitor ground temperatures that significantly influence product migration. Ground temperature monitoring is especially important given the changes to site conditions following building demolition and site re-grading. Thermistors record temperature variation at depth on a continual basis, providing a detailed temporal assessment. The network of thermistors was expanded in 2011 to include two thermistors installed in areas on site where remediation activities modified the landscape and may have altered the ground temperature regime in the immediate vicinity. The two additional thermistors were installed in PVC pipes in Seepage Areas A and Seepage Area B/C. The thermistor strings are approximately 17-18 m in length with temperature nodes installed every 1.0 m. Dataloggers connected to each thermistor string collect temperature data on a defined interval.
Task X - Collection of Meteorological Data

This task includes troubleshooting any instrumentation and data downloading issues from the meteorological station.

Task XI – On-site Health and Safety

The objective of on-site Health and Safety is to ensure that all AHMP work is carried out without incident. The AHMP Contractor is required to prepare a Site Specific Health and Safety Plan (SSHASP) to cover the specific tasks and activities that will be completed on the site. The SSHASP must meet AANDC EHS management system requirements and satisfy all Authorities Having Authority. Key aspects of on-site H&S include:

- Daily safety meetings
- Satellite phone, first aid kits and survival kit (‘Big Blue’ warehouse is available as emergency refuge)
- Bear monitors for each site visit
- Field team certified on ATV operation
- At least 1 team member certified in First Aid and CPR Training.
- Two-way radio communication.
- Appropriate level of PPE for the work environment.
- Hazards identification.
- Waste handling.

Task XII – Maintenance of On-site Equipment

The work required for the AHMP involves the use of ATVs, a truck, a boat and other equipment that requires general maintenance. Regular inspections and minor preventative maintenance is routinely completed on the equipment to ensure the equipment remained in good working order. Where necessary, personnel adjusted the tire pressure or add engine oil. Mechanical maintenance such as repairs will be arranged by the Crown as necessary and preventative maintenance such as oil changes will be scheduled by the Crown for every field season.

Task XIII – Installation, Operation and Maintenance of Camp and Logistics

All monitoring events will be completed with daily flights between Yellowknife and Colomac. A Crown funded camp will not be installed at Colomac for the AHMP.

Task XIV – Colomac Hydrocarbon Advisory Group (CHAG)

The objective of this task is to organize the review of the AHMP data by the Colomac Hydrocarbon Advisory Group (CHAG). The CHAG meets at the completion of the each AHMP monitoring year to review and discuss all of the data collected and evaluated the data as it pertains to the monitoring program in subsequent years.

Task XV – Teleconferences

The objective of the teleconferences is for CHAG to discuss data produced through the year.
Task XVI – Implementation Plan

A final implementation plan, including all of the methodologies and logistical details required to complete the tasks outlined in each annual Workplan, is prepared and submitted to the Crown for review as part of annual workplanning processes.

Task XVII – Co-ordination of Data Review

The objective of this task is to provide data to the Crown for review, with the intent that the data would be reviewed and the monitoring program adjusted where necessary and where possible.

Task XVIII – Completion of Annual Reporting

The annual report provides a detailed interpretation and analysis of the annual data, and comparison to results of the previous AHMP and the historical data. The annual report includes:

- Overall remedial objective and goal identification – “i.e. protect Steeves Lake”
- Groundwater and hydrocarbon assessment including trend analyses for water and product levels including dissolved phase (where applicable) based on historic and current data.
- Groundwater and surface water quality results analysis and a comparison to the CCME guidelines including any relevant trends with respect to future compliance of guidelines.
- Product recovery volumes, recovery rates, and an assessment of potential areas and/or wells which are the most productive in terms of yielding product.
- Ground temperature data evaluation and possible changes to the thermal regime based on changes to the site conditions.
- Meteorological data summarization and the influence of local climate on product migration.
- Inspection logs descriptions, detailing the findings from our monthly seep and shoreline assessments, and a discussion of any corrective action taken concerning the results of the inspections.
- Quality Assurance and Quality Control protocol summaries for the site.
- Previous year results analysis from the Colomac Hydrocarbon Advisory Group.
- Recommendations for the ongoing monitoring program.

Task XIX – Creation of a Colomac Database

The purpose of this task was to finalize development of the EQuIS database for Colomac results but it has been decided that the data can be collected in a more cost effective manner and the task has been eliminated from the AHMP program.

Task XX – Completion of a Peat Absorption Study

The objective of the Peat Adsorption Study is to evaluate the adsorption capacity of the peat installed in the Steeves Lake cap. The study was intended to allow determination of the quantity and change out rates of spent peat and/or alternative methods of managing hydrocarbon discharge to the peat. The study determined that peat will be an excellent sorbent for both free phase and dissolved phase hydrocarbons. As there is no peat left on the Colomac site to use for change out of spent peat, it was decided to not pursue this study further.
Task XXI – Reporting on the Data Compilation and Review

The objective of the task of data compilation and review is to compile the historical site technical data and conduct a detailed data review and analysis. A summary report presenting the findings of the detailed data compilation and review was submitted to the Crown in 2012.

4.5.2 Future Monitoring

Product recovery will be completed as part of the 2013 AHMP season and it anticipated that this will be the final season in which product recovery will occur. The EFR unit will remain at Colomac for at least two (2) years after the end of product recovery (for field seasons in 2014 and 2015) in case there is large accumulation in wells in the Colomac well field or there is a break-out of product along the Steeves Lake sediment cap. Collection of petroleum impacted materials (free product, impacted water, peat, carbon, sorbents) will be completed through each AHMP season and disposal options for spent peat in the trench are still being considered. Drums will be stored in the former MPE container until they are shipped for disposal at the end of each field season. As the AHMP continues, it is anticipated that the need for waste management will decrease. Monitoring well data collection and ground water sampling will continue as an integral part of the monitoring well data collection until 2015. As indicated by the monitoring, specific wells may no longer carry any value and will be decommissioned as the program evolves. Groundwater monitoring will continue and include:

<table>
<thead>
<tr>
<th>Table 1. 2011 Groundwater Sampling Program</th>
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<tbody>
<tr>
<td><strong>Sampling Event</strong></td>
</tr>
<tr>
<td>Semi-Annual (July and August)</td>
</tr>
<tr>
<td>Annual (July)</td>
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**Notes:**
1. The selected wells are subject to change based on each annual groundwater data review. Wells were chosen from a variety of wells across the site, including wells with known product, the five new deep bedrock monitoring wells installed along the new shoreline cap and 14 other wells appropriately spaced on-site. This was help to promote representative water quality sampling across the site.
2. The groundwater concentrations were compared to CCME guidelines.

Monitoring Steeves Lake Shoreline for cap and restoration performance will form an integral part of each Colomac site visit. As Steeves Lake is the down-gradient receptor of migrating petroleum hydrocarbon, it is very important to ensure that visual evidence of seepage is noted to allow a proper response before the petroleum can enter Steeves Lake. Special response (contingency) for Steeves Lake shoreline will continue to be required as long as the potential for seepage break-out
of free phase hydrocarbon exists. In the event that a hydrocarbon free-product seep is observed, containment and recovery measures will be taken including placement of sorbent pads or sorbent booms along the area and, if applicable, collection of free product using the EFR. Surface water quality monitoring will continue to 2015 and is summarized in Table 2:

### Table 2. 2011 Surface Water Sampling Program

<table>
<thead>
<tr>
<th>Sampling Event</th>
<th>Sampling Location</th>
<th>Analytical Parameters (^{(1)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-Annual (July 13(^{th}) and August 24(^{rd}) site visits)</td>
<td>Inlet to Steeves Lake&lt;br&gt;Outlet to Steeves Lake&lt;br&gt;Seepage Area A&lt;br&gt;Seepage Area B/C</td>
<td>General Chemistry: pH, conductivity&lt;br&gt;Metals: full metal scan&lt;br&gt;Petroleum Hydrocarbons: F1(-BTEX), F2-F4&lt;br&gt;Field Measurements: pH, conductivity, temperature and dissolved oxygen&lt;br&gt;Cations and Anions: Ca, Mg, K, Na, Ba, Sr, Cl, PO4, SO4, Br</td>
</tr>
</tbody>
</table>

**Notes:**

\(^{(1)}\) The surface water sample results were compared to CCME guidelines.

Collection of thermistor data will continue to determine long-term trends in the thermal regime of the Colomac sub-surface. This is very important through the first years of the AHMP as a new thermal equilibrium has been established following the re-grading and the removal of buildings on the site. It is not known how long continued monitoring of the thermal data will be required to establish a reliable thermal baseline. Climatic change in the region will also affect the thermal regime and the potential for changes in the migration of the residual hydrocarbons.

The CHAG will continue to meet at the completion of each AHMP monitoring year to review and discuss all of the data collected and evaluated the data as it pertains to the monitoring program in subsequent years. The expert panel will be needed to analyse and interpret AHMP data until a relatively stable steady state can be achieved for the sub-surface thermal regime, plume stability and estimated contaminant flux into Steeves Lake.

### 4.6 Geotechnical and Post-Construction Monitoring

A large portion of the remedial work at Colomac has involved the construction of engineered structures and major civil earthworks. The long term performance of these structures and works are critical to remedial success and long term site stability and as such, require comprehensive monitoring. Design drawings for all aspects of the major civil works (tailings cap, Dam 1B, spillway and discharge channel) were submitted to the Wek’eezhii Land and Water Board in October 2005 with the final as-built report being submitted to the Board in February 2008.

#### 4.6.1 Status

**Tailings Cap**

The objectives of the tailings covers are to prevent contact between the tailings and wildlife, and to minimize the generation of dust, while presenting neither an attraction to caribou, nor an impediment to their movement.

Except for an area at the south end of the Spruce Lake tailings that was left open for deposition and burial of approved mill wastes (SLDC), most of the exposed tailings were covered in 2006 with waste rock, and in some areas, a layer of filter fabric between the tailings and the waste rock.
The area left open for deposition and burial of approved plant site waste was covered in 2011 by tailings and a layer of waste rock in accordance with the previously constructed cover. Instrumentation previously installed in the tailings in support of the investigation for the design of the Remediation Plan was destroyed during the installation of the tailings cover. The Remediation Plan did not call for replacement or additional instrumentation to be installed in the tailings and/or tailings covers.

To meet those objectives, the Remediation Plan determined that the covers should consist of inert rock taken from the mine waste rock piles, that the surface material should be fine enough to allow caribou passage, and that no attempt should be made to encourage vegetation. The Remediation Plan also called for re-grading of the Spruce Lake tailings surface to promote drainage and, in some areas were the water table was elevated, a geotextile layer within the cover to prevent the upward movement of tailings fines.

Dam 1/1B

The principal function of Dam 1B is to prevent the escape of contaminated seepage from the TCA to the downstream environment. In that function, it replaced the pump-back system at the toe of Dam 1A that required year-round operation. The objectives for Dam 1B were, therefore, control of seepage and long-term stability. The specific design criteria adopted for the Dam 1B were stability, as defined by the Canadian Dam Association, and site specific seepage and thermal criteria (since the base of Dam 1B is keyed into permafrost). The construction of Dam 1B and the placement of the waste rock infill between Dams 1A and 1B were completed over the 2006/2007 winter period. Instrumentation associated with the performance of Dam 1B consisted of thermistors and survey hubs installed during the construction of the dam. The pump-back system immediately downstream of Dam 1A was shut down in a controlled, gradual manner between December 12, 2008 and March 9, 2009.

Dyke 7 Spillway

The objective of the Dyke 7 spillway is to provide for the passage of water from the Spruce Lake tailings surface to Tailings Lake, and thereby to stop the historical piping of water and tailings through Dyke 7. The specific design criteria adopted for the Dyke 7 spillway were hydraulic capacity to pass a probable maximum flood (PMF) and minimum requirements for long-term maintenance. The Dyke 7 Spillway was constructed in 2006. There is no instrumentation associated with the performance of the Dyke 7 Spillway.

Discharge Channel

The objective of the Tailings Lake discharge channel is to provide for the passage of water out of Tailings Lake, which collects all of the drainage from the former Tailings Containment Area (TCA). The specific design criteria adopted for the Tailings Lake discharge channel were hydraulic capacity to pass a PMF and minimum requirements for long-term maintenance. The Tailings Lake discharge channel was constructed in 2006. There is no instrumentation associated with the performance of the discharge channel.

Primary Crusher Cap
The objective of the cap is the elimination of any potential threat to the safety of people or wildlife due to falls or ground failures. The engineered design was based on backfilling the open vertical chamber with waste rock, placing steel beams and plating over the back fill and then covering the steel plating with a mound of soil that sheds surface water away from the steel plating. The cap was installed in 2010.

Steeves Lake Shoreline Restoration

The objective of the shoreline restoration was to establish a secure, erosion-resistant cap that provides separation between Steeves Lake and the hydrocarbon-contaminated sediments at the near shore. The design was based on the placement of a rock and soil cap along the impacted shoreline and establishment of re-vegetation in some areas. The cap was constructed in 2010 with drainage improvements in 2011 using borrow material from existing site quarries, waste rock dumps and peat from the Dam 1 valley stockpile.

Zone 2.5 Landfill

The objective of the landfill was to establish a permanent cover over the non-hazardous landfill via the placement of rock fill lifts over the wastes and grading the cap to a stable configuration. The landfill was closed gradually installed in 2010 with final grading in 2011.

4.6.2 Future Monitoring

The Geotechnical Engineer’s recommendations for the long-term geotechnical monitoring requirements for the Colomac Site have been developed on the basis of the following considerations:

- The 20-yr requirement (until 2027) for the functionality of the thermosyphons in Dam 1B is a key driver for the duration of site inspections. It is appropriate that checking of the thermosyphon functionality should occur once every winter, or at the most, once every other winter.
- Full inspection by a Geotechnical Engineer is appropriate once every 5 yrs for Dam 1B.
- To the extent that the Geotechnical Engineer is on site, it would be efficient and cost-effective to do inspections at the other features on the same day.
- In situations that could be perceived as needing a functionality check more frequently than once every 5 years, it seems appropriate to visit the site in summer every 2 or 3 years, and this could be done by a technician or technologist, i.e. not necessarily a Geotechnical Engineer.
- To the extent possible, the thermistors should be read whenever someone visits the site (as a minimum, we would recommend that this occur at least once annually, i.e. when the functionality of the thermosyphons is each winter).
## 5.0 Monitoring Schedule

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Component</th>
<th>Performance Issue</th>
<th>Monitoring Requirement</th>
<th>Frequency</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial</td>
<td>Re-vegetation</td>
<td>. natural re-generation (primary and secondary succession) . bio-diversity . coverage</td>
<td>. on the ground surveys . transects . aerial . spatial GIS</td>
<td>annually</td>
<td>. 2012-15 . re-evaluate at that time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>. 2015-20 . re-evaluate at that time</td>
</tr>
<tr>
<td>Flora</td>
<td></td>
<td>. acceptable contaminant levels . functional habitat</td>
<td>. sampling/analysis of indicator species</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Fauna</td>
<td></td>
<td>. acceptable contaminant levels . functional habitat</td>
<td>. sampling/analysis of indicator species</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Aquatic</td>
<td>Flora</td>
<td>. acceptable contaminant levels . functional habitat</td>
<td>. sampling/analysis of indicator species</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td>Fauna</td>
<td>. acceptable contaminant levels . functional habitat</td>
<td>. sampling/analysis of indicator species</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td>Water quality</td>
<td>. local and downstream receiving environments achievement of WL discharge limits</td>
<td>. chemical and physical parameters set out in WL . water level surveys . data collection and analysis . on the ground assessment of man-made structures and earthworks and overall site drainage . twice annually (peak flow in June and low flow in Sept)</td>
<td>. monthly during open water season . once under ice</td>
<td>. 2012-15 . re-evaluate at that time and renew Type B WL</td>
</tr>
<tr>
<td></td>
<td>Hydrology</td>
<td>. natural flow restoration and maintenance . man-made structures performance (French drain at Baton Lake, Spot and Truck Lake channels) . stream crossings – flow, fish passage, erosion control . pit water levels (infill and outflow) . Zone 2.5 Pit water level monitoring and protection of landfill</td>
<td>. water level surveys . data collection and analysis . on the ground assessment of man-made structures and earthworks and overall site drainage</td>
<td>. twice annually (peak flow in June and low flow in Sept)</td>
<td>. 2012-15 . re-evaluate at that time</td>
</tr>
<tr>
<td></td>
<td>Hydrocarbons</td>
<td>Free product</td>
<td>. residual free product migration to Steeves Lake is effectively cut-off allowing for natural attenuation processes</td>
<td>. opportunistic free product recovery during data collection . monitoring well data interpretation . development of sub-surface model and determination of steady state</td>
<td>. monthly during open water season</td>
</tr>
<tr>
<td>Aspect</td>
<td>Component</td>
<td>Performance Issue</td>
<td>Monitoring Requirement</td>
<td>Frequency</td>
<td>Period</td>
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</tr>
<tr>
<td>Instrumentation (monitoring wells, met data)</td>
<td></td>
<td></td>
<td>conditions</td>
<td>any significant product accumulations</td>
<td>2012-15</td>
</tr>
<tr>
<td>Surface and ground water quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2012-15</td>
</tr>
<tr>
<td>Geotechnical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailings cover</td>
<td>Primary: long term settlement must not prevent surface drainage from reporting to the Dyke 7 Spillway; tailings must not migrate through the rock fill cover, i.e. via piping, etc. Secondary: cover should not represent a threat to wildlife; significant vegetative growth should not establish itself on the cover</td>
<td>Visual inspection, photographic record and documentation</td>
<td>Once every five years by a Geotechnical Engineer</td>
<td>Through 2027; re-evaluate at that time</td>
<td></td>
</tr>
<tr>
<td>Dyke 7 Spillway</td>
<td>Primary: drainage swales should remain intact; the spillway should remain unobstructed in general conformance with its design; the stilling pool should remain intact</td>
<td>Visual inspection, photographic record and documentation</td>
<td>. Once every two to three years by a Civil Technician or Technologist . Once every five years by a Geotechnical Engineer</td>
<td>Through 2027; re-evaluate at that time</td>
<td></td>
</tr>
<tr>
<td>Discharge Channel</td>
<td>Primary: discharge channel should remain open in general conformance with its design Secondary: there should be no significant erosion of the channel that would affect its integrity or its “fish friendliness”</td>
<td>Visual inspection, photographic record and documentation</td>
<td>. Once every two to three years by a Civil Technician or Technologist . Once every five years by a Geotechnical Engineer</td>
<td>Through 2027; re-evaluate at that time</td>
<td></td>
</tr>
<tr>
<td>Dam 1/1B</td>
<td>Primary: the dam must continue to limit seepage from the TCA; the physical stability of the dam must be maintained Secondary: the thermosyphons should remain functional for their 20-yr design life, i.e. at least until 2027</td>
<td>Visual inspection, photographic record and documentation Confirmation of thermosyphon functionality. Collection of thermistor data.</td>
<td>. Visual inspections should be done once every two to three years by a Civil Technician or Technologist . Once every five years by a Geotechnical Engineer.</td>
<td>Through 2027; re-evaluate at that time</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Component</td>
<td>Performance Issue</td>
<td>Monitoring Requirement</td>
<td>Frequency</td>
<td>Period</td>
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<tr>
<td></td>
<td>Primary Crusher</td>
<td>Primary: potential settlement of the cap should not represent a threat to humans or wildlife that might access this area</td>
<td>Visual inspection, photographic record and documentation</td>
<td>Once every five years by a Professional, i.e. Civil Technician/Technologist or Geotechnical Engineer</td>
<td>Through 2027; re-evaluate at that time</td>
</tr>
<tr>
<td></td>
<td>Steeves Lake Shoreline</td>
<td>Primary: the cap should prevent general separation between the lake and the underlying hydrocarbon-contaminated sediments at the edge of Steeves Lake, and should not, therefore, erode or otherwise degrade  Secondary: the cap should, over time, be overtaken by vegetation</td>
<td>Visual inspection, photographic record and documentation</td>
<td>Once every five years by a Geotechnical Engineer</td>
<td>Through 2027; re-evaluate at that time</td>
</tr>
<tr>
<td></td>
<td>Zone 2.5Pit Landfill</td>
<td>Primary: the landfill should remain covered and essentially intact, despite the gradual degradation of the adjacent pit slopes over time</td>
<td>Visual inspection, photographic record and documentation</td>
<td>Once every five years by a Geotechnical Engineer</td>
<td>Through 2027; re-evaluate at that time</td>
</tr>
</tbody>
</table>
6.0 REPORTING REQUIREMENTS

It is anticipated that Colomac monitoring reporting will flow primarily through the conditions of the existing Water Licence and any licences issued in the future.

7.0 PLAN REVISION

Monitoring data collected over the next three years (2012-15) will undergo a thorough review and the Post-Reclamation Monitoring and Residual Hydrocarbon Remediation Management Plan will be revised accordingly at that time.

8.0 CONCLUSIONS

The Post-Reclamation and Residual Hydrocarbon Monitoring Program forms the final phase of the Colomac project life cycle. Long term monitoring is a critical aspect of the final closure process for any contaminated site, but perhaps more so for Colomac, given the scale and nature of the remedial effort over the past twelve (12) years. Confirmation of long term stability of the Colomac site can only be achieved through a comprehensive monitoring program as presented in this document.

As has been the case over the Colomac project lifecycle; from emergency care and maintenance to remediation planning, through to final site remediation, the Tlicho will continue to be actively involved with all aspects of the monitoring program at Colomac. The results of the monitoring program will be effectively communicated to all stakeholders through the Wek’eezhii Land and Water Board and public registry.
Figure 1  Colomac Site Map 1

Legend
- Spruce Lake Disposal cell
- Big Blue Warehouse
- Primary Crusher Area

SNP Sample Locations
- Active
- Inactive
- Proposed Reserve Boundary Amendment

Existing Reserve Boundary
- 68B/6-3-11, 88B/6-5-11

Map Units: 1:45,000

This map is intended for general information only. It is neither a technical reference tool, nor a legal document. Aboriginal Affairs and Northern Development Canada (AADC) will not be held liable for any errors or inaccuracies.
Figure 2  Colomac Site Map 2
Figure 3  Colomac Site Map 3
Figure 4  Colomac SNP Map

Figure 1-1: Map of Surveillance Network Program (SNP) Sampling Sites for Colomac Gold Mine

* Map courtesy of Bill Coody, Contaminants and Remediation Directorate, Aboriginal Affairs and Northern Development Canada
Figure 5  Colomac Hydrology Map 1
Figure 6  Colomac Hydrology Map 2
Figure 7  Colomac AHMP Map