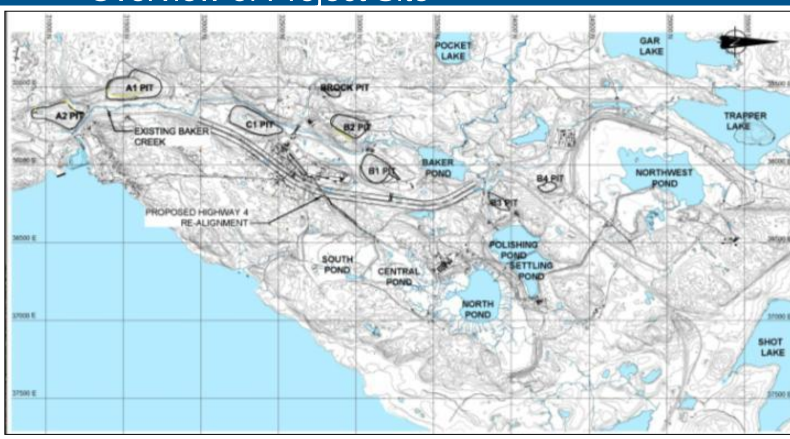
Giant Mine Remediation Project

Surface - Open Pits and B1 Pit Subsidence

John Hull, P.Eng., P.E.
Darren Kennard, M.Sc., P.Eng.

Giant Mine Remediation Project

Overview of Project Site



- The Giant Mine Remediation Project consists of many different components distributed over a wide area that are intricately linked
  - Open pits, underground, tailings, surface waste and water management, and others

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Presentation Topics

- General Design Philosophy for Pit Closure
- General Site Layout and Pit Locations
- Existing Geotechnical Hazards of the Pits and Post Remediation Concepts
- Pit B1 Instability and Project Linkage to Underground
- Summary

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Open Pits

GENERAL DESIGN PHILOSOPHY

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Fundamental Assumptions for the Design Process

Fundamental Assumptions:

1. No intended present or future recreational use of the site for public purposes or public activities
2. Public access restricted as practical
3. Criteria to be consistent with the Northwest Territories Mine Health and Safety Act and Regulations

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General Philosophy for Remedial Design

Activities, level of effort, and associated costs, for the open pits areas according to the following categories:

1. Areas where localized rock falls, pit floor instability, and pit wall instability will not impact public safety, sensitive infrastructure, arsenic chambers or other;

2. Areas where localized rock falls, pit floor instability, and pit wall instability may impact public safety and sensitive or critical public infrastructure or other; and

3. Areas where localized rock falls, pit floor instability, pit wall instability or some combination of these will impact the arsenic chambers, stopes, or the surrounding freeze infrastructure.

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Open Pits

GENERAL SITE LAYOUT AND PIT LOCATIONS

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Location of Open Pits Discussed in this Presentation

- Open pits to be closed as part of the Giant Mine Remediation Project.
- Also shown are underground workings beneath pits.

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Open Pits

EXISTING GEOTECHNICAL HAZARDS AND REMEDIATION CONCEPTS

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Methodology

- Collect additional geotechnical data from site visits and surface geotechnical mapping in 2010 and 2011
- Define 'safe' setback distances from pit crests to implement remedial designs, such as fencing and berms
  - Set back distances based on standard analytical methods for pit slope design

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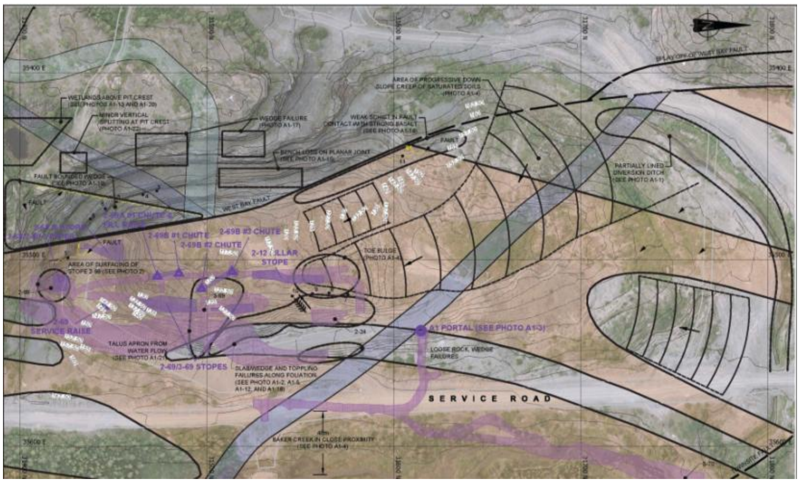
Geotechnical Hazards A1 Pit



- A1 Pit overlain by geology showing Baker Creek, multiple intersections with underground workings, A1 Portal, surface creep of soils, and other geotechnical hazards

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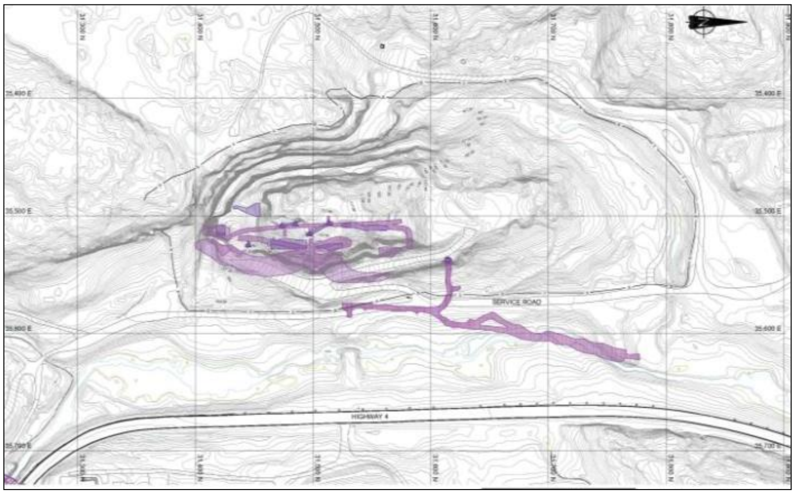
Remediation A1 Pit



- A1 Pit showing remedial designs, which includes sealing A1 portal and other surface openings, fencing and berms to prevent public access

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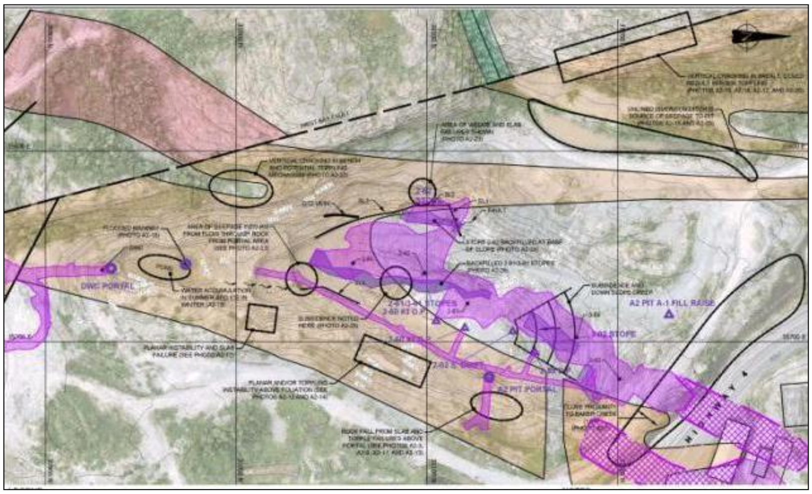
Geotechnical Hazards A2 Pit

- A2 Pit overlain by geology showing Baker Creek, multiple intersections with underground workings, DWC Portal area, A2 Portal, surface creep of soils, and other geotechnical hazards.



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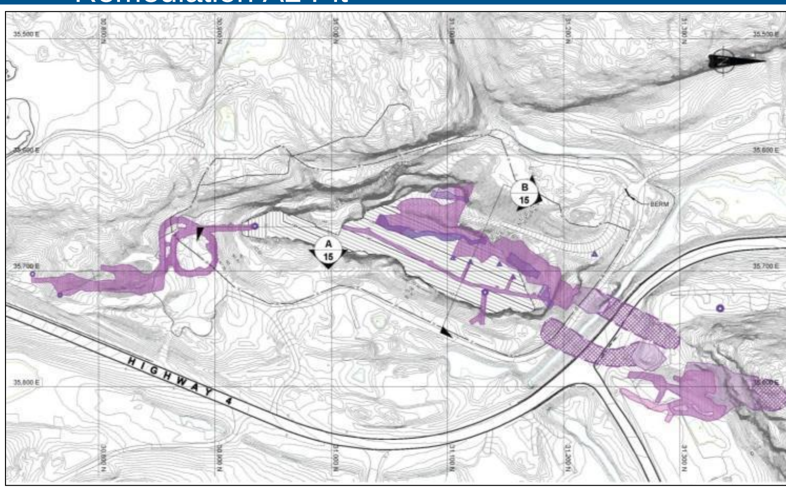
Remediation A2 Pit



- A2 Pit showing remedial designs, which includes sealing A2 portal, backfilling with clean fill and grading of benches at DWC Portal, buttressing of east wall with minor zone of backfill, and fencing and berms to prevent public access.

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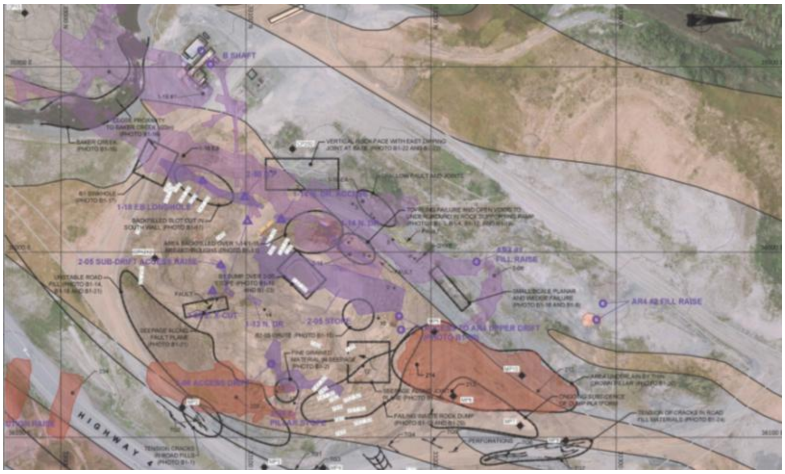
Geotechnical Hazards B1Pit

- B1Pit overlain by geology showing Baker Creek at south crest, sinkhole on south service road, multiple intersections with underground workings, tension cracks along east and northeast service road, and other geotechnical hazards.



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Open Pits

PIT B1 INSTABILITY AND PROJECT LINKAGE TO UNDERGROUND

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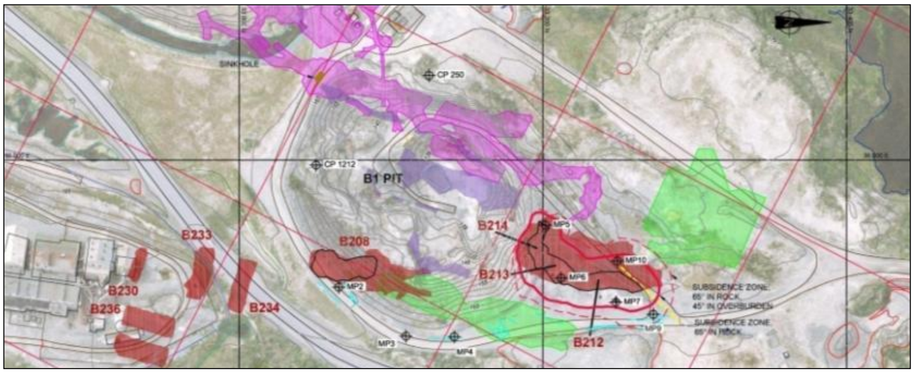
Pit B1 Subsidence



- B1Pit showing the locations of important arsenic stopes, monitoring points, and key geotechnical considerations such as subsidence and sinkhole.

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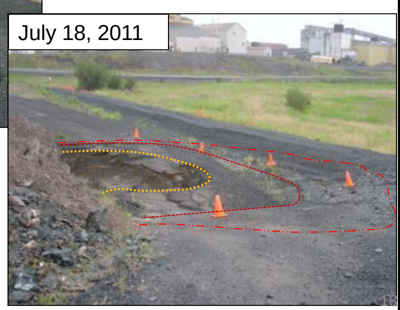
Pit B1 Sinkhole – South End of Pit

- Sinkhole continues to grow



- Sinkhole due to loss of material into underground

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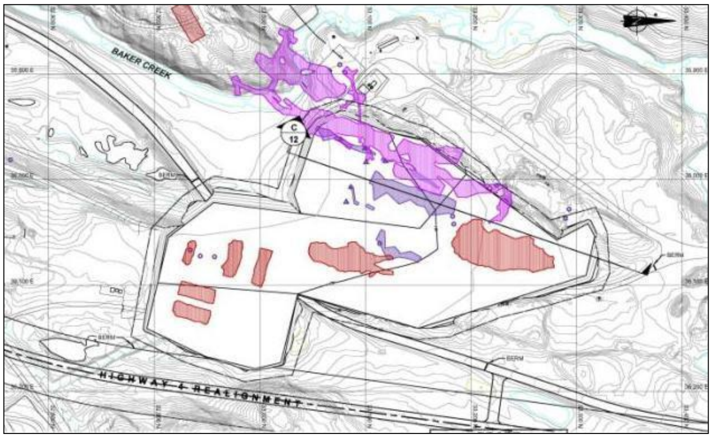
Remediation B1 Pit



- B1 Pit remedial designs, which include: backfilling of the pit using contaminated waste materials in a controlled manner in preparation of installing freeze system, backfilling of underground workings and stabilizing the ground conditions. Backfill will be capped and graded for collection of run-off water. Security fencing in this area will be more robust due to the sensitive infrastructure of the freeze.

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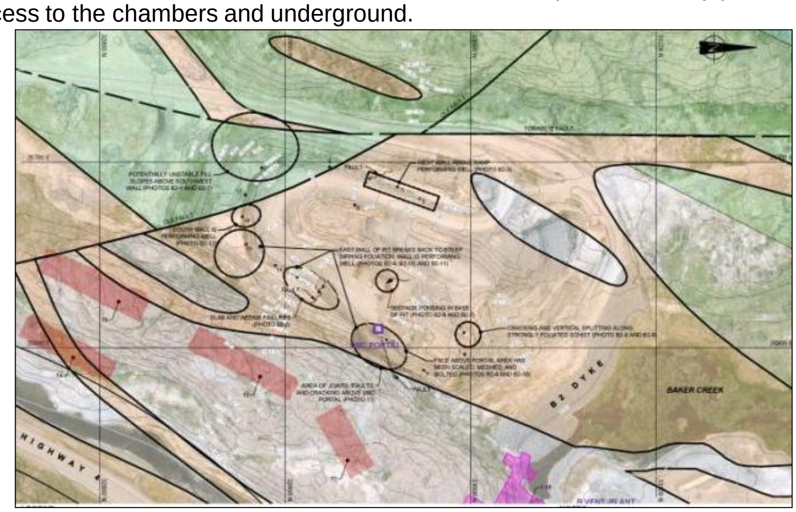
Geotechnical Hazards B2 Pit

- B2Pit overlain by geology showing Baker Creek at north crest behind B2 dike, the B2 portal, and arsenic chambers behind east wall. The B2 portal currently provides access to the chambers and underground.



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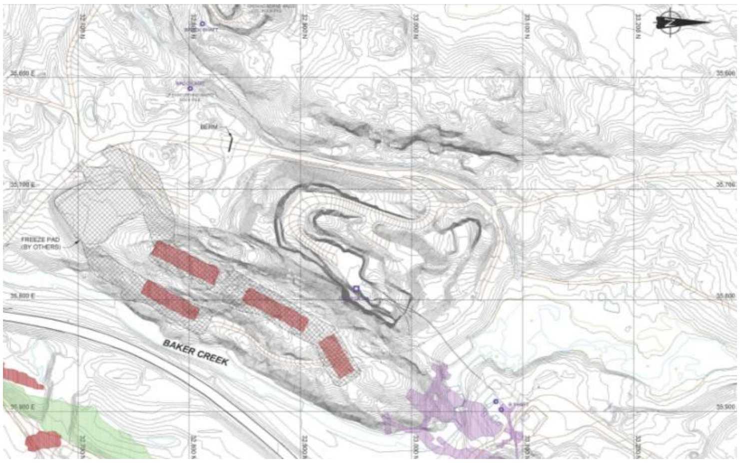
Remediation B2 Pit



- Current design thinking for B2 Pit which includes backfilling of the pit using contaminated waste materials to stabilize slopes, backfilling and sealing of the B2 portal and underground workings, fencing and berms to prevent public access to area. Backfill will be capped and graded to west for collection of run-off water.

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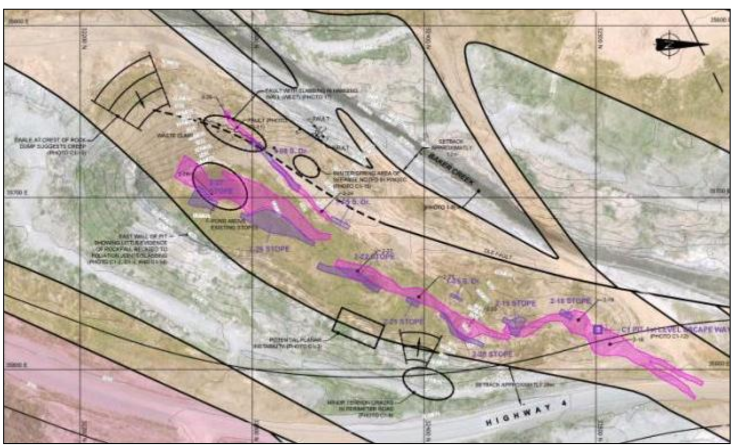
Geotechnical Hazards C1 Pit

- C1 Pit overlain by geology showing multiple intersections with underground workings, Baker Creek as close as 17 m along west pit crest, and Highway 4 along northeast pit crest, down slope creep of fill materials at south wall, and vegetation and wetlands through the base of the pit.



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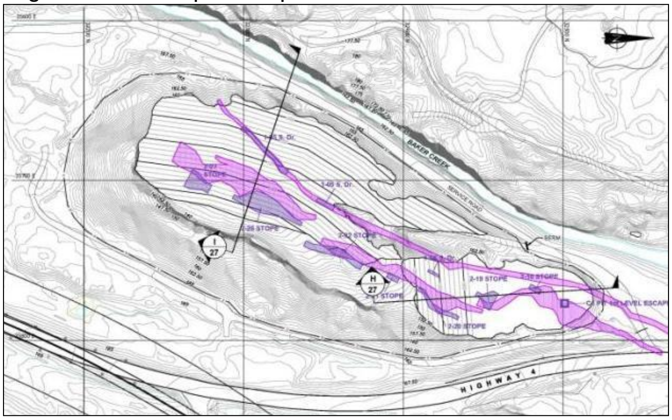
Remediation C1 Pit

- C1 Pit remedial designs include partial backfilling of the pit using clean materials to stabilize west slope, backfilling and sealing of surface and underground workings, and fencing and berms to prevent public access to area.



- If Baker Creek alignment is moved away from the west pit crest, then backfilling of the pit for slope stabilization may not be necessary.

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Open Pits

SUMMARY

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Giant Mine Remediation Project
Summary

- Remediation of the Open Pits is focused on minimizing risk to the general public health and safety, and to the environment, using practical and cost effective methods consistent with current standard practices
- Remedial activities are consistent with NWT Mine Health and Safety Act and Regulations

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Comparison with DAR Objectives

- Proposed remedial designs are consistent with fundamental objectives of the DAR
- The current study is based on on-going studies including geotechnical mapping and site visits
- There are some changes to recommendations presented in the DAR, and those are under review as part of the current design effort

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Contaminated Surficial Materials

Surface – Contaminated Materials

Arthur Cole, P.Eng.

Giant Mine Remediation Project

Outline

- Review of 2007 Remediation Plan
- Results of the 2010/11 Delineation Investigation
- Preliminary Design Strategy
- Classes of Excavation
- Summary

C-Shaft looking east.

Giant Mine Remediation Project

2007 Remediation Plan

- Two main contaminants of concern
  - Arsenic
  - Petroleum Hydrocarbons (PHCs)
- The Site was subdivided into investigation areas.
- Materials containing the highest arsenic concentrations were located within the Mill Area and West of the Settling Ponds.
- Materials containing PHC above criteria were also identified.

Arsenic contaminated mine rock.

PHC contaminated materials.

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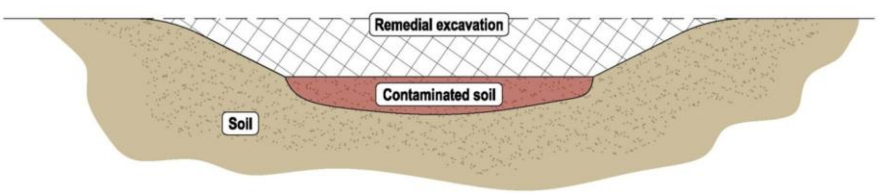
2007 Remediation Plan

- Remediation excavation depth was set at 2.0 m.
- Any contaminated materials found below 2.0 m will be covered in place and re-graded to promote surface runoff.
- These areas will be delineated and identified on Site maps to prevent accidental excavation of the contaminated materials in the future.



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Giant Mine Remediation Project

2010/11 Delineation Investigation

- Completed a review of all known historical investigations, compiled all historical data, and identified data gaps.
- Purpose was to further refine estimates of the extent of contaminated materials.
- Field program consisted of the advancement of 115 test pits, 105 hand auger test holes, and 8 boreholes.

A typical hand auger test hole being advanced.

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2010/11 Delineation Investigation

- A total of 336 soil samples were submitted for laboratory analysis of arsenic and 69 soil samples were submitted for laboratory analysis of PHCs.
- A total volume of about 960,000 m3 of contaminated materials (including tailings not in the TCA) were identified.
- This increase in the volume was due to both an increase in the size and depth of known areas of contamination.

A typical test pit being advanced.

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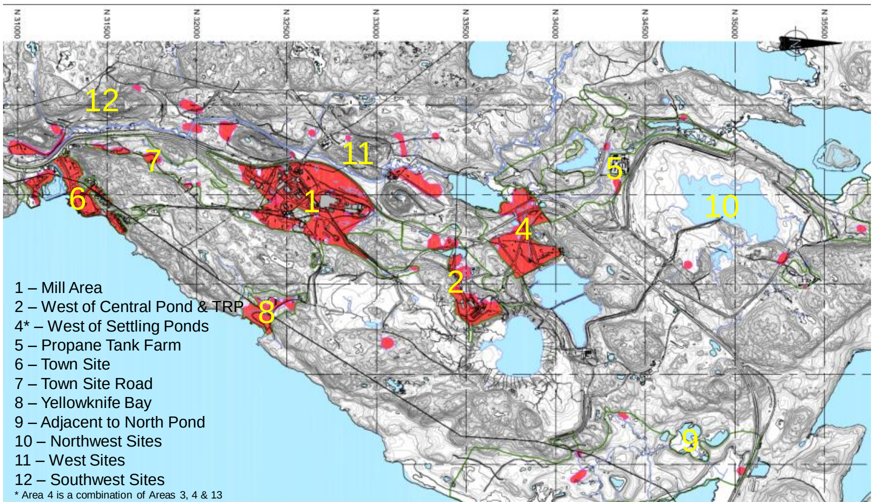
Areas of Contamination



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Preliminary Design Strategy

Materials are segregated based on “type”:

- Contaminated Soils – Natural soil deposits or fill, other than waste rock or tailings.
- Tailings – Tailings and/or calcine that have been spilled or deposited outside of the impoundments.
- Waste Rock – Rock used as fill on surface.

2010/11 Delineation Investigation		**Preliminary Design - Cap of Four Key Areas**	**Volume for on Site Disposal**
Contaminated Soil	77,022 m^3	Mill Pond (-39,210 m^3) Area 4 Tailings (-219,562 m^3) Calcine Pond (-53,488 m^3) Yellowknife Bay Tailings (-4,800 m^3)	
Tailings	317,060 m^3		
Waste Rock	566,612 m^3		
TOTAL	**960,694 m^3**	**317,060 m^3**	**643,634 m^3**

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Giant Mine Remediation Project
Preliminary Design Strategy

Materials were segregated based on "chemistry":

- Type A – Marginally Arsenic Affected (<3,000 mg/kg)
- Type B – Heavily Arsenic Affected (>3,000 mg/kg)
- Type C – Tailings
- Type D – PHC Affected

Contaminated Materials	Arsenic (m^3)			PHCs (m^3)	TOTAL (m^3)
	Type A	Type B	Type C	Type D	
Contaminated Soil	66,491	7,667	0	2,864	**77,022**
Tailings	0	0	0	0	**0**
Waste Rock	9,213	557,399	0	0	**566,612**
TOTAL (m^3)	**75,704**	**565,066**	**0**	**2,864**	**643,634**

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Giant Mine Remediation Project
Classes of Excavation

The 40 remedial excavations have been "classified" based on the following post-remediation outcomes:

- Class I. Contaminated materials will be completely removed (30 excavations).
- Class II. Majority of the contaminated materials will be excavated, but isolated pockets (deeper than 2m) remain (6 excavations).
- Class III. The thickness of affected materials significantly exceeds 2.0 m – no contaminated materials excavated (4 areas).

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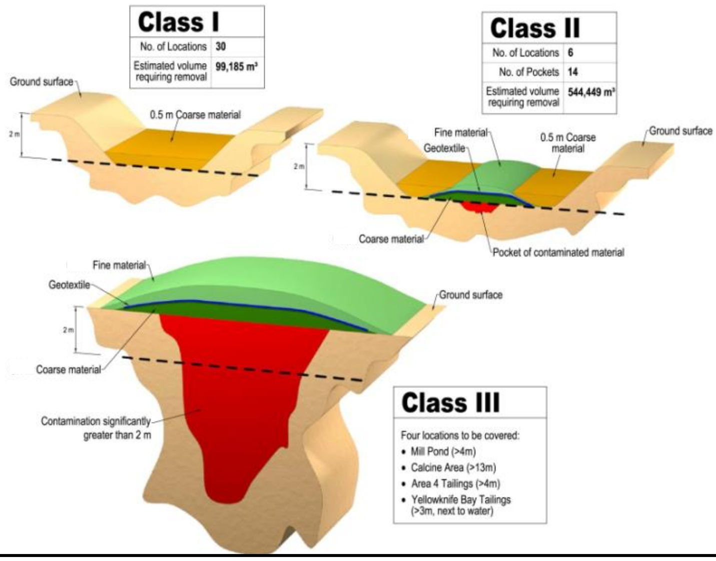
Classes of Excavation



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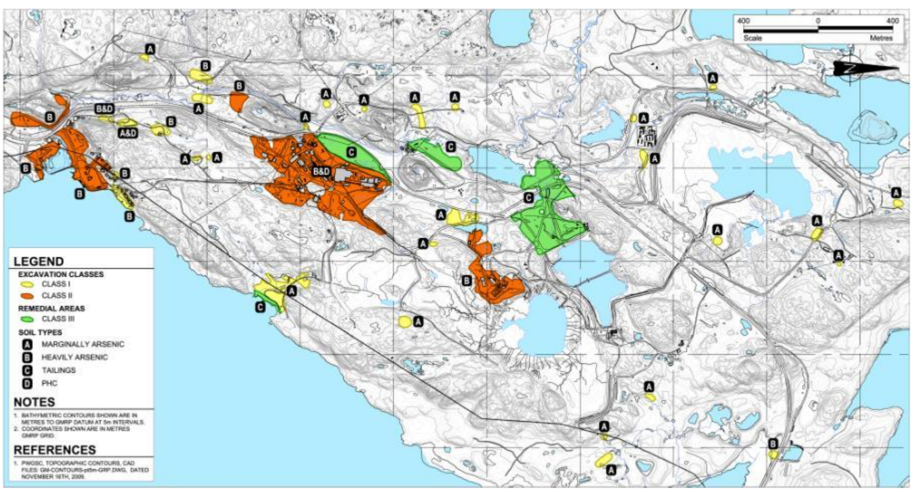
Overall Remedial Strategy



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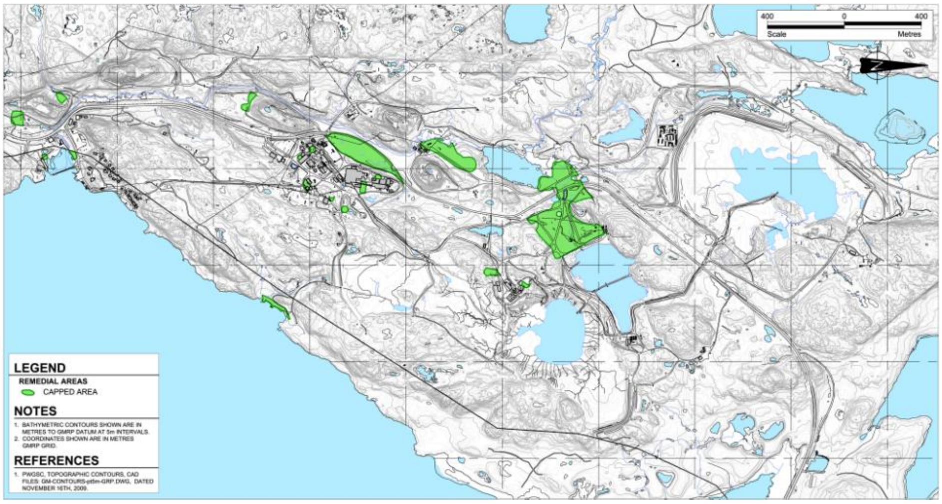
Post Remediation Site Map



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Summary

- Remedial excavation work to occur over a 3 year period
- Work will proceed from the “satellite” areas towards the Mill Area
- All remaining pockets (Class II) and capped areas (Class III) will be delineated and identified on Site maps to prevent accidental excavation of the contaminated material in the future

A typical test pit excavation.

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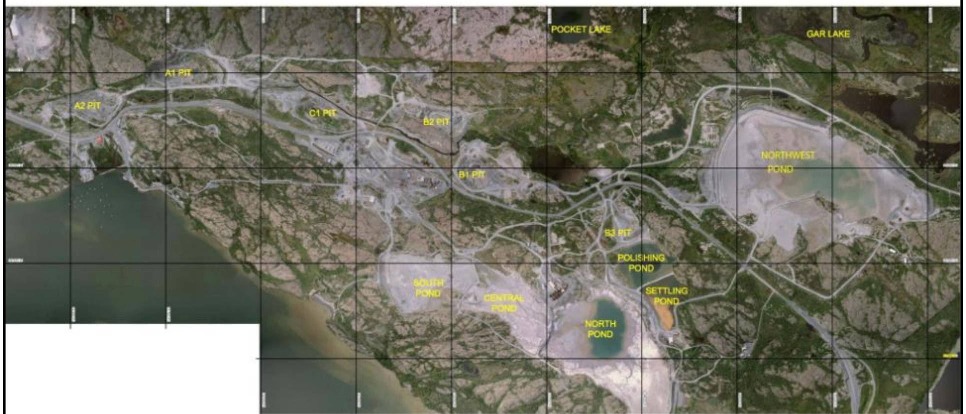
Surface – Tailings Remediation

John Hull, P.Eng., P. E.



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PRESENTATION TOPICS

- Summary of remediation design for the tailings containment areas and water treatment ponds
- Locations of main features associated with this design
- Tailings cover system design and objectives
- Tailings remediation design details
- Monitoring and maintenance
- Historic foreshore tailings

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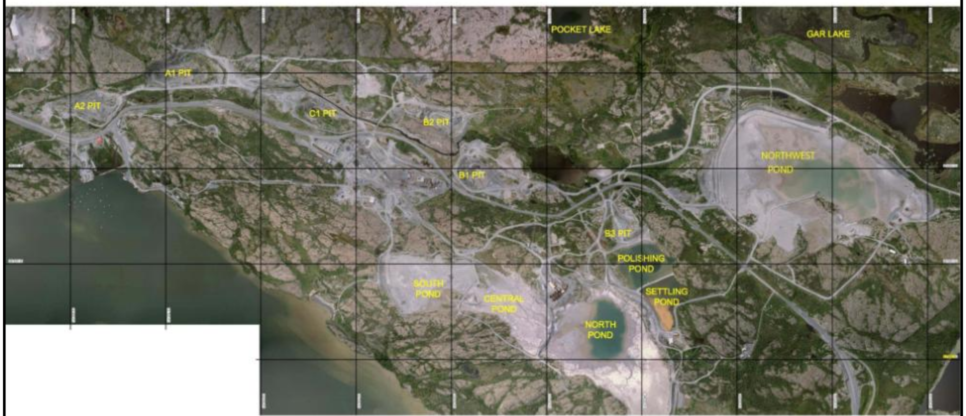
Tailings Remediation

Photo of site showing locations of the tailings containment areas



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Tailings Remediation

Photo of site showing potential borrow locations

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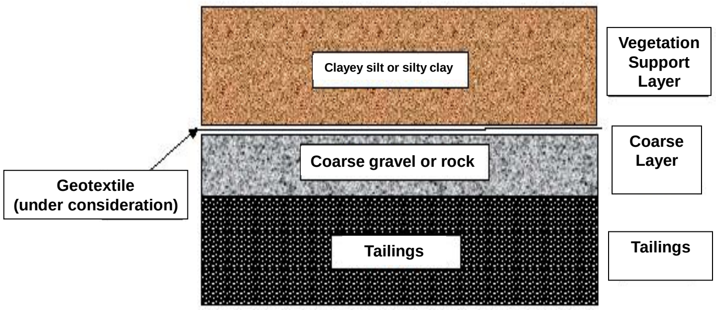
Tailings Cover Design

- Vegetation water storage layer constructed from on-site borrow
- Coarse layer constructed from rock from on-site quarries
- Tailings surface will be re-graded prior to placing cover



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Tailings Remediation

- The tailings surface will be re-graded to uniform slopes and to promote drainage
- A portion of the tailings from the South and Central Ponds may be excavated to be used for underground backfill
- A potential landfill site is on one of the containment areas, tailings surface will be graded such that surface water will flow away and/or around the landfill
- The Polishing Pond and Settling Pond will be drained, re-graded and capped in a similar manner to the tailings containment areas
- Surface drainage from the water treatment ponds and tailings containment areas will be directed to constructed permanent spillways
- The spillways will direct surface water to the environment in post-closure period.

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Tailings Remediation

- Ongoing monitoring and maintenance is planned
- Monitoring will be more frequent in the years after construction
- In the longer term, monitoring frequency and size will be governed by performance of the cover
- Maintenance will be carried out as required based on the monitoring program

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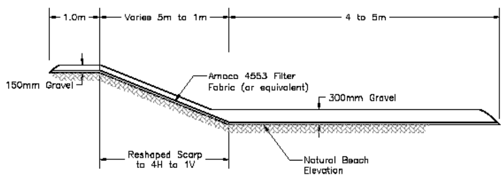
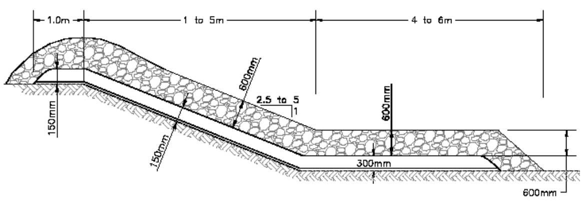
Historic Foreshore Tailings

- Existing design will be extended laterally and within foreshore area



TYPICAL CROSS SECTION
GRAVEL AND FILTER LAYER
NOT TO SCALE



TYPICAL CROSS SECTION
RIP RAP PLACEMENT
NOT TO SCALE

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Historic Foreshore Tailings

- Existing design consists of rock over gravel over geotextile filter fabric
- Cover will be extended to cover tailings on the beach area
- Cover will be extended into the water, within the area directly affected by wave action
- Tailings further up the valley will be remediated as part of the contaminated soils program

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Introduction

This presentation will include the following items:

1. Summary of current waste locations
2. Overview of types of waste and volumes
3. Hazardous material removal process
4. Review of waste disposal options
5. Non-hazardous landfill site location and design overview
6. Long term monitoring

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Summary of Waste Locations

1. Surface Debris – including used equipment storage areas, tire and barrel dumps, misc. waste piles
2. Waste generated when all structures and utility lines with no future use are demolished
3. Hazardous Wastes located underground, consisting of construction materials and equipment

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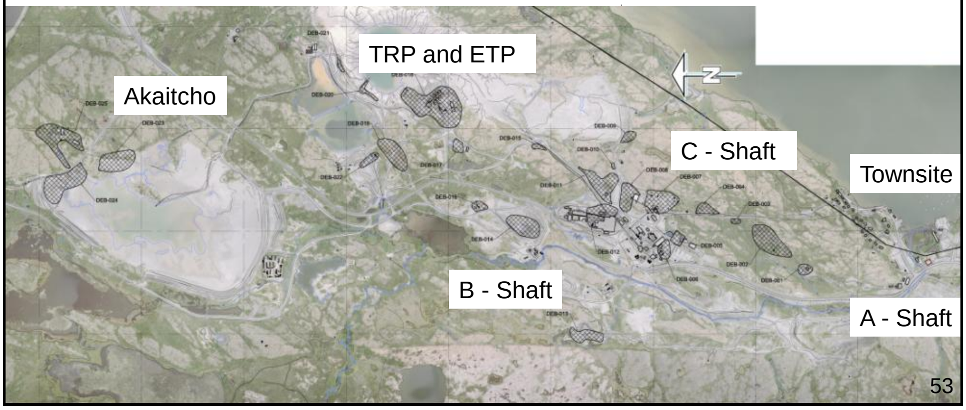
Summary of Waste Locations – Debris Areas and Existing Structures

Over 100 structures and 23 identified surface debris areas



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Overview of Waste

- Non-hazardous wastes
- Mercury containing equipment
- Ozone depleting substances
- Asbestos
- PCB containing equipment
- Other TDG regulated materials (flammable, corrosive, compressed gases)

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Overview of Waste – Cont.

- Leachable lead amended paints
- Arsenic trioxide dust
- Semi processed ore
- New water treatment plant sludge

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Development of Waste Volumes

- Estimates of waste volumes were completed through field surveys (2010 and 2011)
- Surveys included the collection of field measurements and analytical testing to identify hazardous products.
- Volumes presented in previous surveys of the Mill and Roaster Complex (2003, 2009) were also included in the waste volume estimate
- Surveys completed on surface debris areas, onsite structures and underground (hazardous building materials only)

Summary of Estimated Volumes

Non-Hazardous	Hazardous Materials					
General Demolition Waste (m^3)	Oils/Fuels/Petroleum Products (m^3)	Asbestos (m^3)	Chemicals, PCBs, Mercury, ODS (m^3)	Leachable Lead Amended Paint (m^3)	Semi-Processed Ore	Arsenic Dust/Wastes Impacted with Arsenic (m^3)
66,530	220	3,170	110	1,560	1,250	7,890

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Hazardous Building Material Removal Process

- Removal prior to the demolition of the onsite structures.
- Underground hazardous building materials will be removed.
- Hazardous materials will be collected, packaged and transported according to applicable regulations.
- Non-hazardous materials will be decontaminated prior to disposal in on-site landfill.

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Overview of Waste Disposal

Waste Type	Current Design Concept
Non-hazardous	On-site landfill, in the area of the Central Tailings Pond
Asbestos	Dedicated area within on-site landfill
Semi-processed ore from crusher, conveyor and mill building	On-site - Tailings Pond
PCB containing materials, TDG items, mercury , ozone depleting substances, lead amended paint, fuels/oils, petroleum products (POL)	Offsite – Approved out of Territory Facility

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Overview of Waste Disposal – Cont.

Waste Type	Current Design Concept	Disposal Options
Arsenic Trioxide Dust/Process Residuals	On-Site disposal options being evaluated	Onsite options include: Chamber 15, B1 Pit New underground chamber, pit or quarry
New Water Treatment Plant Sludge	On-Site disposal options being evaluated	Within frozen blocks in short term and in new engineered facility designed for the disposal of the sludge

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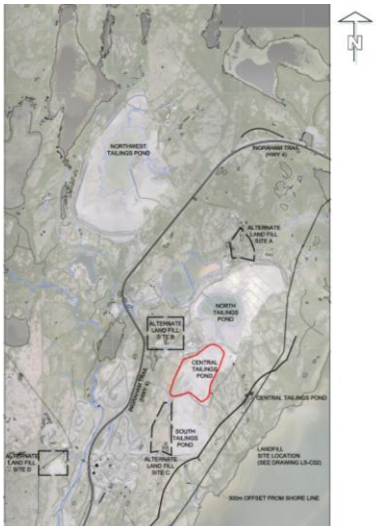
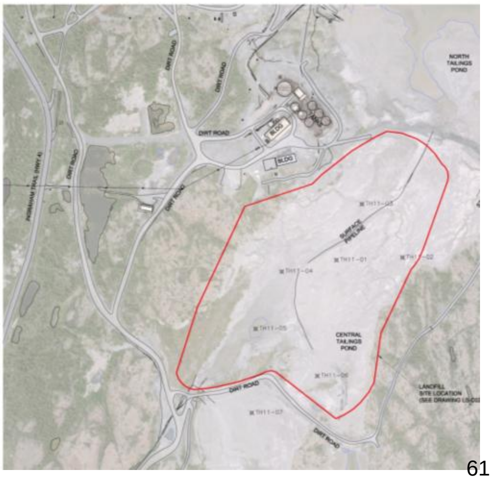
Landfill Site Location – Current Design Concept





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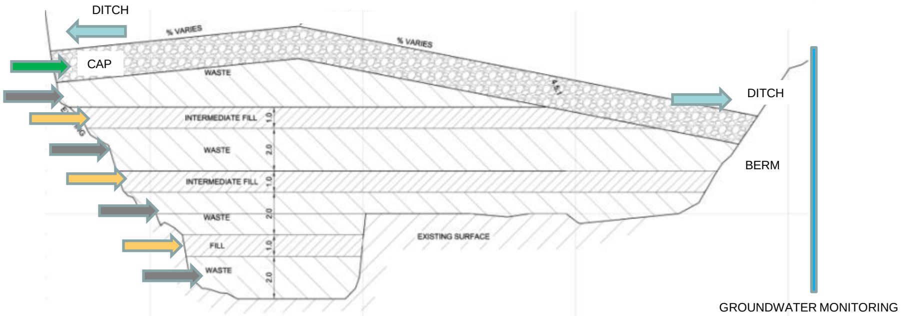
Landfill Design – Based on Best Practices



Landfill – Typical Cross Section

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Future Monitoring and Long Term Management

- As indicated in DAR 14.2, annual inspections of the berms, cap and drainage network to observe evidence of changes of condition of the physical works.
- Groundwater will be monitored in both shallow and & deep monitoring wells, per DAR 14.2.
- All sampling will follow industry standards
- Monitoring results to be included in Annual Reports and Status of Environment Reports

Summary

- The Central tailings pond is being considered for the construction of non-hazardous landfill.
- Evaluation of onsite disposal options for arsenic trioxide wastes and water treatment plant sludge is currently ongoing.
- An ongoing maintenance and long term inspection and groundwater monitoring program will commence once the landfill site has been constructed.

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AIR QUALITY OVERVIEW

Giant Mine Remediation Project Environmental Assessment
Technical Sessions – October 17-21, 2011

Bruce Halbert, SENES Consultants Limited

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Air Quality Indicators

Key Indicators	Rationale
Particulate Matter	- Primary air quality contributor to human health - Emitted from local sources - Monitored by the GNWT in Yellowknife and AANDC at various locations on the Giant Mine site
Arsenic	- Primary contaminant of concern associated with Giant Mine and within the surrounding environment - Potential risk to human health and to terrestrial and aquatic biota - Monitored by the GNWT in Yellowknife and AANDC at various locations on Giant Mine site
Sulphur Dioxide and Nitrogen Oxides	- Emitted and measured locally - Potential effects on human health and terrestrial and aquatic biota - Can be transported from long-range sources - Chemically converted in the atmosphere to acid rain - Monitored by the GNWT in Yellowknife

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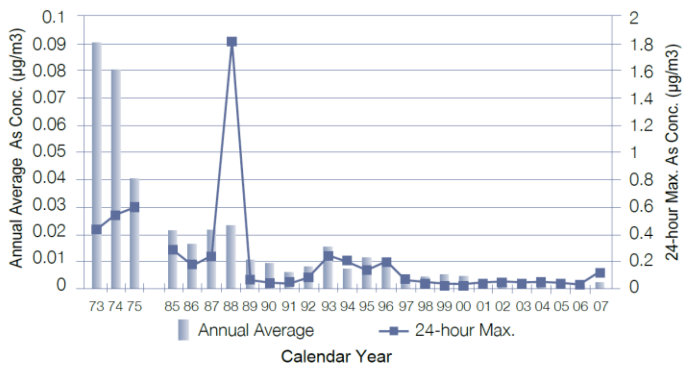
Yellowknife - Baseline Air Quality

Airborne Arsenic Concentrations



Source: GNWT – Environment and Natural Resources

Note: Since 1985, arsenic concentrations have exceeded the 24-hour arsenic criterion of 0.3 µg/m³ on only two occasions. Both events occurred in 1988 and coincided with a roaster baghouse malfunction.

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Positive Effects of Remediation

Air Quality

- During existing Care and Maintenance activities, dust mitigation measures are routinely carried out as required to limit dispersion of air-borne contaminants (dust and arsenic).
- Completion of the Remediation Phase will serve to immobilize existing sources of air-borne contaminants.
- The Remediation Project is expected to have long-term positive air quality benefits.

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Assessment of Potential Adverse Effects
Types of Effects

There is a potential that some negative effects on Air Quality will occur during the implementation of the Project including:

- Dispersion of particulate matter (i.e., dust);
- Mobilization of contaminants (specifically arsenic); and
- Combustion emissions.

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Assessment of Potential Adverse Effects
Methodology

- The DAR included a screening level air quality dispersion modeling assessment using the U.S. EPA Industrial Source Complex Short-Term (ISCST3) model.
- Maximum 1-hour, 24-hour and annual average ground-level concentrations of various air quality parameters were estimated at on-site and off-site sensitive receptor locations.
- It was conservatively assumed that the following activities were occurring simultaneously:
    - Freeze Plant Operation and Active Freezing;
    - Baker Creek Rehabilitation;
    - Contaminated Soils Excavation and Remediation;
    - Tailings and Sludge Pond Remediation;
    - Freeze System Installation; and
    - Buildings and Infrastructure Demolition and Disposal.

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Assessment of Potential Adverse Effects

Key Assumptions

- Peak power requirement of 3 megawatts (MW) was assumed to be provided by diesel-fired electricity generation at the Jackfish Power Plant;
- All other Project activities were assumed to occur for 10 hours per day, 7 days per week and 365 days per year. Winter activities were assumed to be 50% of the peak summer rates;
- Potential dust emissions are reduced by 80% during the unfrozen period of the year through light watering or application of chemical suppressants;
- During the winter months, it was assumed that mine roads would be sanded with clean material; and
- Arsenic emission rates were estimated as a percentage of TSP emission rates based on average concentrations from samples collected at each activity area of the site.

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Receptor Locations

The following receptor locations were selected for the effects assessment based on extended public use or occupancy:

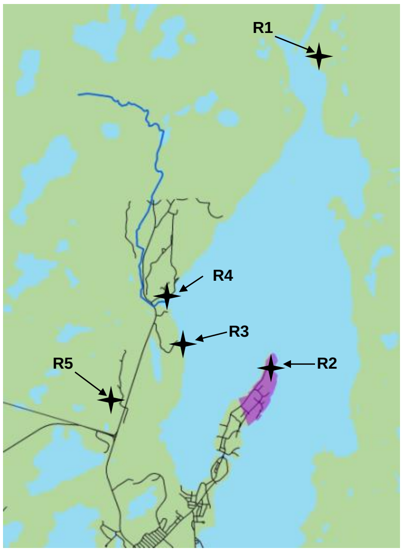
R1 - Yellowknife River Park;

R2 - N'dilo Residential Receptor;

R3 - Back Bay Residential Receptor;

R4 - Boat Launch Recreational Receptor;

R5 - Municipal Landfill Receptor.



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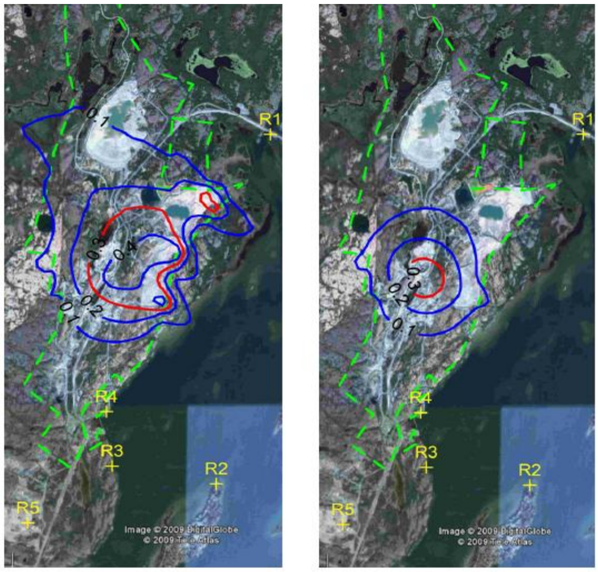
Modeling Results

Maximum 24-hour Arsenic Concentration (µg/m³)

With Wind Erosion | **Without Wind Erosion**



Boundary of the Site Study Area | Concentration isopleths | Areas exceeding the applicable criterion

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Modeling Results

Arsenic

Predicted Arsenic Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Maximum 24-hour Arsenic Concentration (µg/m³)
R1 - Yellowknife River Park	0.02
R2 - N'dilo Residential Receptor	0.01
R3 - Back Bay Residential Receptor	0.01
R4 - Boat Launch Recreational Receptor	0.02
R5 - Municipal Landfill Receptor	0.01
Ambient Air Quality Criterion	**0.3**
Background	**0.004**

Additional Modeling Results

Particulate Matter

Predicted Maximum Particulate Matter Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Annual Average Concentration (µg/m³)	Maximum 24-hour Concentration (µg/m³)		
	TSP	TSP	PM_{10}	$PM_{2.5}$
R1 - Yellowknife River Park	18	29	18	10
R2 - N'dilo Residential Receptor	19	30	15	9
R3 - Back Bay Residential Receptor	19	31	16	7
R4 - Boat Launch Recreational Receptor	20	47	25	10
R5 - Municipal Landfill Receptor	19	31	16	7
Ambient Air Quality Criterion	**60**	**120**	**50**	**30**
Background	**18**	**18**	**9**	**2**

Additional Modeling Results

Nitrogen Dioxide

Predicted Maximum Nitrogen Dioxide Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Annual Average Concentration (µg/m³)	Maximum 24-hour Concentration (µg/m³)	Maximum 1-hour Concentration (µg/m³)
R1 - Yellowknife River Park	6	14	98
R2 - N'dilo Residential Receptor	7	15	127
R3 - Back Bay Residential Receptor	7	16	150
R4 - Boat Launch Recreational Receptor	7	29	194
R5 - Municipal Landfill Receptor	8	29	220
Ambient Air Quality Criterion	**100**	**200**	**400**
Background	**6**	**6**	**6**

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Additional Modeling Results

Sulphur Dioxide

Predicted Maximum Sulphur Dioxide Concentrations in Air at Off-Site Sensitive Receptors

Receptor	Annual Average Concentration (μg/m³)	Maximum 24-hour Concentration (μg/m³)	Maximum 1-hour Concentration (μg/m³)
R1 - Yellowknife River Park	3	6	51
R2 - N'dilo Residential Receptor	3	8	77
R3 - Back Bay Residential Receptor	4	8	72
R4 - Boat Launch Recreational. Receptor	4	11	119
R5 - Municipal Landfill Receptor	3	9	121
Ambient Air Quality Criterion	**30**	**150**	**450**
Background	**3**	**3**	**3**

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Modeling Results

Overall Conclusions

Based on the screening level air quality assessment presented in the DAR:

- There are no predicted exceedances of any air quality indicators associated with the worst-case scenario at any of the sensitive receptor locations.
- Of particular importance, arsenic concentrations at all of the sensitive receptor locations are predicted to remain well bellow applicable criteria (<10%), even under the worst-case scenario.

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Air Quality Monitoring

- Air quality monitoring of TSP and metals has been in place at the Giant Mine since 2004. Ambient air quality monitoring is also performed by the GNWT in Yellowknife.
- The existing air quality monitoring program will be modified and incorporated into an Air Quality Environmental Management Plan (EMP) prior to initiation of active remediation.
- To facilitate adaptive management, the Air Quality EMP will identify Action Levels that trigger additional management actions, if required.
- Site wide air quality monitoring will be continued until surface remediation activities are complete and for three years thereafter. At that time, the need for continued monitoring will be assessed and revisions to the program will be made as appropriate.

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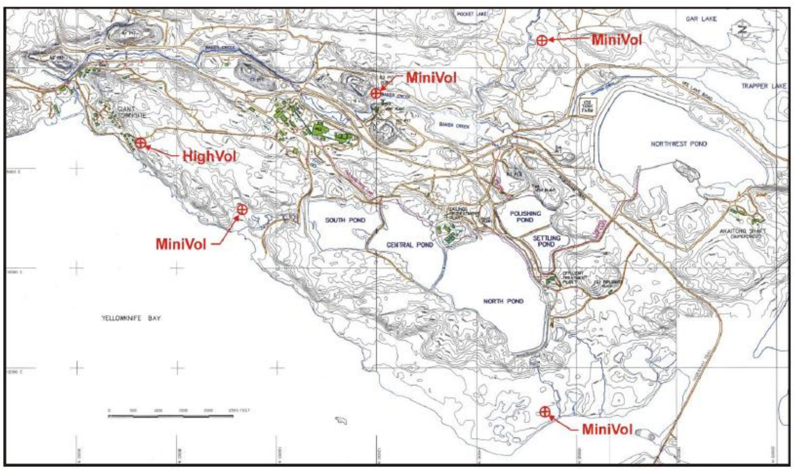
Proposed Air Quality Monitoring Stations



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Air Quality – Supplemental Studies

- The DAR air quality assessment assumed that the 3 MW of electricity required by the Remediation Project would be generated at the diesel-fired Jackfish Power Plant.
- During the Information Request (IR) process, a supplemental screening assessment was done based on the assumption that the Jackfish Power Plant would be operating at full capacity (27 MW).
- The supplemental screening assessment predicted that concentrations of nitrogen dioxide would be elevated at off-site locations under extreme meteorological conditions.
- Given the results of the screening level assessment, AANDC and the GNWT have initiated work on a more comprehensive air quality dispersion modeling (e.g., CALPUFF) of Jackfish Power Plant emissions to provide a clearer picture of potential cumulative effects of facility when operated at full rated capacity.

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Questions?

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