Water Model Evaluation Plans
NorthMet Project

Revised Draft
23 December 2011

1.0 Introduction

The NorthMet Project SDEIS is using computational models to estimate the potential for pollutants that leach from mine waste to degrade the quality of surface or groundwater. The generic term for the type of models proposed for the NorthMet project water quality predictions is "dynamic systems models (DSM). These are computational tools that track the movement of material through various compartments. The specific code used for the NorthMet project is GoldSim, a proprietary but publically available DSM. Two models are being developed for the NorthMet DEIS. The first will evaluate the Mine Site, including open pits, waste rock stockpiles, overburden storage areas, waste water treatment plant (WWTP), surface water flow, groundwater containment, and offsite groundwater migration. The second will cover the Plant Site, including process facilities, ponds, WWTP, existing tailings basin, future tailings disposal, surface water flow, groundwater containment, and offsite groundwater migration. The water-quality models for the NorthMet project are probabilistic, so that uncertainty in the parameters describing the release and transport of pollutants is used to estimate uncertainty in predictions.

The model calculations are supported by extensive site-specific measurements of pollutant concentrations in the waste and the rate at which these pollutants leach from these materials. In the period since the models were first applied for the 2009 NorthMet DEIS, they have undergone extensive revision in an "Impact Assessment Planning" (IAP) process—a collaborative effort in which the project co-lead agencies (MnDNR, USACE, and USFS), and technical experts from participating agencies (USEPA) and tribes, met repeatedly to refinement the water quality models. An important component in the IAP process was selecting ranges for model parameters that would contribute to prediction uncertainty.

The NorthMet water quality models now incorporate the range of transport effects that the IAP team identified as important, and uncertainty in model parameters spans the range agreed upon by the team. Further, the models are largely transparent, meaning that all of the information on environmental behavior of the proposed NorthMet Mine—sampling and analysis of materials, configurations of the mine facilities, assumptions about water flow and solute transport—are presented in the technical support documents for the SDEIS. In particular, the work plans developed for the water quality modeling describe in detail the conceptual models and present the ranges for all model parameters (PolyMet, 2011a and 2011b).

A disadvantage of this collaborative model-design process is that the models are moderately complicated. GoldSim contains modules that automate certain calculations, and it does incorporate automatically mass balance tracking, unit conversions, and Monte Carlo tools for propagating uncertainty. But many of the governing equations specific to the NorthMet project had to be programmed into the model by PolyMet's consultant, Barr Engineering. In addition to potential errors in conceptualization, which can affect all predictive models, the configuration process for the NorthMet Mine could have introduced computational errors caused incorrect logic, transcription mistakes, or other errors in the computer code. This memo presents a framework for evaluating whether the NorthMet Project water quality models accurately implement the assumptions and fate and transport calculations agreed upon by the co-lead agencies.

2.0 Background

This evaluation framework proposed herein is for a "high-level" review, in which the GoldSim model is evaluated by comparing model predictions to targeted test cases where results can be calculated independently. This approach is in contrast to a more detailed review of computer code, which is generally impractical to conduct for complicated models, and may be less reliable method for evaluating overall model accuracy.

Considering the mass balance component in a high-level review, each model component can be viewed as an *internal* water and/or chemical balance that must meet the following conditions:

Water volume in – water volume out = change in water volume storage

Chemical mass in – chemical mass out = change in chemical mass storage

These relationships must hold for each internal component and for the system as a whole. A typical review conducts an independent calculation to determine whether the model is preserving mass balance on individual facilities.

This review focuses on assessing model accuracy in:

- Tracking mass balance (water and chemicals),
- Predicting reaction rates (primarily pollutant dissolution) relative to benchmark rates for analogous conditions, and
- Propagating uncertainty from model parameters through to estimate uncertainty in water quality predictions.

3.0 Model Evaluation Work Plan

The Model Evaluation Work Plan includes two distinct phases that are part of the overall model review process, as conceptualized below in Figure 1. Approval of this work plan (referred to as the QA/QC document in Figure 1) is a pre-requisite for the Co-Leads to authorize PolyMet to initiate modeling. As part of Phase I, ERM will also conduct a review of model inputs concurrent with the initiation of model execution to provide assurance to the Co-Leads that the approved guidance from the IAP Process has been properly incorporated into the models. Phase II focuses on the model outputs and specifically addresses hydraulic flow and solute migration. These are clearly related components--pollutants migrate almost entirely as solutes in migrating water, but they are addressed separately in this plan because they are managed very differently in the GoldSim model. The GoldSim model output review will be conducted by the Co-Lead agencies and/or their consultants using a separate GoldSim license.

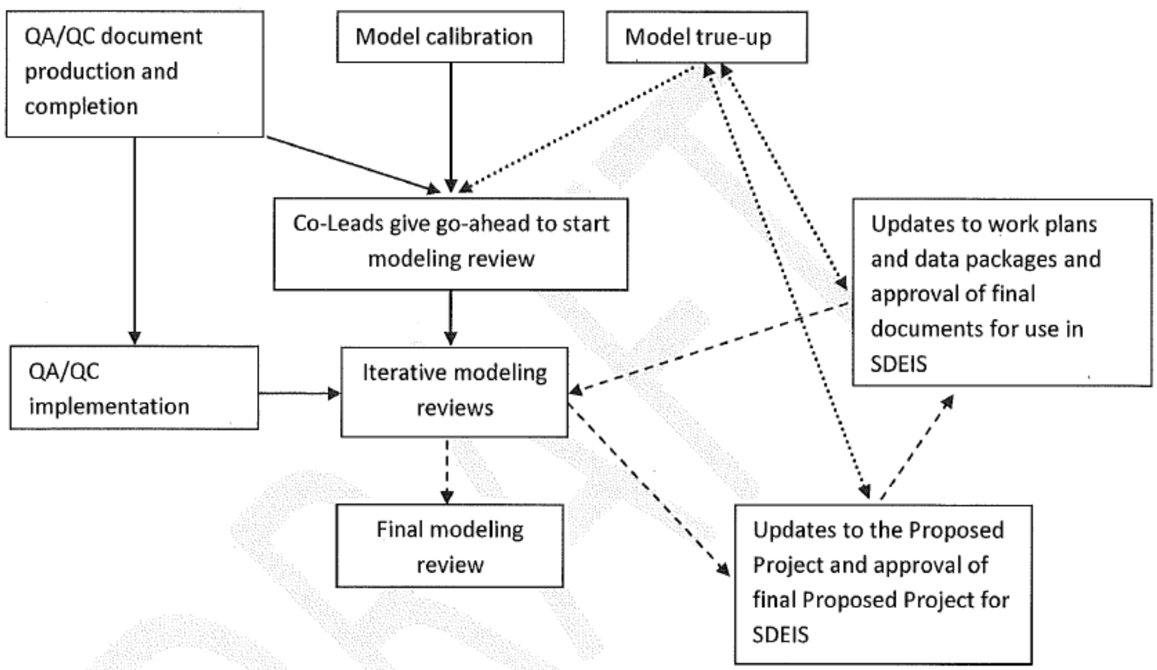

Figure 1. NorthMet EIS Modeling and Model Outcome Review Process
Source: MnDNR, 15 December 2011 (Draft)

3.1 Phase I – Model Input Review

Phase I focuses on model inputs and should occur before or at least concurrently with model execution by PolyMet/Barr. ERM will review the inputs to the GoldSim models to ensure they reflect the agreed upon guidance approved by the Co-Leads. This specifically includes confirming the probabilistic input distributions and the deterministic values established during the IAP Process, as amended by subsequent discussions between PolyMet and the Co-Leads, are accurately incorporated into GoldSim. This work will be led by Fred Marinelli, a subcontractor to ERM and a GoldSim specialist. This work should begin immediately upon approval by the Co-Leads of this Evaluation Plan.

3.2 Phase II – Model Output Review

Phase II focuses on model out puts and will, to some extent, occur as part of Barr's iterative modeling, but will primarily focus on confirming the GoldSim model computations to again provide the Co-Leads, as well as all readers of the SDEIS, the confidence that the GoldSim model functioned properly. ERM will evaluate the key model outputs, which include the models hydraulic and water quality components. We describe below the types of tests and diagnostics that ERM will perform as part of this review.

3.2.1 Hydraulic Model Evaluation

The evaluation procedures for hydraulic model components are based use of GoldSim's ability to export tabulated summaries of model parameters and select results at specified points connecting model cells (i.e., between mine facilities) and at selected points in time. ERM will conduct the following three confirmatory tests.

1. Confirmation of Values for Temporally-constant Parameters

A standard practice in model review is to "echo" parameter values to demonstrate that the model is using the parameters as entered. This process is somewhat more complicated in the probabilistic model, where many parameters are expressed as random values over specified ranges, but remains a practical test procedure.

Those water-related inputs (both deterministic and probabilistic) that are established at the beginning of the simulation and do not change between time steps will be compiled into one Excel spreadsheet. These tabulated results containing the parameter symbol description, units, and, at each new realization, its value. Deterministic parameters remain at constant values. But uncertain parameters are reported with their random probability value (between zero and 1) and the associated parameter value taken from the cumulative probability relationship. Results from these tabulated values of model parameter will be assessed for consistency with the assumed distributions set as input to the model.

2. Confirmation of Values for Temporally-changing Parameters

This process will check the values used in the model for uncertain parameters that change randomly at each time step. For each model time step, GoldSim will write to a spreadsheet the values for all of the water-related inputs, one line for each time step and columns will list the inputs used during that time step. Deterministic parameters should be represented as a single constant value over time. Parameters that are uncertain over time will be represented by a probability distribution that can be compared against the probability distribution assumed in the model input.

3. Confirmation of Hydraulic Mass Balance for Each Mine Facility

The ability to extract information from GoldSim at select time points and at select junctions between facilities will be used to check whether water mass balance is preserved in the model. In practice, water balance can be assessed by having GoldSim write a separate Excel table to record inflows, outflows, and change in storage for each facility at user-selected time steps. Hydraulic mass balance will be calculated for major facilities on the Mine Site (Table 1) and Plant Site (Table 2) at select points in time that cover the simulation period.

Table 1. Mine Site Component Water Balances

Component Name	**Features Inside the Water Balance Component** (refer to Figures A, B, and C in Mine Site Workplan)
Haul Road	Haul Road Pond, Liner, Ground
RTH	RTH Pond, Liner, Ground
LOSP	LOSP, Liner, Ground
Cat 4	Cat 4, Liner, Ground
Cat 2/3	Cat 2/3, Liner, Ground
Cat 1	Cat 1, StW, Cover, GW Containment, Ground (to Partridge R), Ground (to East Pit), Ground (to West Pit)
EQ	EQ Ponds, Liner, Ground
WWTP	WWTP
CPS	CPS Pond, CPS
OSLA	OSLA, StW Mgt, Ground
West Pit	West Pit, Ground
East Pit	East Pit, Ground

Table 2. Plant Site Component Water Balances

Component Name	**Features Inside the Water-Balance Component** (refer to Figures A, B, and C in Plant Site Workplan [PolyMet 2011b])
HRF	HRF, Liner
Hydromet	Hydrometallurgical Plan
LTVSMC 2W	LTVSMC Tailings (2W)
2E	Cell 2E Pond
1E	Cell 1E Pond
NM Tails	NorthMet Tailings
Ben	Beneficiation Plant
Beach	NorthMet Beach
LTVSMC E	LTVSMC Tailings (1E / 2E)
Wells	Interception Wells
Embankments	Embankments, Barrier
Seep	Surface Seep SD-026
Toe	Toe of FTB
Buttress	Buttress
GW	Groundwater Transport
River	Embarrass River SW model, Tributaries
5N Pit	Area 5N Pit Overflow, SD-033
FTB WWTP	FTB WWTP

3.2.2 Geochemical Model Evaluation

Specific components proposed for review of pollutant dissolution and migration include select tests of calculations accuracy (e.g. mass balance tests comparing solute lost from a source to the mass received down stream) and benchmarking tests of pollution release rates (e.g., sulfate should leach from waste rock facilities at a rate that is related to the measured oxidation-rate tests on NorthMet mine rock). Where possible, this evaluation attempts to reproduce major finding of a model with a simple calculation, eliminating at least partially the common complaint that the models have been rendered opaque by their complexity.

The focus in the review of solute transport is on those components that are believed to pose the greatest risk to water quality. For pollutants, these are the solutes with surface and groundwater standards that are know to leach from NorthMet Project waste rock and tailings. A final list of at least 3 representative analytes to use in evaluating model implementation of pollutant behavior will be selected by the Co-Lead Agencies and their consultants. For facilities, the most important are those that will be subject to long-term weathering: the Cat 1 waste rock facility and tailings basin, both of which will oxidize and weather into perpetuity; and the West Pit Lake, which will be exposed to the atmosphere for several decades before being flooded by the lake. For chemical effects, the concentration caps (i.e., maximum concentrations of solutes expected from leachate) in the Cat 1 rock have large uncertainty and can have a large effect on water quality impacts; these are included for explicit evaluation in this plan. And for transport pathways, the groundwater between waste rock or tailings and surface water are a major conduit for pollutants, and the solute transport component in this is targeted for independent evaluation.

We describe below ten confirmatory tests that will be performed. Houston Kempton will have the lead for conducting these analyses, with support from Fred Marinelli and the rest of the ERM Team. As indicated above, this work would begin as soon as some preliminary model results are available, and will comprehensively be conducted on the final model results.

1. Oxidation Rates and Solute Release from Pit Wall Rock

Select a single model year during infilling of the West Pit Lake and compare the change in total mass of SO_4 (plus at least 2 other solutes) in the Pit Lake predicted by GoldSim model against the change that should have occurred due to loads from wall rock flooding, wall rock runoff, and ground water inflow.

Implementation

Load of sulfate in the pit lake over a time step is:

- 50% of sulfate released by oxidation of all wall rock above the lake during the time step,
- 100% of cumulative sulfate stored in the rock that is inundated over the time step,
- 100 % of sulfate produced by oxidation in the rock that is inundated over the time step.
- Groundwater load (flow rate * time step * sulfate concentration in groundwater)

This calculation should be done on the West Pit (the East Pit will be backfilled and water quality managed separately).

In executing calculation:

- Set the model to average conditions,
- Select a time duration for mass-balance test (e.g., year 10 to 11 after filling begins)
- Run the model past this time and record load changes (volume & concentration) for SO_4 (plus at least 2 other solutes)
- Independently calculate what the load of SO_4 (plus at least 2 other solutes) that should have loaded over the time step, based on wall rock loading and groundwater inflow.

The accuracy of the lake model is determined by comparing the calculated change in load of SO_4 and other test solutes in the West Pit Lake between year 10 and 11, and the model prediction of the same.

Complications to consider:

- The sulfate production rate increases, then decays over time (eq. 9.3 in Waste Characterization Report, and parameters a_0 and a_1), except that no decay is modeled for Cat 1 or Virginia Fm. wall rock.
- Rates may be scaled down for temperature and fragment size —it is not clear how temperature correction is applied in addition to decay equation parameters a_0 and a_1

Parameters (West Pit):

- Area of each rock type above each level in the pit (PolyMet 2011a, Model work plans, Plant Site, Fig 1-4)
- Average sulfur concentration in the wall rock above each level in the pit (Model work plans, Plant Site: Cat 1 in Fig 1-5, Cat 2/3 in Figure 1-6, Ore in Figure 1-7, [the Model Work Plans for the Plant Site are missing information on sulfur content in Cat 4 Duluth Complex rock)
- Pit volume vs. stage (PolyMet 2011a, Fig 1-1)
- Oxidation rate in the reactive wall rock veneer
    - Cat 1: (PolyMet 2011a, Table 1-24)
    - Cat 2/3: (PolyMet 2011a, Table 1-25)
    - Cat 4 Duluth: (PolyMet 2011a,, Table 1-26)
    - Ore: (PolyMet 2011a, Table 1-27)
- Thickness of wall rock reactive veneer (PolyMet 2011a, Table 1-1, parameters “Wall_Depth_DC” = 1 to 3 m, “Wall_Depth_VF” = 2 to 6 m,
- Density of wall rock in veneer (PolyMet 2011a, Table 1-1, parameters “WR_Sp_gravity” = 2.93 t/m^3)
- Combined scale factor for temp & size (need to see if this is built into a_0 and a_1 parameters)
    - Decay in oxidation over time (PolyMet 2011c, Eq. 9.3-1; PolyMet 2011a, Table 1-1, parameters = “Decay_a1” and “Decay_a0”
    - Equations in PolyMet 2011c, Eq 9.3-1:
        - SO_4 [mg/kg-wk] = 10^{((a₁ * log(time[wks])) + a₀}.

2. Oxidation Rate in Tailings

During operations, the tailings will oxidize at a rate that is limited by oxygen diffusion, which in turn is related to the moisture content in the tailings and the intrinsic oxidation rate of the tailings under atmospheric conditions. With GoldSim set to average conditions in a deterministic simulation, the moisture content and intrinsic oxidation rate of the tailings (laboratory rate, scaled by temperature) can be compared to a separate model calibrated to the NorthMet tailings.

Implementation

Set the GoldSim model to conduct a deterministic simulation of tailings during mine operations—this will produce fixed values for water flux through and water content in the tailings (PolyMet 2011b [Water Modeling Workplan - Plant Site Ver 11]), then:

- Determine total oxidation rate in the tailings beach estimate by GoldSim under average conditions,
- Conduct a parallel estimate of total oxidation rate in the tailings beach using the same assumptions (intrinsic oxidation rate, porosity, and moisture content) using a separate model (the Pyrox model was used in the previous 2009 DEIS as a benchmark for comparing the oxidation rate predicted in the NorthMet tailings—see parameters in Table 1-1, "Saturation-Diffusion Inputs", and Table 1-16 for solute release rates in coarse tailings).

Result is comparison of oxidation rates, reported as sulfate production, in GoldSim to the rate estimated by Pyrox model.

3. Solute Transport in Groundwater

The accuracy of the groundwater transport component in GoldSim will evaluate the testing proposed in Barr Engineering's quality assurance plan for the model (PolyMet 2011c, Section 2.4.1 Test Case – Groundwater Transport). The Barr comparison will include development of a deterministic configuration in GoldSim for groundwater flow from the Cat 2/3 stockpile. This evaluation plan will review this comparison to determine whether the results are adequate. If the Co-Lead Agencies determine that a separate and independent evaluation of the groundwater transport model is warranted, they may conduct this using a separate analytical or numerical model that reproduces conditions used in the GoldSim model.

4. Comparison to Field Scale Analog: Amax Stockpile

PolyMet's model QAPP includes a benchmark comparison of measured solute release rates from Duluth Complex mine waste under field conditions to solute release rates estimated by a GoldSim model of the same material (PolyMet 2011c, Section 2.4.6 [Model Corroboration – Geochemistry Model of the AMAX Piles]). The AMAX test piles are a collection of 1,000-ton waste rock that were placed on lined pads and monitored between 1978 and 1993. The AMAX piles were analyzed to determine sulfur content and particle-size distribution, and splits were subjected to laboratory kinetic testing. This comparison will be reviewed for reliability and applicability as a benchmark test for NorthMet model.

5. *Waste Rock (Cat 1) Mass Balance*

The mass balance on SO_4 (plus at least 2 other solutes) that is leached out of the Cat 1 waste rock stockpile can be checked by tracking the cumulative mass of each of these solutes leached from the pile over a 200-year model simulation period. The cumulative mass leached out of the facility should equal the total mass initially present in the facility, or, if the GoldSim model indicates that some pollutant remains in the waste rock pile after 200 years, then cumulative lost mass in outflow can be compared to initial total mass less the mass remaining in the rock at year 200. This will need to be conducted using a deterministic configuration of the GoldSim model for the Cat 1 stockpile.

Implementation

- Set Cat 1 rock facility to average initial composition (concentrations of sulfide S and other selected test solutes, and water percolation rate),
- Calculate mass of each solute that should be in the Cat 1 facility,
- Record flow and concentration in model discharge from Cat 1 facility for 200 year simulation,
- Calculate cumulative SO_4 (plus other selected test solutes) released in flow form the Cat 1 facility,

Check mass balance for SO_4 (plus other selected test solutes):

Model mass remaining at yr 200 = (initial mass) – (cumulative load lost, based on flow & concentration)

6. *Waste Rock (Cat 2/3, Cat 4 (Duluth Complex and Virginia Formations) Mass Balance*

The mass balance on SO_4 (plus other selected test solutes) that is leached out of the Cat 2/3, Cat 4 (Duluty Complex) and Cat 4 (Virginia Formation) can be evaluated by tracking cumulative solute release over two discreet single-year periods: one before onset of acidic conditions, and one after. Over each 1-year period, the mass lost from each facility, as determined by flow and concentration in effluent, should equal the mass lost from each facility as recorded in the GoldSim internal model mass balance. This will need to be conducted using a deterministic configuration of the GoldSim model for the rock stockpiles.

Implementation

- Set flow rate through waste rock facilities high enough that concentrations of all solutes are below their solubility caps (i.e., solubility caps should not have any effect),
- Set *non-acid solubility caps* to their deterministic median value (PolyMet 2011a, Table 1-31)
- Set *acidic solubility caps* to their deterministic, median values (PolyMet 2011a, Table 1-32, and Table 1-33)
- Record flow and concentrations (SO_4 plus other selected test solutes) out of each of these 3 facilities for:
    - 1^{st} year (Time 0 to 12 months, before onset of acid in all but Cat 4 VA formation), and
    - 10^{th} year (i.e., after all materials have become acidic).

Check mass balances:

Mass balance on SO_4:

- Mass of SO_4 leached over *1st year* (based on flow * concentration) = (*non-acidic oxidation rate* [PolyMet 2011a, Tables 1-25 to 1-28])* (mass of rock)* 1yr
- Mass of SO_4 leached over *10th year* (based on flow * concentration) = (*acidic oxidation rate*) * (mass of rock)* 1 yr.

Mass balance on other selected test solutes:

- Mass of metal leached over *1st year* (based on model flow * concentration) = (*non-acidic oxidation rate* [PolyMet 2011a, Tables 1-25 to 1-28])) * (mass of rock) * (metal/ SO_4 release ratio) * 1yr
- Mass of metal leached over *10th year* (based on model flow * concentration)= (*acidic oxidation rate*) * (metal/ SO_4 release ratio) * (mass of rock) * 1 yr

7. Tailings Mass Balance

The mass balance on SO_4 (plus other selected test solutes) that is leached out of the tailings over a 1-year period can be estimated by multiplying solute concentrations by flow in the total seepage from the NorthMet tailings. Components in this flow include discharge to groundwater, discharge to seeps, and discharge to the tailings pond. The mass leached from the tailings over a 1-year period should equal the loss in mass of these solutes from the tailings.

Implementation

- Select a year during construction of the tailings facility (e.g., year 10, the mid point),
- Set the GoldSim model to average conditions for a deterministic simulation,
- Record model flow and model concentrations of SO_4 (plus other selected test solutes) in discharge from the NorthMet tailings to groundwater, seeps, and the tailings.
- Compare total solutes lost in seepage over the year to mass lost in the GoldSim internal mass-balance tracking

8. Concentration Caps in Waste Rock and Tailings

Concentration caps are empirical maximum-allowed values for solute concentrations in various mine waste. They are not strictly a component of mass balance, but are more closely related to mass balance than benchmarks. If the GoldSim model is configured so that water flow is very low, then concentrations of all solutes will be at their concentration caps. Comparison of model concentration in effluent from waste rock and tailing against the model solubility caps will test whether these concentration caps are implemented correctly. Testing should cover the periods before *and after* the onset of acidic conditions in Cat 2/3, Cat 4, and ore (e.g., before ~4 years, then after ~8 years) to evaluate the implementation of different caps under these two conditions.

Implementation

There are separate solubility caps for the different materials (listed in PolyMet 2011a, Water Modeling Workplan – Mine Site Ver 3):

- Cat 1 waste rock and the NorthMet tailings (these are not expected to ever become acidic; see PolyMet 2011a, Table 1-30);
- Cat 2/3, Cat 4, and Ore solubility limits (see PolyMet 2011a, Table 1-31 for non-acidic conditions, PolyMet 2011a, Table 1-32 for acidic conditions in Duluth complex rock, and PolyMet 2011a, Table 1-33 for Acidic conditions in Virginia Formation rock).
- The West Pit Lake, which will be exposed to the atmosphere for several decades before being flooded by the lake.

The duration of exposure of rock before it becomes acidic, causing solute concentrations to jump to a higher threshold, is:

- Cat 1 rock and tailings: Infinite
- Cat 2/3 rock: 6.81 years (range 5.33 to 7.99)
- Cat 4 (Duluth complex): 5.41 years (range 4.97 to 6.81)
- Cat 4 (Virginia formation): 0 years

Procedure (for tailings, Cat 1, Cat 2/3, and Cat 4 rock):

1. Set solubility caps to deterministic, average values.
2. Reduce meteoric water flow so that all solutes are limited by their solubility limits,
3. Monitor model concentrations of all solutes in discharge from tailings and the 3 waste-rock over 10-year time (i.e. beyond when Cat 2/3 and Cat 4 become acidic).

9. Solubility caps in tailings: Uncertainty in SO_4 and other test solutes

A dramatic reduction in the water flow through the tailings enough would increase oxidation rates and increase solute concentrations in the pore water to the point that all solutes are at their concentration caps (concentration caps listed in PolyMet 2011b, Water Modeling Workplan - Plant Site Ver 11 AUG2011, Table 1-16). By setting GoldSim so that water flow into the tailings impoundment is very low, and then fixing all parameters except one concentration cap to deterministic average values (i.e., using GoldSim "sensitivity mode"), the concentrations of a random variable in seepage from the tailings should have a distribution that matches the uncertainty distribution assumed for the concentration cap for that variable.

Implementation

- Set all parameters in GoldSim tailings model to deterministic average values except for the solubility caps for SO_4, which remain as random variables (as defined in PolyMet 2011b, Table 1-16).
- Reduce flow rate through the tailings basin so that concentrations of all solutes are limited by their concentration caps.
- Compare the distribution in concentrations of SO_4 (plus other selected test solutes) in tailings basin seepage to the distributions assumed as input (PolyMet 2011b, Table 1-16) to determine whether uncertainty in concentration caps is propagated accurately through the model.

- Repeat this for the additional 2 or more selected test solutes, in separate "sensitivity mode" GoldSim model runs.

10. Dissolution Rates in Cat 2/3 Rock: Uncertainty for SO_4 and other solutes

The dissolution rates SO_4 (and other selected test solutes) in effluent from the Cat 2/3 stockpile are related (i.e., many metals dissolve in proportion to SO_4; PolyMet 2011a, Table 1-25 in Water Modeling Workplan - Mine Site Ver 3 complete). By setting GoldSim so that water flow into the Cat 2/3 pile is very high, none of the solutes will be limited by concentration caps, and the probability distributions for solute concentrations in stockpile effluent should be similar to the distributions assumed for dissolution rates.

Implementation

- Set all parameters in GoldSim model simulation of the Cat 2/3 stockpile to deterministic average values except for the dissolution rate of SO_4 (see values in PolyMet 2011a Table 1-25).
- Increase flow rate through the Cat 2/3 stockpile so that *none of the* solutes are limited by their concentration caps.
- For the last month in the 1^{st} year of modeling (i.e., non-acidic conditions), compare the distribution in predicted concentrations of SO_4 (plus other selected test solutes that are linked to SO_4 dissolution rates) in Cat 2/3 stockpile seepage to the distributions assumed in the input for these parameters (PolyMet 2011a, Table 1-25) to determine whether uncertainty in predicted stockpile seepage is the same as the distribution assumed for the parameters.

3.2.3 Model Evaluation Documentation

ERM will coordinate with PolyMet and the Co-Lead agencies to correct any input or computational errors uncovered. ERM will produce a summary report documenting the Model Evaluation Process for the record.

4.0 References

CEQ, 1978. Regulations for Implementing NEPA, US Council on Environment Quality, Part 1508 (Terminology). http://ceq.hss.doe.gv/nepa/regs/ceq/toc_ceq.htm

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PolyMet Mining (2011a). NorthMet Mine Site Water Modeling Work Plan. September 26, 2011.

PolyMet Mining (2011b). NorthMet Plant Site Water Modeling Work Plan August 11, 2011.

PolyMet Mining (2011c). Mine Site Water Quality Model Quality Assurance Project Plan. November 7, 2011.