NorthMet Project

Plant Site Water Quality Model Quality Assurance Project Plan

Prepared by
Barr Engineering Company
On behalf of
PolyMet Mining, Inc.

Version 1

Issue Date: April 20, 2012

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1.0 Introduction

This document presents the Plant Site Water Quality Model Quality Assurance Project Plan (PSWQ-QAPP, or simply QAPP) for the water quality modeling presented in the Water Modeling Data Package Volume 2 – Plant Site (Reference (1)) and the NorthMet Plant Site Water Modeling Work Plan (Reference (2)). This QAPP follows the general guidance provided by EPA's Guidance for Quality Assurance Project Plans for Modeling (EPA QA/G-5M) as well as Barr Engineering Company's (Barr) Quality Management Plan, which was prepared in accordance to EPA QA/R-2.

1.1 Project Definition and Objectives

The primary objective of the probabilistic water quality model is to compare potential water quality impacts between project alternatives for the NorthMet Project (Project), in this case the No Action alternative and the Proposed Project alternative (also referred to as the Plant Site – Draft Alternative). This work is being conducted in support of the SDEIS for the Project. Details on the Project description are provided in Reference (3), and the model scenarios are documented in Section 3.1 of Reference (1). Water quality impacts are to be evaluated at specified locations within the surficial deposits and in area streams. Locations for evaluation are presented in Reference (1) Section 5.5 (surface water) and Section 5.4.2 (groundwater).

The probabilistic water quality modeling for the Plant Site will be conducted using GoldSim Version 10.5, SP2 (GoldSim Technology Group, 2011). The selection of this modeling platform, including a discussion of modeling needs and other platforms considered, is included in Section 3.2 of Reference (4) .

1.2 Background

The development of the work plan for the water quality modeling covered by this QAPP has been a rigorous process lead by the Co-lead Agencies for the SDEIS. This process, referred to as the Impact Assessment Planning (IAP) process, involved the Co-lead Agencies and Cooperating Agencies, and included the formation of small technical teams to discuss details of the water quality modeling and associated impact criteria. These discussions, and the water modeling work plans and data packages that document the decisions made in these discussions, addressed the following topics:

- Identification of the problem, including types of model output and locations for evaluation;
- Peer review of theory and equations used in the modeling;
- Selection of modeling platform;
- Identification of input parameters needed for modeling
- Assessment of accuracy and appropriateness of input data for use in the modeling; and

- Definition of output data that should be provided from the model.

The work plan and associated data packages, which provide the documentation of assumptions, theory, parameterization and input data discussed during the IAP process, are subject to Co-lead Agency review and approval. These topics will not be discussed in detail in this QAPP. Instead, this QAPP focus on how the model will be reviewed and verified in order to help ensure that the model is constructed consistent with the approved work plans and performs as expected.

1.3 Project/Task Organization

Barr will be performing the modeling work covered in this QAPP under contract to PolyMet Mining, Inc. (PolyMet). SRK Consultants, also under contract to PolyMet, are providing technical oversight of geochemistry aspects of the modeling which is described in Reference (5). The modeling is being conducted under the direction of the SDEIS Co-lead Agencies: the US Army Corps of Engineers, the US Forest Service, and the Minnesota Department of Natural Resources. The Co-lead Agencies may choose to include Cooperating Agencies, such as the U.S. Environmental Protection Agency, the Fond du Lac Band of Lake Superior Chippewa, the Bois Forte Band of Chippewa, and the Grand Portage Band of Lake Superior Chippewa, as well as the EIS contractor, ERM. The Co-lead Agencies have developed a technical review team for the Plant Site Water Quality Model, consisting of representatives from the Co-lead Agencies, a Regulating Agency (Minnesota Pollution Control Agency) and select Cooperating Agencies.

1.4 Special Training Requirements

The work covered by this QAPP requires the modeling team to have training or experience in several specific areas, including:

- Groundwater flow and contaminant transport modeling;
- Surface water hydrology modeling;
- Aqueous geochemistry; and
- Probabilistic modeling.

All lead modelers executing this work have taken formal training on the use of the modeling platform being used (GoldSim) for probabilistic modeling (training provided by GoldSim Technology Group on September 28-30, 2010).

Model reviewers need to have a basic understanding of the above areas, and must have a working familiarity with GoldSim. GoldSim Technology Group and Barr Engineering have held two “Introduction to GoldSim Probabilistic Simulation Environment” training sessions for the Co-lead and Cooperating Agencies (September 28, 2010 and June 2, 2011).

2.0 Quality Assurance Procedures

2.1 Data Quality Objectives

Because the data needs for the model and sources of data used for model inputs were addressed as part of the IAP and work plan review processes, review of model performance is more appropriate than data quality objectives. This QAPP addresses model performance by focusing on model corroboration and evaluation of model outputs. Section 2.3 documents the peer reviews that will be conducted on the GoldSim model and other associated models. Section 2.4 documents model performance evaluation tests that will be conducted.

Input data used in the model do have limitations due to incompleteness, measurement error, representativeness, etc. These issues are addressed by using a probabilistic modeling approach, which uses explicit representations of uncertainty and variability in defining the distribution parameters for the model inputs. The distributions parameters were subjected to technical review during the IAP and work plan review processes.

2.2 Model Calibration

Portions of the GoldSim model will be calibrated; the MODFLOW model, which provides data for use as input into the GoldSim model, will also be calibrated. Calibration of these models is discussed in the following locations:

- MODFLOW Model, Attachment A of Reference (1)
- GoldSim Model, Section 10.2.1 of Reference (5) and Sections 5.3.2 and 6.1.3.1.1 of Reference (1)

There were several portions of the GoldSim Model that were calibrated. Laboratory release rates for LTVSMC tailings were adjusted to mach field conditions observed at the Tailings Basin (Section 10.2.1 of Reference (5)). The water quality distributions used for groundwater and surface runoff from undisturbed areas will also be calibrated to match observed concentrations in the Embarrass River unimpacted by mining (Sections 5.3.2 of Reference (1)). Finally, evaporation and runoff rates from Cell 2W were calibrated to match the infiltration rates predicted by the MODFLOW model and variability determined from the Meyer Model (see Section 6.1.3.1.1 of Reference (1)).

2.3 Model Peer Review

The GoldSim model will undergo internal peer review using the GoldSim Model Technical Review Checklist provided in Appendix A. This review will focus on a review of model inputs relative to proposed values provided in the approved work plans, consistency of model construction relative to Reference (3), and verification that model equations are consistent with documentation provided in Reference (2) and Reference (1).

The MODFLOW models of the Tailings Basin will undergo peer review using the MODFLOW Model Technical Review Checklist provided in Appendix A. The Tailings Basin MODFLOW model is used to estimate seepage rates from the basin to each groundwater flow path, the sources of seepage for each flow path, and the depth of the phreatic surface within the Tailings Basin.

Each peer review will be conducted by Barr technical staff familiar with the model being reviewed (GoldSim or MODFLOW) and the Project, but not directly responsible for the construction of the models. Model review will be documented with the Model Technical Review Checklists, which will be provided with final model documentation.

2.4 Model Performance Evaluations

Model performance evaluation includes the quantitative and qualitative methods for evaluating the degree to which the model corresponds to reality. Several types of evaluations will be performed:

- Test cases – basic model runs where an analytical solution is available or an empirical solution is known to ensure that algorithms and computational processes are implemented correctly;
- Model check – either simple desktop calculation checks of model results or model mass balance checks;
- Sensitivity analysis; and
- Corroboration of model results with observations.

Several model performance evaluations have already been conducted or scoped through the IAP process. These evaluations are summarized below. Additional evaluations may be identified during the modeling process either as a result of the internal peer reviews of the model, or as a result of the Co-lead Agencies formal review of the model. All model performance evaluations that are performed will be documented with the submittal of the modeling results in Reference (1).

2.4.1 Model Check – Tailings Basin Mass Balance

The contaminant transport functions within the GoldSim software are designed to maintain a consistent mass balance throughout the calculation procedure. Constituent mass is not allowed to enter or leave the system unless a transport pathway is defined by the user. A mass balance check will be implemented for the Tailings Basin to verify this functionality. This model check will help to ensure that all inflows and outflows of constituent mass from each feature are properly accounted for and documented.

2.4.2 Sensitivity Analysis – Interception Wells Capture Efficiency

The sensitivity of model predictions to the amount of Tailings Basin seepage is captured by the groundwater interception wells will be assessed. Interception wells are planned for

capturing seepage from the Tailings Basin so that it does not seep water to the environment in excess of 500 gallons per acre per day. Additional seepage collection may be necessary in order to meet applicable water quality standards at the evaluation locations. The effects of collecting more or less seepage will be assessed in terms of both impacts to water quality predations in groundwater and surface water down gradient of the Tailings Basin, and water quality within the Tailings Basin ponds.

2.4.3 Model Corroboration – Existing Conditions Model vs Water Monitoring Data

The proposed modeling methodologies for the generation of load from the LTVSMC Tailings Basin and the transportation of this load to the receiving streams will be corroborated by simulating existing conditions with the GoldSim model.

A model simulation of existing conditions will be prepared and used to compare model estimated and measured concentrations at PM-13, MLC-2, PM-19 and PM-11. These monitoring locations are downstream of the Tailings Basin, and in the case of PM-13, downstream of Area 5. This step focused on evaluating the model assumption and initial parameter values associated with the load generation at the Tailings Basin and the transport of this load to the receiving streams.

3.0 Documentation

Reference (4) will document the data, model formulation and details, and assumptions used in the model. This document will also present the methods and results of the Model Peer Review and Model Corroboration steps from Section 2.3 and 2.4 above. Any deviations in the model design, construction, calibration, or input values will be documented. Results of the calibration of the GoldSim model (see Section 2.2) will be presented to the technical review team established by the Co-lead Agencies prior to proceeding with the modeling.

An annotated version of the GoldSim model will be provided to the Co-lead Agencies for their review. All reports will be internally peer reviewed for data accuracy prior to release. Reference (4), Reference (5) and the GoldSim model files will be posted to the project website. In addition, the model files from the MODFLOW model will be made available for review by the Co-lead Agencies.

Revision History

Date	Version	Description
04/20/2012	1	Initial release

References

1. **PolyMet Mining, Inc.** NorthMet Project - Water Modeling Data Package, Volume 2 - Plant Site (v6). April 2012.

2. —. *NorthMet Project - Plant Site Water Modeling Work Plan (v5).* April 2012.

3. —. NorthMet Project - Project Description (v3). 2011.

4. —. NorthMet Project - Water Modeling Data Package, Volume 1 - Mine Site (v). December 2011.

5. —. NorthMet Project - Waste Characterization Data Package (v8). February 2012.

6. *User's Documentation for MODFLOW-96, an updated to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model.* **McDonald, M.G. and Harbaugh, A.W.** 1996, U.S. Geological Survey Open-File Report 96-485.

7. *MT3DMS: A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide.* **Zheng, C. and Wang, P.P.** 1999, U.S. Army Corps of Engineers Contract Report SERDP-99-1.

List of Appendices

Appendix A Model Technical Review Checklist

Appendix A

Model Technical Review Checklist

MODEL TECHNICAL REVIEW CHECKLIST

General - GoldSim

1. MODEL NAME:	**2. MODEL DATE:**
3. MODEL LOCATION:	
4. PROJECT NUMBER:	**5. PROJECT PIC:**
6. PRIMARY MODELER:	**7. REVIEWER:**
8. REVIEWER (<u>After</u> review is completed and all comments were resolved):	

printed name _____ concurrent signature _____ date _____

No.	Criteria	Comments/Notes
1	Do model input values match documented input values?	

Model Technical Review Checklist
General - GoldSim

No.	Criteria	Comments/Notes
2	Are model equations consistent with equations or conceptual model document in the Work Plan?	

MODEL TECHNICAL REVIEW CHECKLIST

MODFLOW

1. MODEL NAME:	**2. MODEL DATE:**
3. MODEL LOCATION:	
4. PROJECT NUMBER:	**5. PROJECT PIC:**
6. PRIMARY MODELER:	**7. REVIEWER:**
8. REVIEWER (<u>After</u> review is completed and all comments were resolved):	

printed name _____ concurrent signature _____ date _____

No.	Criteria	Comments/Notes
1	Is the choice of mathematical model appropriate (analytical/numerical)?	
2	Is the purpose of the model (i.e. the problem(s) the model is intended to evaluate) clearly defined?	
3	Is the spatial extent of the model appropriate?	

4	In the number of model layers justified?	
5	Is the model discretization (planer) appropriate?	
6	Is steady state simulated?	
7	Is the stress period reasonable?	
8	Is the number of time steps per stress period justified?	
9	Are the applied boundary conditions plausible and unrestrictive?	
10	Are boundary condition locations consistent with the model grid configuration?	

11	Are the initial conditions defensible?	
12	Do model input values match documented input values?	
13	Are the calibrated parameter distributions and ranges plausible?	
14	Is model mass balance error between -1% and 1%?	
15	Does the calibration statistic satisfy agreed performance criteria if specified, or industry standards if not specified?	
16	Are model predictions made at scales consistent with model space and time scales?	
17	Are model predictions plausible?	

18	Are model predictions likely to be impacted by constraining boundary conditions?	
19	If boundary conditions affect the predictions, are the predictions defensible?	

MODEL TECHNICAL REVIEW CHECKLIST

XP-SWMM

1. MODEL NAME:	**2. MODEL DATE:**
3. MODEL LOCATION:	
4. PROJECT NUMBER:	**5. PROJECT PIC:**
6. PRIMARY MODELER:	**7. REVIEWER:**
8. REVIEWER (<u>After</u> review is completed and all comments were resolved):	

printed name _____ concurrent signature _____ date _____

No.	Criteria	Comments/Notes
1	Is runoff continuity error between -1% to 1%. If not correct or determine why & impacts? (Table R5)	
2	Does the Number of watersheds listed in the output file match Arc View?	
3	Does the Total watershed area listed in the output file match the total study area?	

4	Does the total rainfall amount listed in the output file match the rainfall amount for the storm frequency and duration that is being modeled?	
5	Are the rainfall dates contained within the Runoff simulation dates?	
6	Is the same rainfall global database being used for all the watersheds? (Table R2)	
7	Is the same runoff methodology being used for all the watersheds? (Table R2)	
8	Is the correct rainfall distribution being used for the simulated storm frequency & duration?	
9	Do the Infiltration inputs (global databases) seem reasonable including overland flow roughness and Horton/Green Ampt parameters (Table R2)	
10	Do the infiltration assumptions include water areas when appropriate (Zero % Detention)?	

11	Are there any flow redirections in the Runoff layer? Does redirected flow get added appropriately?	
12	Were correct units assumed during watershed data entry? (Table R1) (Area = ac, Percent Impervious = % (directly connected only), Width = ft, Slope = ft/ft	
13	Do peak watershed runoff rates seems reasonable when compared to "Rules of Thumb", Rational Method, Barr Method, etc? (Table R9)	
14	Does runoff volumes seems reasonable when compared to Barr Method, SCS method, etc? (Table R9)	
15	Have all warnings & errors been corrected prior to final simulation? (Error log prior to simulating the Hydraulics layer)	
16	Does the Hydraulics layer simulation dates span the Runoff simulation dates? If no correct.	
17	Is Hydraulics continuity error between -2% to 2% (Table E22). May be allowable as high as 5% but must be checked and explained.	

18	Are "Special Conduits" (Arches, Ellipses, etc) being modeled correctly by XP-SWMM? Check pipe cross sectional area against manufacturer information to make sure correct area is used. (Table E1)	
19	Have conduit minor losses (entrance/exit, other, expansion/contraction) been entered throughout the model? (Table E2)	
20	Has storage information been entered correctly (Depth = El - Node Inv El & area in acres)?	
21	Was Ponding Allowed used? Where & Why?	
22	Check weir parameters to make sure crown El results in weir surcharging only when appropriate.	
23	Check Orifice parameters.	
24	Check Pump curves	

25	Check User Inflow Hydrographs @ all node they are used	
26	Check user defined rating curves and weirs	
27	Are pipe flow & velocities reasonable? (Table E15)	
28	Is there any water being "Lost from the System"? Check for flooding/surcharge (Table E3B & E20). Lost water must be corrected	
29	Are the correct number of weirs, orifices, and pumps being used? (after Table E20)	
30	Is model simulation stable? (i.e., Are there any flow/elevation oscillations in any nodes/links that impact results?) If unstable the model must be corrected.	
31	Are most nodes converging? (Table E18 or E22) If not some model adjustments may be necessary	

32	Are there any open channels (Trapezoidal or Natural Sections) that overtop during the simulation that most be corrected? (Look for * in Table E10)	
33	Is storage being double counted by using channels and a storage node? If so this must be corrected?	
34	Does Hydraulic simulation extended long enough to capture all the peak flows/elevations?	
35	Have initial depths been entered to account for tailwater conditions and pond normal water levels?	
36	Are the correct boundary conditions being used? (Tailwater Elevations)	