Dominion Diamond Corporation

Jay Project Developer's Assessment Report

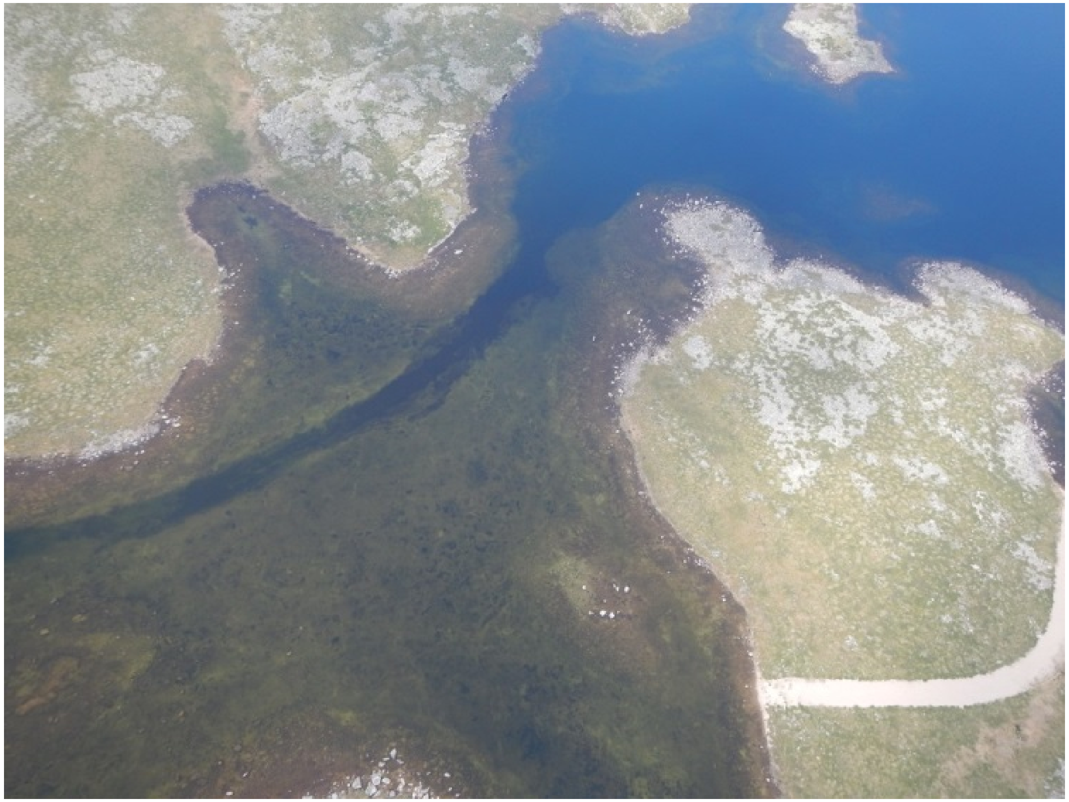
Water Quality

DOMINION DIAMOND

JAY PIPE

Overview

- DAR sections for the Water Quality
- Assessment approach
- Existing Environment
  - Methods
  - Results
- Project Mitigation
- WQ Assessment
  - Methods (modelling)
  - Results
- Conclusions
- Monitoring



Duchess Lake Outlet

DOMINION DIAMOND

JAY PIPE

Introduction

- Water quantity and quality is a Key Line of Inquiry (Section 8)
- Section talks about hydrogeology, hydrology, water quality and aquatic health
- This part of the presentation will focus on water quality

Section/ Appendix Number	Section Title
Section 8	**Key Line of Inquiry: Water Quality and Quantity**
Appendix 8A	Hydrogeological Model for Pre-Mining, Mining, and Closure
Appendix 8B	Hydrogeological Model for Jay Pit - Post Closure
Appendix 8C	Hydrogeological Model for Misery Pit – Post Closure
Appendix 8D	Regional Water Balance Model
Appendix 8E	**Site Discharge Water Quality Modelling**
Appendix 8F	**Hydrodynamic Models of Lac du Sauvage and Lac de Gras**
Appendix 8G	**Hydrodynamic Model of Jay and Misery Pits**
Appendix 8H	**Acute Toxicity Testing of Predicted Jay Effluent**
Annex III	Geology Baseline
Annex VIII	Geochemistry Baseline
Annex IX	Hydrogeology Baseline
Annex X	Hydrology Baseline
Annex XI	**Water and Sediment Quality Baseline**

DOMINION DIAMOND

Developer's Assessment Approach

Assessment Endpoints and Measurement Indicators – Water Quality

Assessment Endpoint	Measurement Indicator

• Maintenance or suitability of surface water quality for healthy and sustainable aquatic and terrestrial ecosystems
• Ecological function is maintained
• Aquatic life is not impaired
• Water is good to drink
	• Concentrations of water and sediment quality constituents:
	  • Field-measured water quality parameters (e.g., temperature, dissolved oxygen, pH, conductivity)
	  • Major ions, total suspended solids, nutrients, and metals in water
	  • Distribution of particle size in surficial lake sediments
	  • Nutrients and metals in sediments

Existing Environment – Methods and Assessment Areas

Baseline and Effects Study Area – Water Quality (1995-2013)

Includes:

- the area used to characterize existing conditions
- Lac du Sauvage basin and tributaries draining into Lac du Sauvage
- Lac de Gras basin and tributaries draining into Lac de Gras

Existing Environment - Results

Lac du Sauvage

Lac de Gras

Lac du Sauvage outlet

Lac de Gras outlet

DOMINION DIAMOND

JAY PIPE

Existing Environment - Results

Other lakes and streams

- Circumneutral, soft water, sensitive to acid deposition
- Low TDS (10 to 28 mg/L in lakes; 11 to 55 mg/L in streams); Ca^{2+},HCO_3^-, SO_4^{2-} dominant
- Low nutrients; trophic status ranged from oligotrophic (Counts) to meso-eutrophic (Duchess)
- Low metals; Al, Cr, Cu, and Fe above CWQGs in study area
- Sediments are primarily silt (at least in areas sampled)
- Ar and Cr often above SQGs; Cu sometimes above SQGs; Hg never above SQGs

Periphyton in an upstream stream

DOMINION DIAMOND

JAY PIPE

Existing Environment - Results

Water Quality – Traditional Knowledge (summarized from Annex XVII)

- Surface water has been used as part of the traditional lifestyle such as for transportation, drinking, fishing, cleaning, and preparation of hides
- The surface water near the Ekati Mine has been described as clear and pure, and is considered high quality for drinking
- Surface water in Lac de Gras has been described as good quality with good taste
- Quality of water is evaluated through:
  - observation of health of submerged vegetation, birds, wildlife, and fish
  - presence/absence of surface foam
  - presence/absence of vegetation
  - clarity, movement, temperature, and taste
- The narrows or outlets of the large lakes stay open for most or all of the winter and are used for fish harvesting and sources for drinking water

Assessment Approach

Assessment Cases

- Base Case – range of conditions over time within the effects study area before application
- Application Case – predictions of the cumulative effects of the Project and existing and approved projects
- Reasonably Foreseeable Development Case

Base Case		Application Case	Reasonably Foreseeable Development Case
Reference Condition	2014 Baseline Conditions		
No or minimal human development • Pre-Ekati	Conditions from all previous, existing, and approved developments before the Project • Ekati and Diavik mines	Base Case plus the Project • Ekati (modified from baseline) and Diavik	Application Case plus reasonably foreseeable developments

DOMINION DIAMOND

JAY PIPE

Assessment – Key Mitigation Summary for Water Quality

Mitigation strategies to reduce potential effects on Water Quality:

- Storage of fine PK (which can be a source of nutrients and metals) in mined-out pits
- Storage of minewater in Misery Pit to delay release to the environment, and limit the period of any minewater release to 5 years
- Transfer of high TDS water to the bottom of the Jay Pit at closure
- Use of a diffuser to control rate and location of minewater release into LdS, to promote mixing, and to prevent erosion of lake bed sediments
- Use of erosion and sediment control measures , such as silt curtains, and detailed monitoring, to manage sediment mobilization and transport
- Use of non-PAG materials for construction near and in water (e.g., dike)
- Management and treatment of sewage at one central location
- Regular application of dust suppression strategies
- Regular maintenance of equipment to reduce emissions

DOMINION DIAMOND

JAY PIPE

Assessment – Primary Pathway

The water quality assessment focused on activities that could directly change water quality, plus considered related effects to hydrogeology and hydrology that could carry through to water quality

- Pathways were identified and screened:
  - 5 No Linkage pathways were identified
  - 6 Secondary pathways were identified
  - 8 Primary pathways were identified and assessed through 2 effects statements:

- Effects of acidifying air emissions and the deposition of dust and metals from air emissions to water quality

- Effects of Project activities to water quality in Lac du Sauvage and Lac de Gras during operations and post-closure

DOMINION DIAMOND

JAY PIPE

Assessment – Primary Pathway – Acidifying Air Emissions

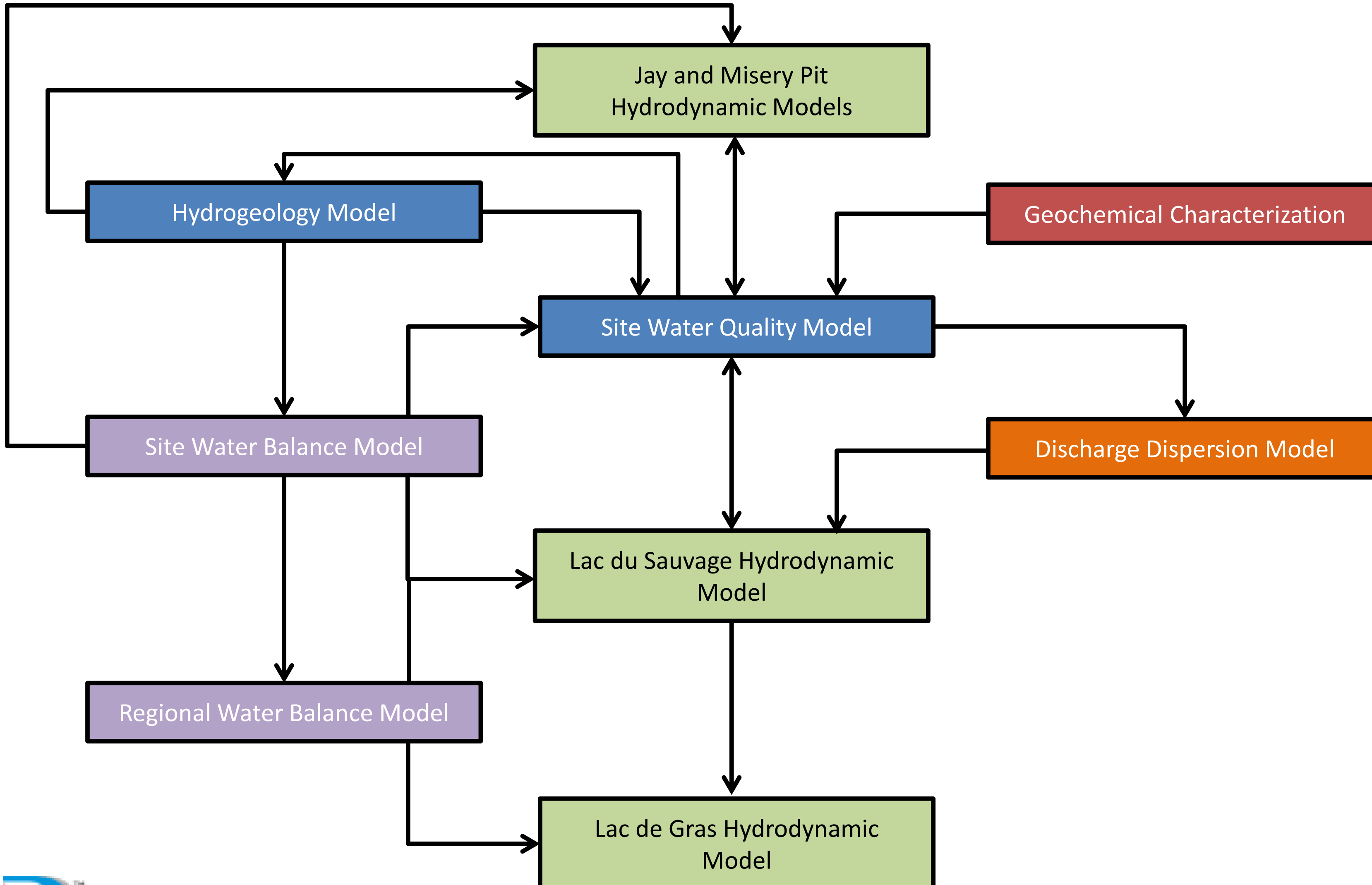
Water Quality - Effects of acidifying air emissions

- The air emissions assessment for surface waters considered the effects of aerial deposition from the Project and surrounding developments on the surface water chemistry of small lakes in the area

- Acidification
  - Incremental Project-related deposition of sulphate and nitrate to the lakes is not predicted to result in lake acidification

- Dust and metals
  - The deposition of metals is expected to decrease in the Application Case
  - The deposition of dust is predicted to decrease in four of the lakes, but increase in two of the lakes
  - The effect of dust deposition is predicted to be small and restricted to localized areas within and close to Project activity

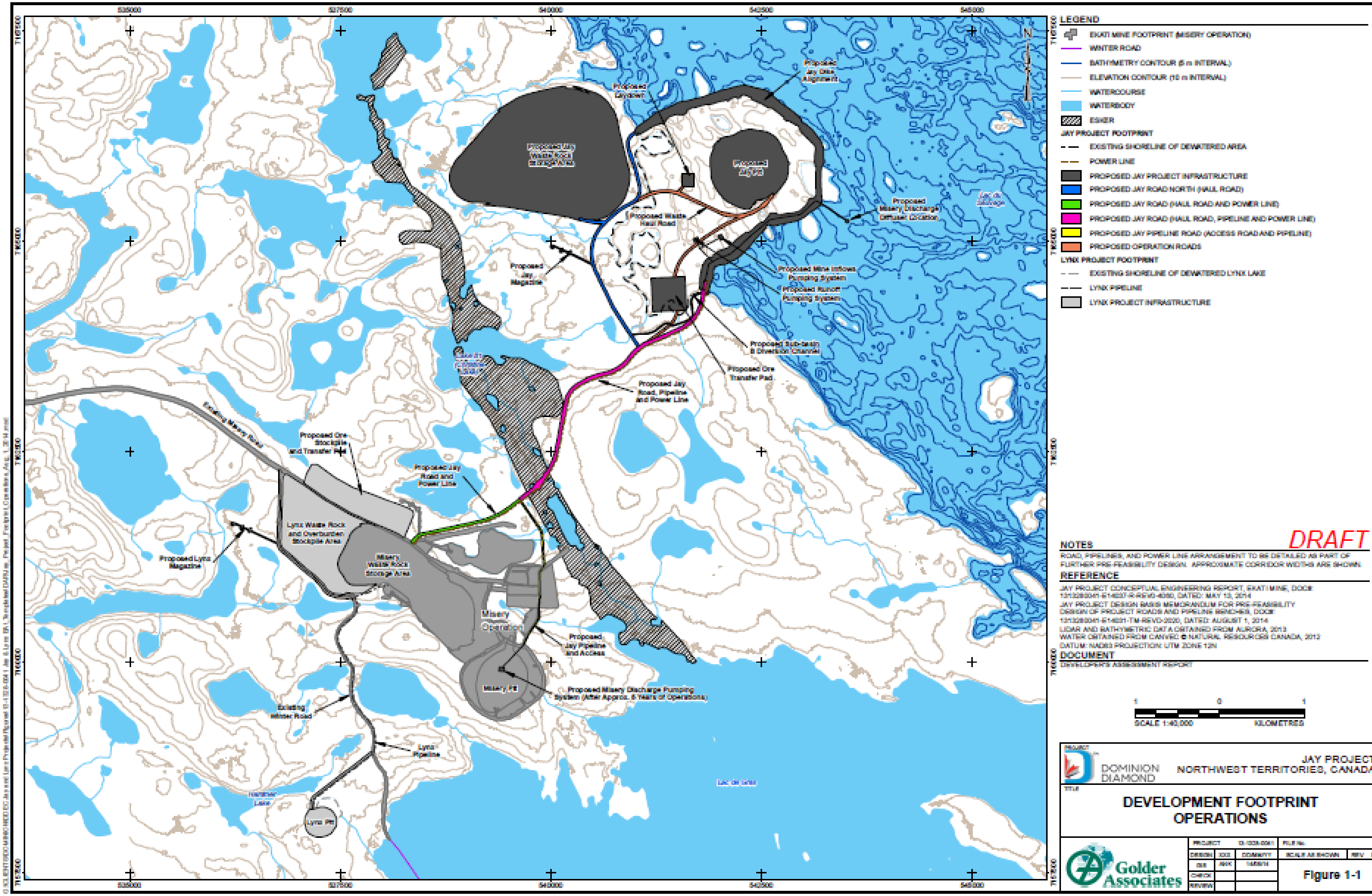
Assessment – Water Quality Modeling



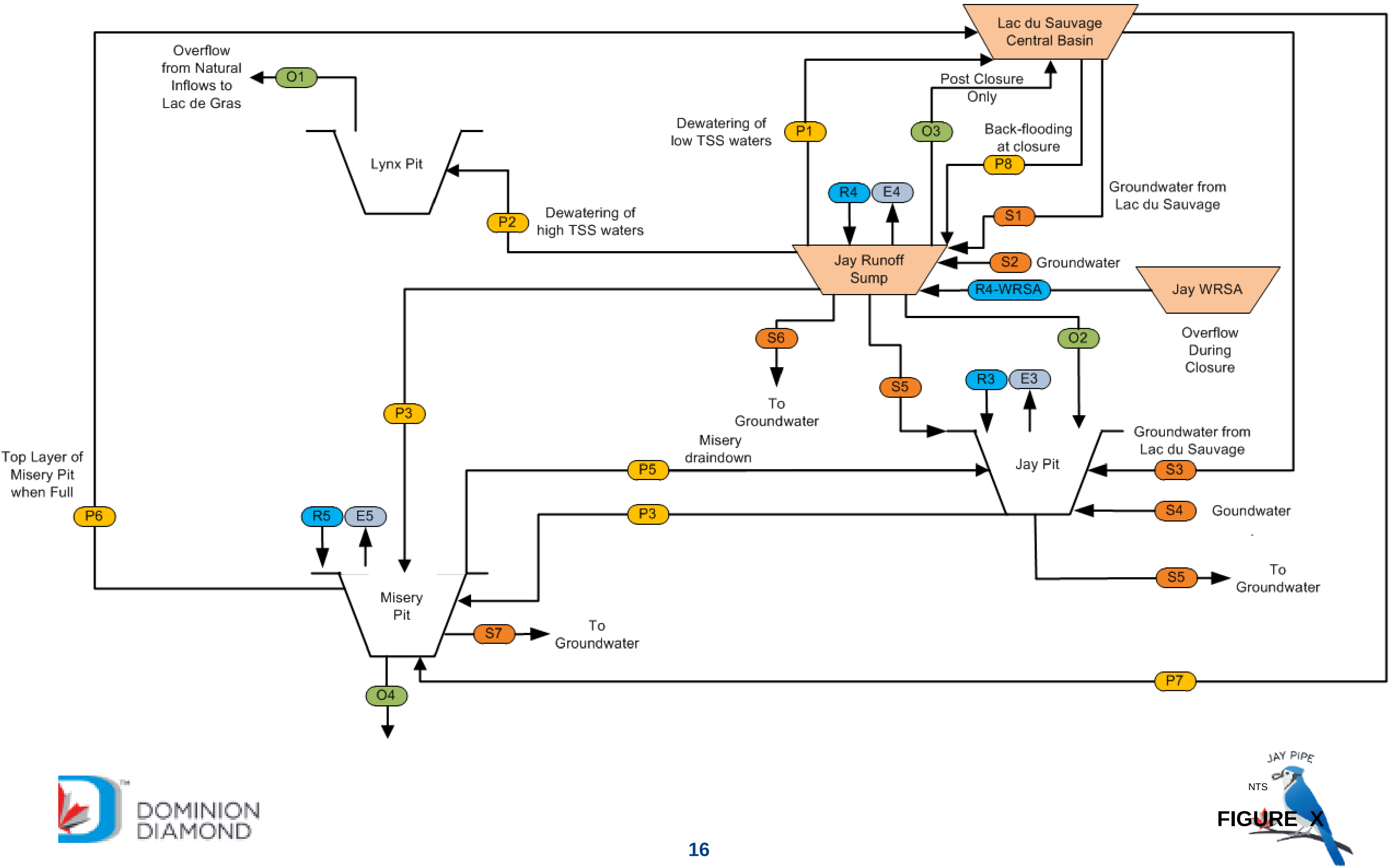
DOMINION DIAMOND

JAY PIPE

Assessment - Site Water Quality Model



Assessment – Conceptual Water Quality Model

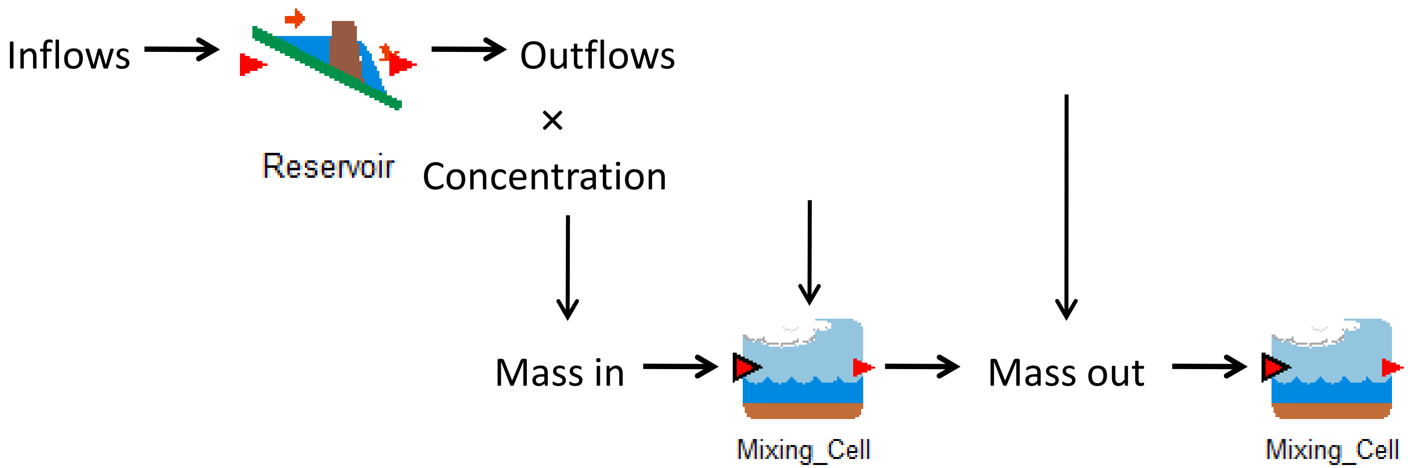


DOMINION DIAMOND

How is water quality calculated in GoldSim™?

GoldSim™ has elements designed to facilitate water quality modeling

Reservoirs - Volumes



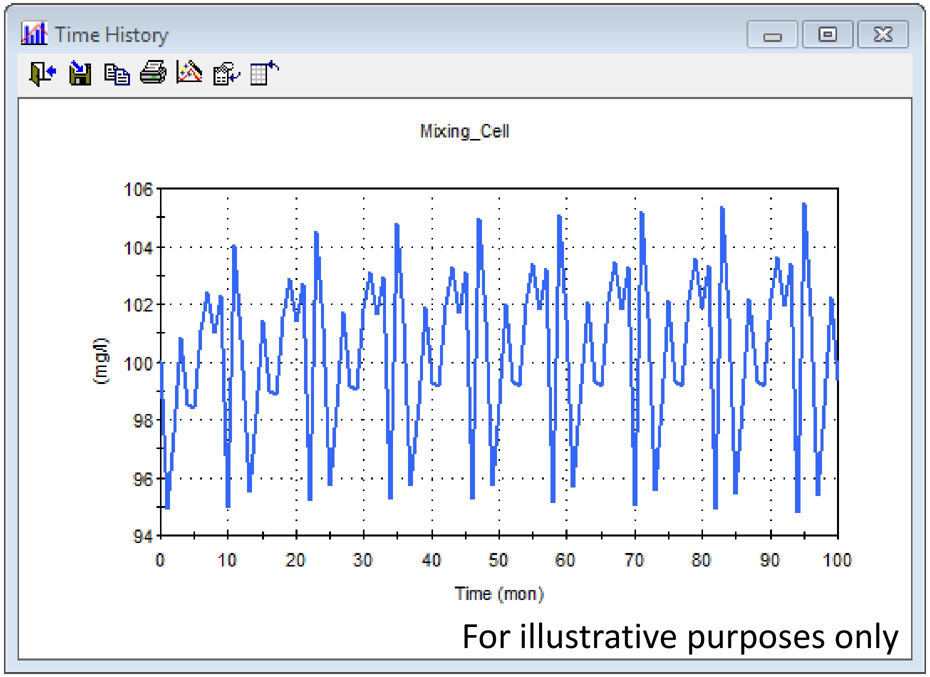
Cell Pathways – Water Quality

Cell pathways are used to track mass inflow and outflow rates to simulate the water quality of a body of water

Assessment – Site Water Quality Model

How is water quality calculated in GoldSim™?

GoldSim™ has elements designed to facilitate water quality modeling



Cell pathways are used to track mass inflow and outflow rates to simulate the water quality of a body of water

Model Inputs

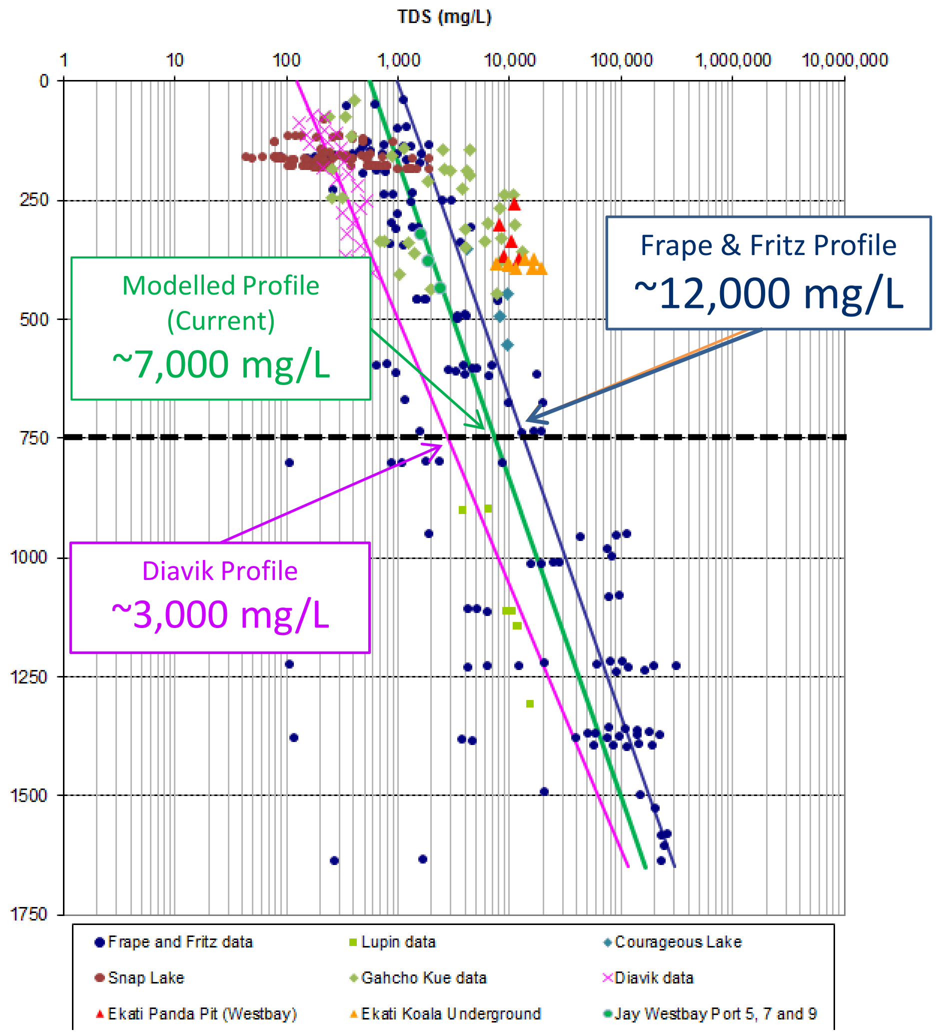
- Total Dissolved Solids
- Major Ions
    - Cl, Ca, Na, Mg, K, SO_4, F
- Dissolved Inorganic Nutrients
    - NO_3, NH_4, P
- Total and Dissolved Metals
    - Ag, Al, As, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Hg, Li, Mn, Mo, Ni, Pb, Sb, Se, Si, Sn, Sr, Ti, Tl, U, V, Zn

Model Inputs

- Surface water and natural runoff
  - Median value from Lac du Sauvage baseline monitoring data
- Open pit water quality
  - Simulated in model
  - NO_3 and NH_4 inputs use median value from pit sump monitoring data from Ekati
- Groundwater
  - TDS simulated in hydrogeological model
  - Parameters correlated to TDS calculated using TDS
  - Parameters not-correlated to TDS use the median value from groundwater baseline data from Ekati, Diavik, and Westbay

Groundwater Profile

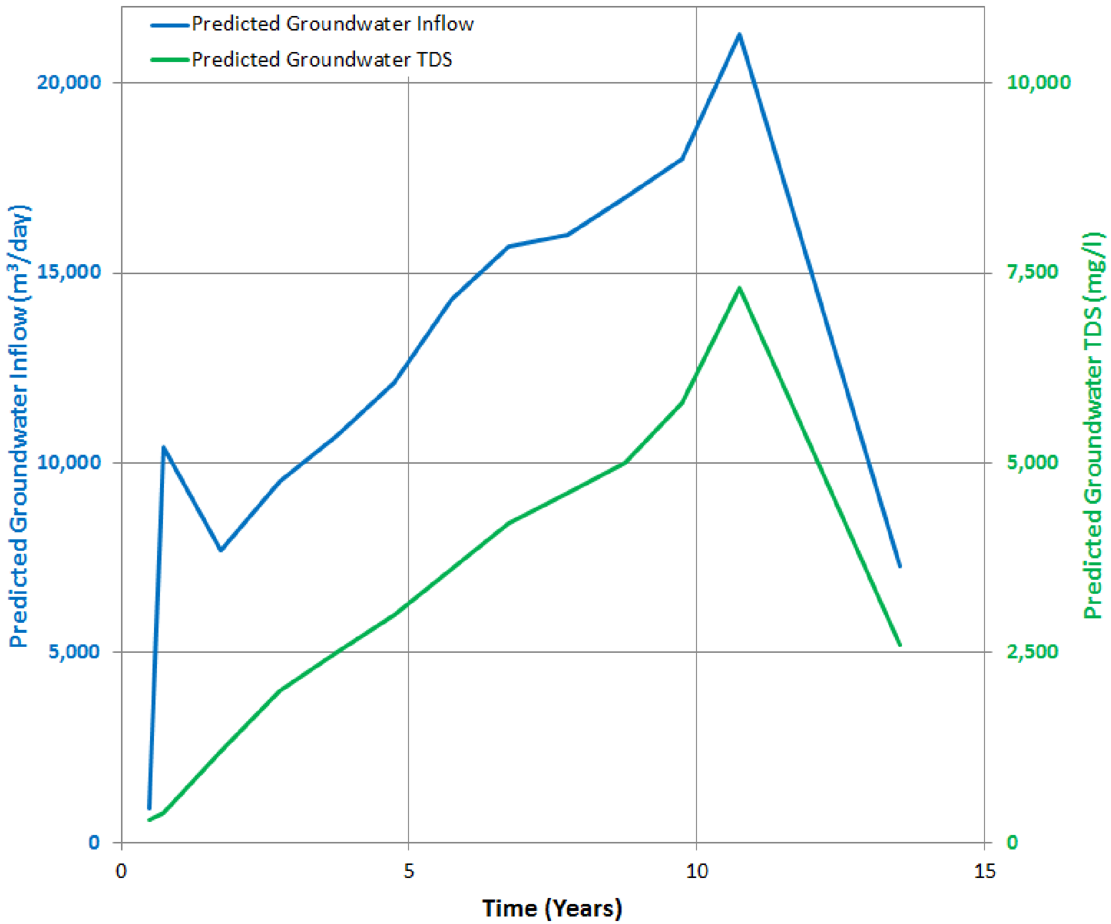
750 m Depth



DOMINION DIAMOND

JAY PIPE

Predicted Groundwater Quantity and Quality



Period	Phase	Duration (Days)	Lakewater (%) in Total
1	Dewatering	180	0%
2	Stripping	90	0%
3	OP Mining	365	1%
4	OP Mining	365	16%
5	OP Mining	365	29%
6	OP Mining	365	37%
7	OP Mining	365	42%
8	OP Mining	365	48%
9	OP Mining	365	54%
10	OP Mining	365	58%
11	OP Mining	365	59%
12	OP Mining	365	56%
13	Closure (OP Flooding)	1018	74%
14	Closure (Sump Flooding)	332	NA

OP: Open Pit

DOMINION DIAMOND

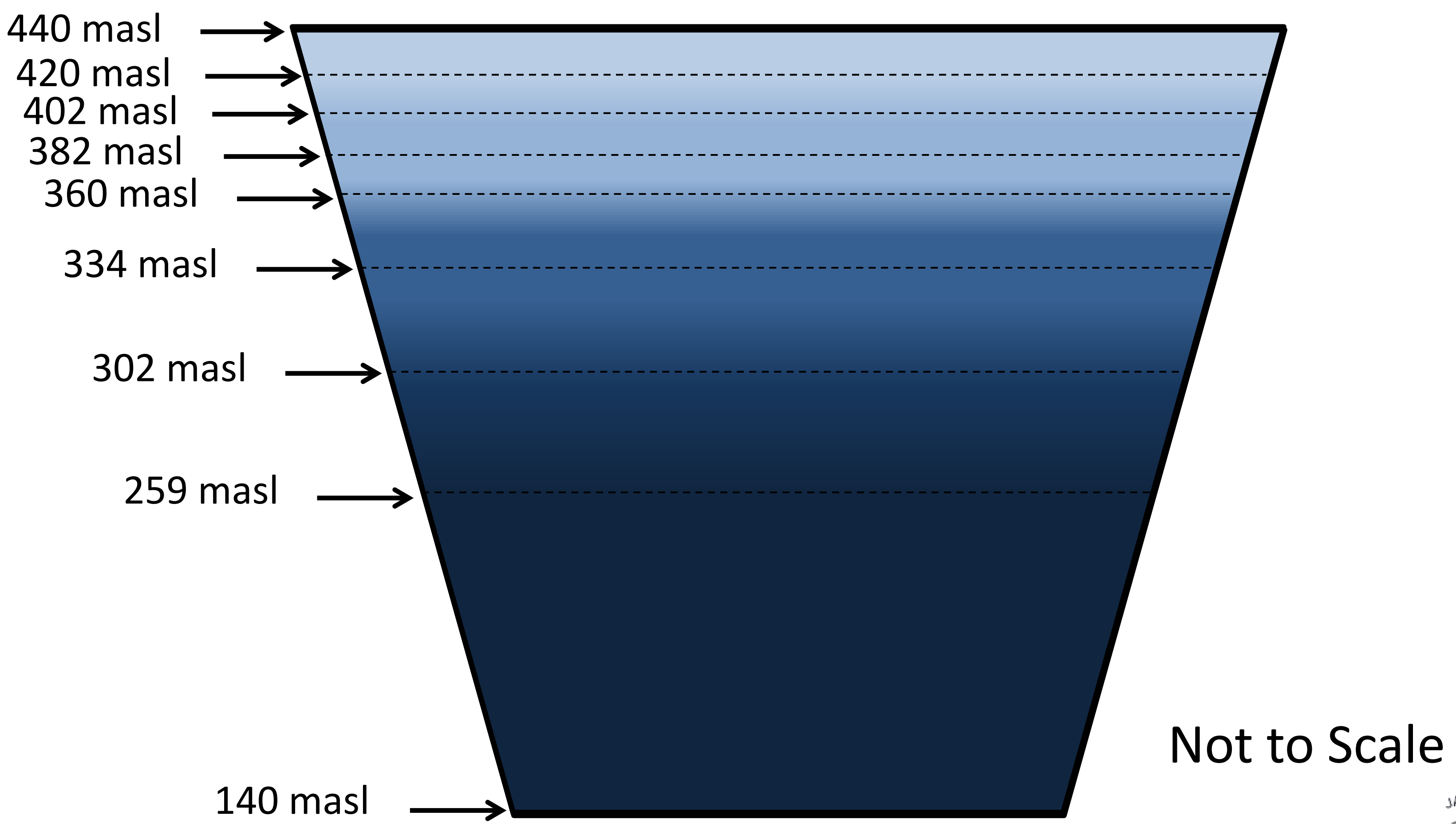
JAY PIPE

Model Inputs

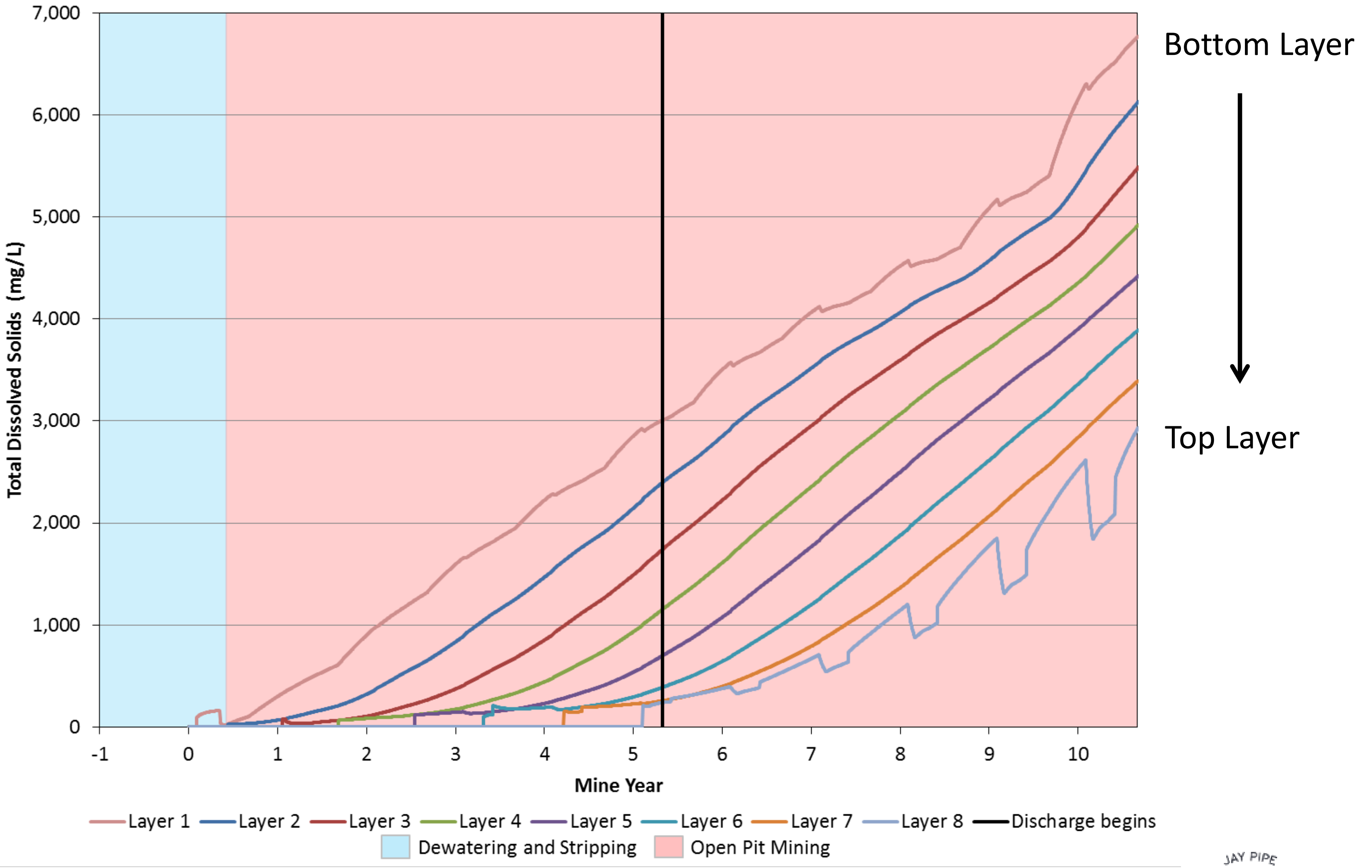
- Model inputs used for waste rock storage area runoff, roads runoff, and pit wall runoff applied stochastic methods to generate a range of results
  - A statistical distribution was developed for each parameter (normal, log-normal, or uniform distribution, or a single constant value)
  - The model was run for 200 realizations
  - For each realization, a value for each parameter was chosen as an input, based on their respective statistical distributions

Assessment – Misery Pit Conceptual Model - Operations

Conceptual Pit Lake Stratification



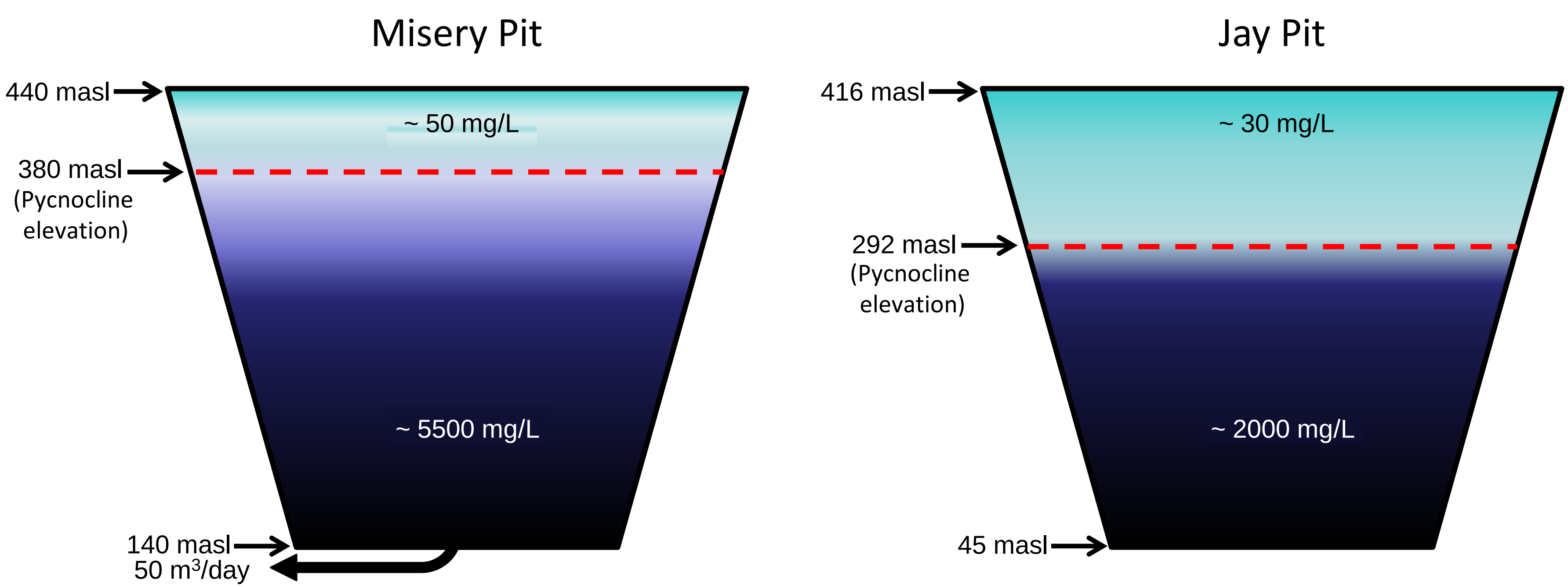
Results – Misery Pit Water Quality



DOMINION DIAMOND

JAY PIPE

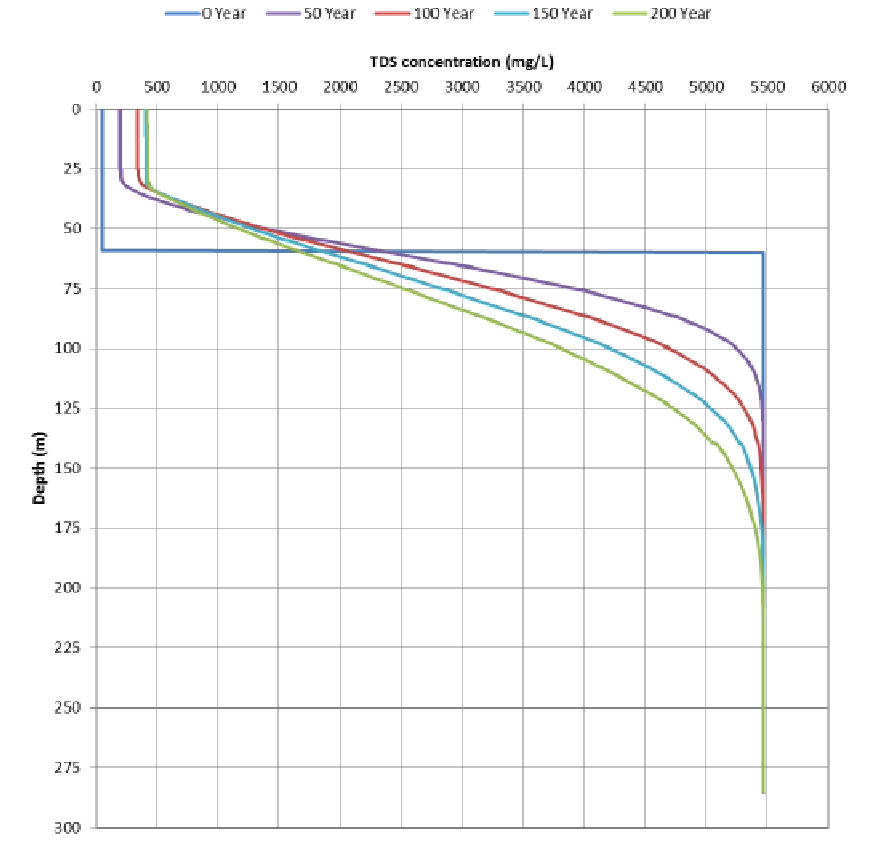
Assessment – Pit Lake Conceptual Model - Post-Closure



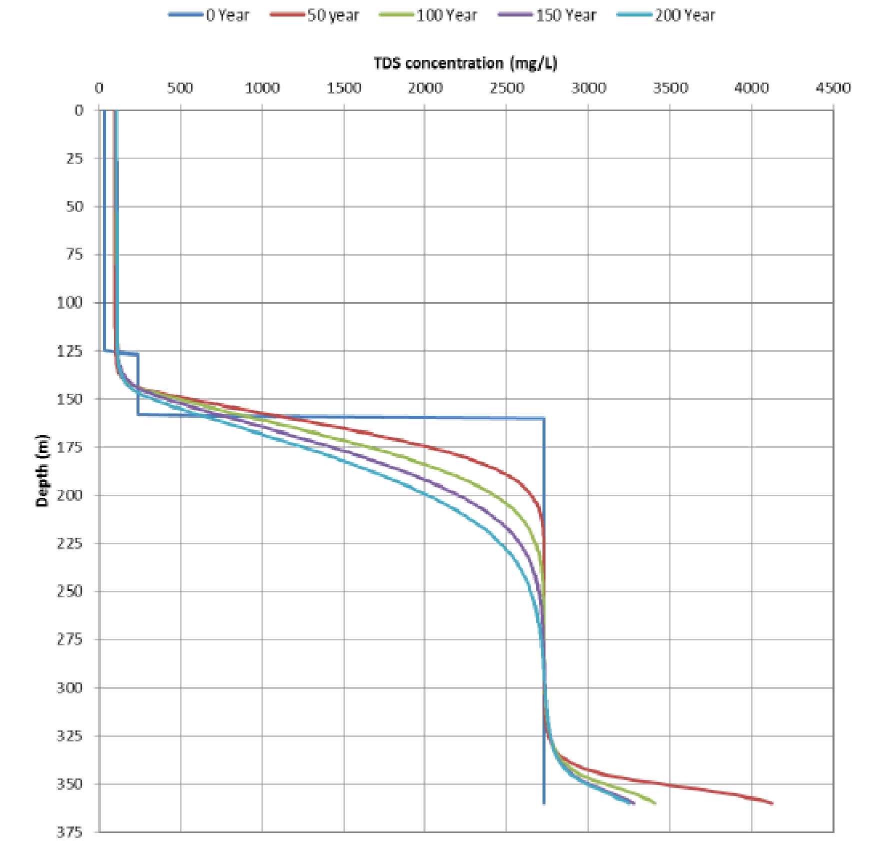
Not to Scale

26

Results – Hydrodynamic Water Quality Model Results



m = metres; mg/L = milligrams per litre.

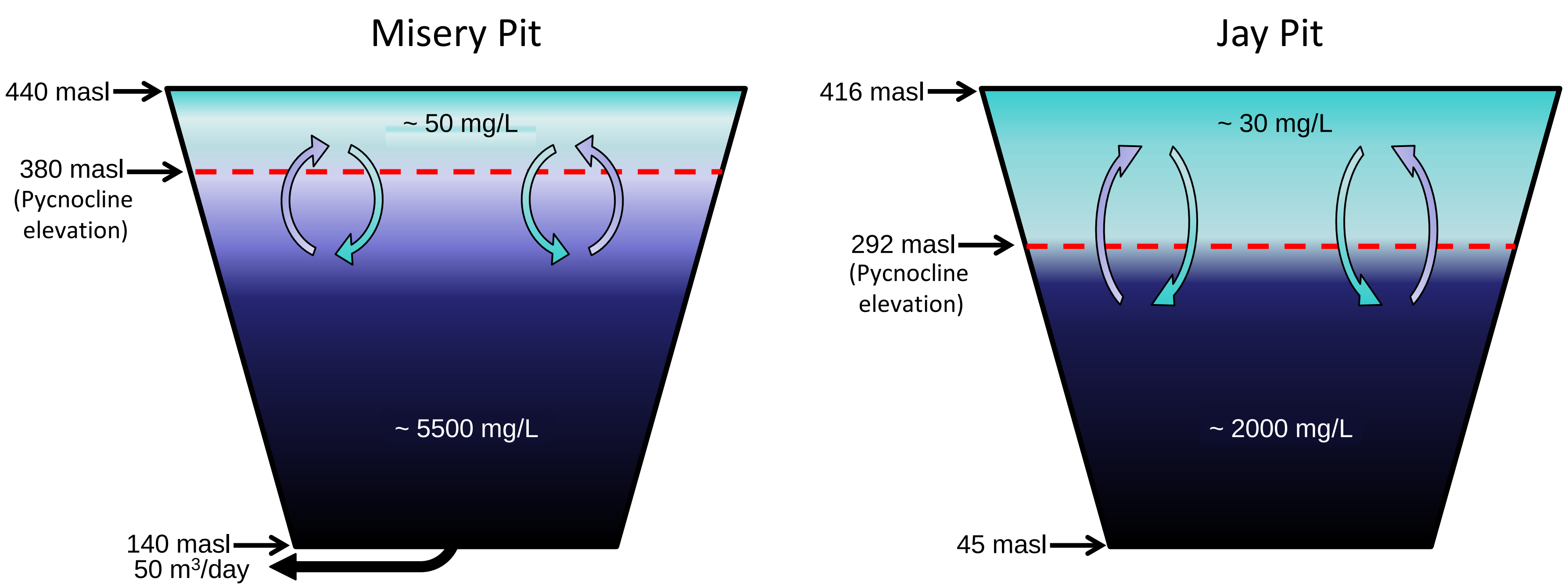


m = metres; mg/L = milligrams per litre.

DOMINION DIAMOND

JAY PIPE

Assessment – Pit Lake Conceptual Model - Post-Closure

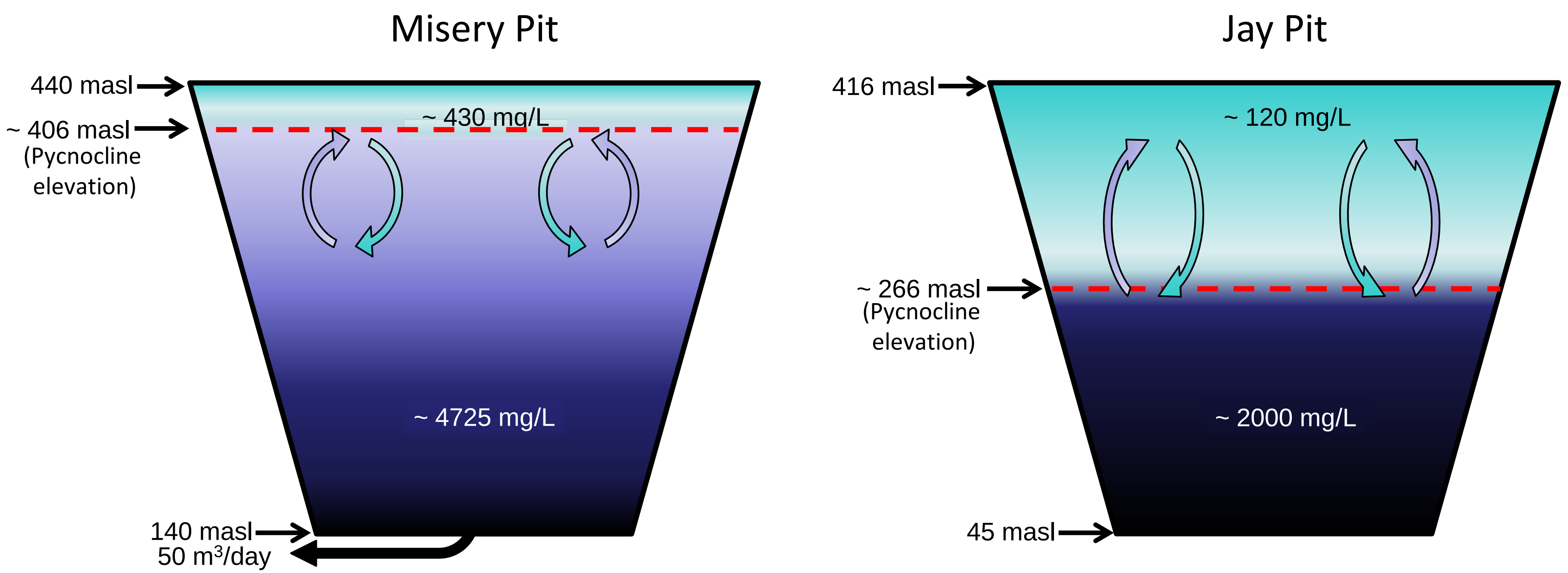


Not to Scale

DOMINION DIAMOND

JAY PIPE

Assessment – Pit Lake Conceptual Model - Post-Closure

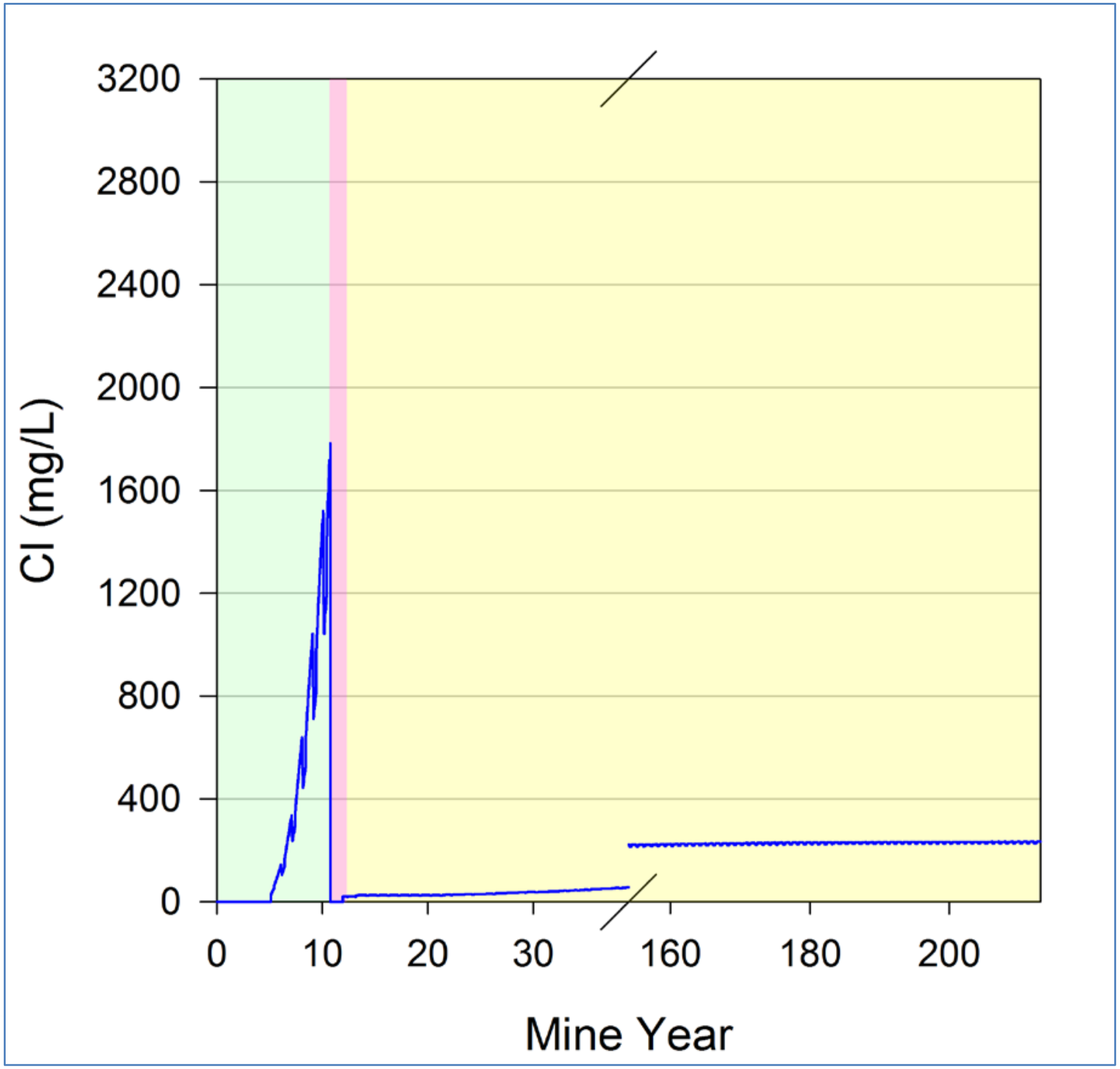


Not to Scale

DOMINION DIAMOND

JAY PIPE

Results – Misery Pit Discharge Water Quality

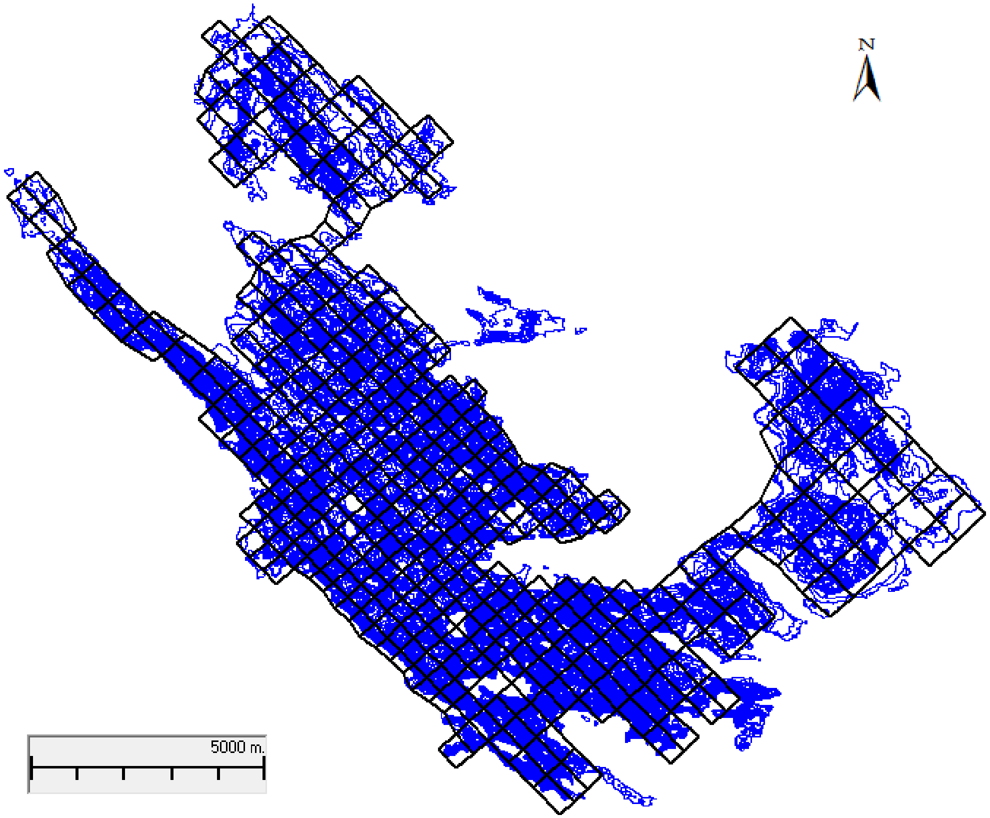


Near-Field Modelling

- A CORMIX model was developed to determine the dilution factor in Lac du Sauvage at the edge of the mixing zone
- The dilution factor is based on several variables including:
  - Density of the discharge
  - Hydrodynamics of the receiving environment
- Several scenarios were evaluated to determine the minimum near field mixing in the CORMIX model:
  - Number of diffuser ports
  - Port spacing along the diffuser
  - Open water wind conditions
  - Ice cover
  - Discharge orientation

Hydrodynamic Modelling: Lac du Sauvage

- Grid spacing varied between approximately 400 m and 800 m horizontally
- Vertical grid resolution was approximately 2 m
- The grid comprised a total of 10 active vertical layers, and 1,552 active cells
- For operations, a portion of the grid was removed to represent the diked of mining area

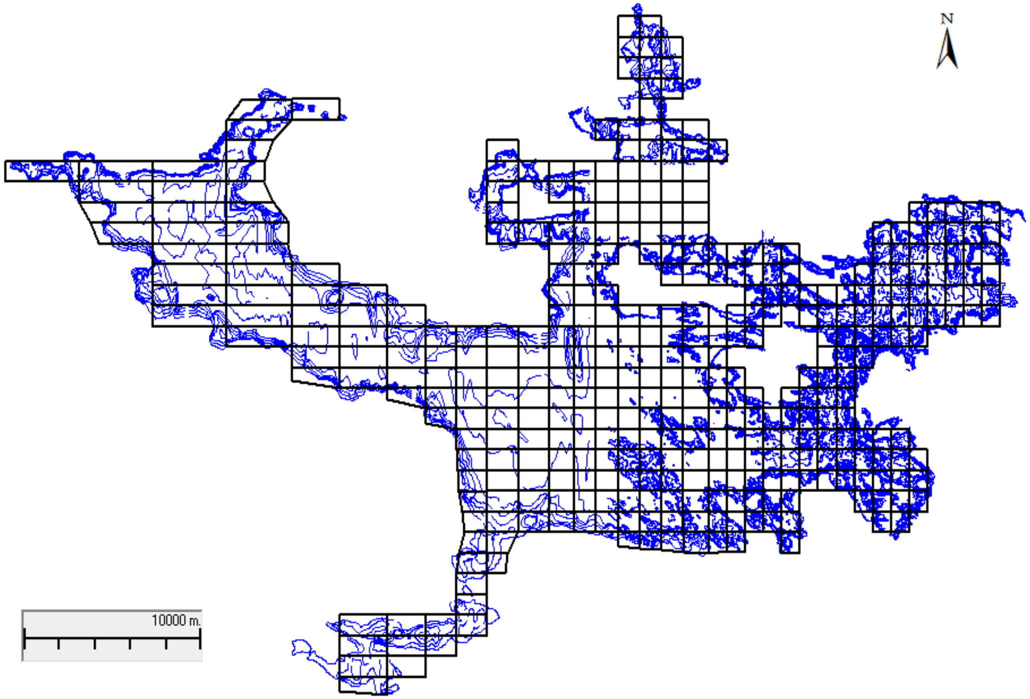


DOMINION DIAMOND

JAY PIPE

Hydrodynamic Modelling: Lac de Gras

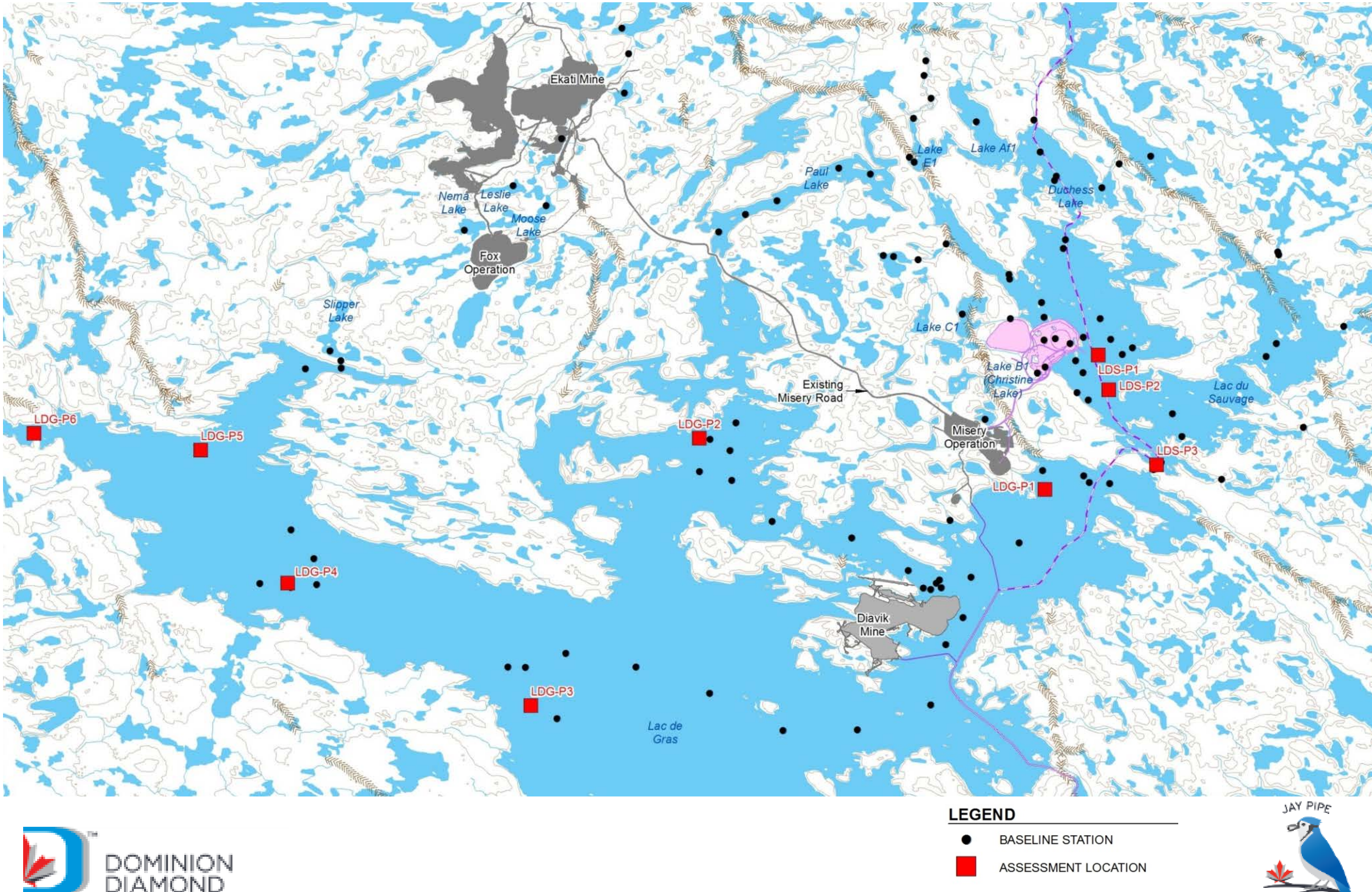
- Grid spacing varied between approximately 1,000 m and 4,000 m horizontally
- Vertical grid resolution was approximately 2 m
- The grid comprised a total of 13 active vertical layers, and 2,298 active cells



DOMINION DIAMOND

JAY PIPE

Assessment – Effects to Lac du Sauvage and Lac de Gras



DOMINION DIAMOND

JAY PIPE

Conservatism and Assumptions

- Conservatism has been incorporated into each of the integrated models used to estimate water quality conditions and into the various source chemistry profiles
- The models were calibrated before running Project simulations
- The approach was to be more conservative to provide a high level of confidence that the results do not underestimate the projected change in water quality conditions
    - High level of confidence that the worst-case condition has been assessed
- There is high level of confidence in the predicted concentrations but with the caveat that monitoring of source terms is required to verify the input assumptions and monitoring of the lakes is required to verify the movement and assimilation patterns in the lakes

Assessment – Effects to Lac du Sauvage and Lac de Gras

- Simulated final discharge minewater quality used in the hydrodynamic model was evaluated for potential toxicity
- Results suggest that effluent will be non-acutely toxic and will not result in localized effects to aquatic life in Lac du Sauvage

- Predicted concentrations for each assessment node for each temporal snap-shot

- Compared the predictions to a screening threshold
  - Ekati Site-specific Water Quality Objectives
  - Canadian aquatic life guidelines
  - Health Canada drinking water guidelines
  - Guidelines from other regions (British Columbia)
  - Published literature
  - Maximum measured recent baseline

- Compared the predictions to the screening threshold to identify parameters of concern or parameters for further review

DOMINION DIAMOND

JAY PIPE

Assessment – Results (WQ Constituent Screening)

Are concentrations of any WQ constituent greater than 10% of their existing condition concentrations?

- No
  - The WQ constituent does not require further review because the Project has not caused a change in the constituent concentration <u>and</u> projected concentrations unlikely to affect aquatic biota or use
- Yes
  - The Project has resulted in a WQ change in the constituent concentration

If yes, are concentrations of any WQ constituent greater than any WQ guidelines or site-specific benchmarks?

- No
  - Trends in the WQ constituent were discussed, but projected WQ constituent concentration unlikely to affect aquatic biota or use
- Yes
  - The WQ constituent is retained for further review under aquatic health, because there is potential for toxicological effect

DOMINION DIAMOND

JAY PIPE

Assessment – Effects to Lac du Sauvage and Lac de Gras

Screening Result	Lac du Sauvage	Lac de Gras
Concentrations are predicted to increase but remain less than the screening value • toxicological effect not anticipated but change due to the Project	• TDS, chloride, potassium, sodium, sulphate, ammonia, nitrate, TP, aluminum, barium, molybdenum, strontium, and uranium • cobalt	• TDS, chloride, potassium, sodium, sulphate, ammonia, nitrate, TP, aluminum, barium, molybdenum strontium, and uranium • arsenic, cadmium, chromium, iron, manganese, nickel, selenium, and vanadium
Concentrations are predicted to increase above the screening value • potential toxicological effect	**None**	**None**

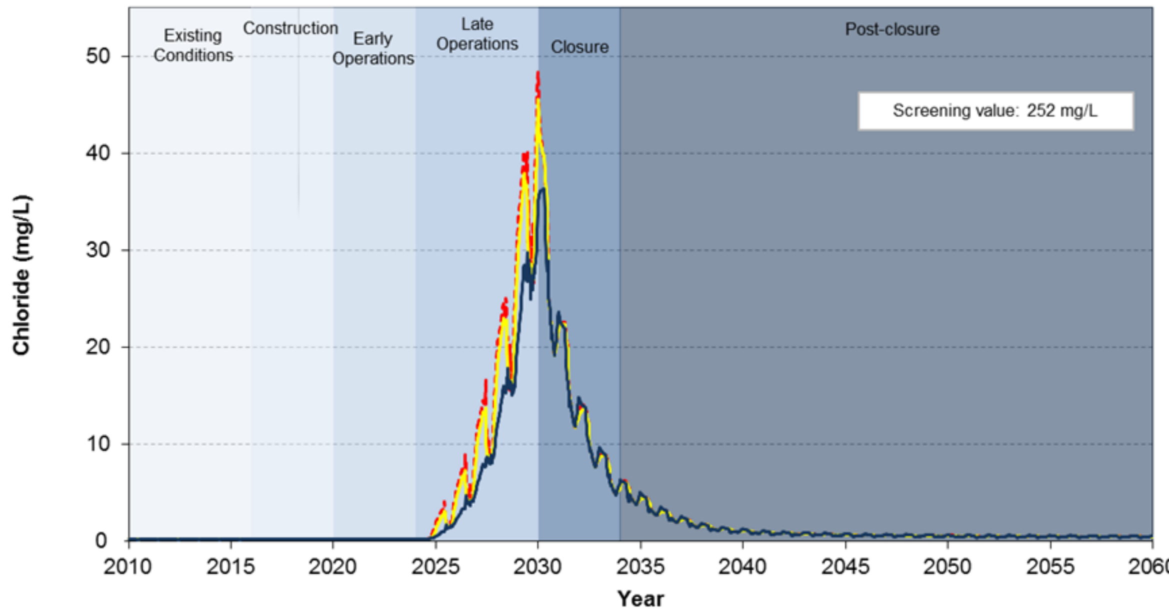
DOMINION DIAMOND

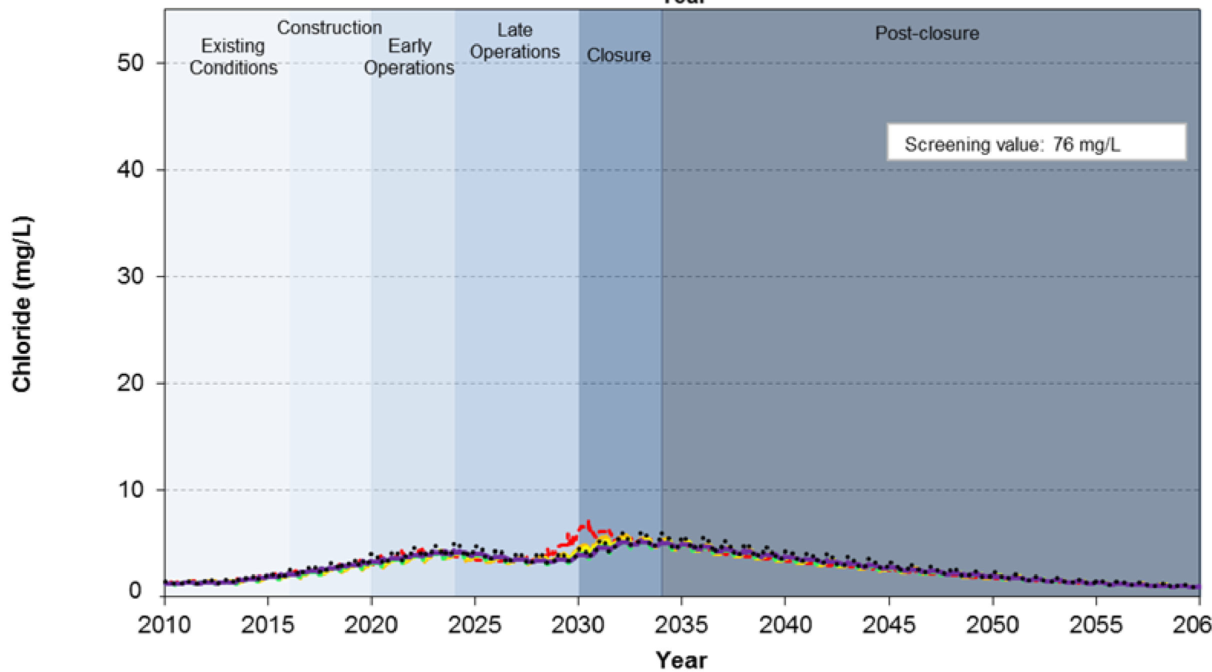
JAY PIPE

Assessment – Results

Example - Chloride

- Responses in LdS and LdG different
- In LdS, response limited to 6-year discharge from Misery Pit
- In LdG, influence from Project discharges to LdS are considerably smaller
- Two peaks in LdG: one linked to Ekati and Diavik inputs, and the second due to LdS (Project) inputs
- Concentrations less than screening threshold





DOMINION DIAMOND

Assessment – Water Quality Summary

- Misery Pit Minewater (for discharge):
  - not predicted to be acutely toxic and localized effects to aquatic life in Lac du Sauvage due to minewater release are not expected
- WQ in LdS and LdG:
  - Concentrations of water quality constituents are predicted to change due to the Project
  - Some modelled WQ constituents differ from the existing conditions (i.e., more than 10% higher than measured maximum values)

    TDS, chloride, ammonia, TP, aluminum, strontium
  - Trends in these constituents were reviewed were evaluated further by Aquatic Health for potential effects to biota
  - However, all predicted WQ constituent concentrations are less than the screening guidelines and benchmarks, and no constituents of concern were identified

DOMINION DIAMOND

JAY PIPE

Impact Classification and Significance – Water Quality

- DAR used multiple approaches and best practices for making predictions
  - Primary Pathways
    - Acidifying air emissions
    - Project activities including management and release of minewater
- Uncertainty addressed through applied conservatism throughout the assessment
  - actual effects would not be underestimated
- Project effects to WQ were classified as being:
  - low magnitude, local to regional in geographic extent, short-term to permanent in duration, continuous in frequency, and reversible to irreversible

Conclusion

- Incremental and cumulative effects from the Project and other developments will not result in significant adverse effects to water quality
  - Water quality will continue to provide for a healthy and sustainable ecosystem
  - Ecological function in LdS and LdG will be maintained and aquatic life will not be impaired
  - Water can be used as a drinking source by humans and wildlife

DOMINION DIAMOND

JAY PIPE

Follow-up and Monitoring – Water Quality

Monitoring programs proposed

- They will address the uncertainties associated with the effect predictions and the performance of environmental design features and mitigation related to the Project
- Several monitoring programs for water quality are requirements for the Type A Water Licence
  - Geochemical site audits
  - SNP
  - AEMP
- More details for the monitoring programs will be developed in the permitting phase, but it is anticipated that they will be an extension of existing Ekati Mine monitoring programs

Thank You