WORK PLAN for SUPPLEMENTAL GROUND WATER CHARACTERIZATION IN RESPONSE TO DP-1403 CONDITION 84

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1.0 INTRODUCTION

At the request of Cobre Mining Company, Inc. (Cobre), Telesto Solutions Inc. (Telesto) has prepared this Work Plan pursuant to Condition 84 of Discharge Permit DP-1403, approved by New Mexico Environmental Department (NMED) on December 10, 2004. Condition 84 of DP-1403 reads as follows:

> *Cobre shall perform a study to supplement existing ground water studies and evaluate the hydrologic conditions beneath the Continental Mine Facility. Within 240 days after the effective date of this Supplemental Discharge Permit, Cobre shall submit to NMED for approval a work plan, including an implementation schedule, for a study to evaluate the hydrologic conditions beneath the Continental Mine Facility. The study shall consider the data needs for the Pit Lake Formation study described in Condition 85 and the abatement plan required in Condition 32. The study shall be designed to determine whether the proposed closure alternatives will achieve the requirements of the WQA* [New Mexico 1987 Water Quality Act] *and the WQCC* [New Mexico Water Quality Control Commission] *regulations. As part of the study, Cobre may be required to install additional monitoring wells for the collection of temperature, flow direction, water quality and water level data beneath the Continental Mine Facility.*

The Continental Mine site (Figures 1 and 2) is comprised of the Continental Pit and associated mine facilities including tailings impoundments, waste rock stockpiles, and underground workings. Cobre suspended mining from the Continental Pit in 1999, but has received regulatory approval to resume and expand the Continental Pit mining operation. After the end of mining, it is anticipated that if dewatering is not emplaced a pit lake will form in the Continental Pit.

As part of this Work Plan, a numerical ground water flow model will be developed to evaluate the hydrologic conditions beneath the Continental Mine and provide the basis for a dynamic systems model (DSM) used to assess mine impacts. To fulfill the requirements of Condition 84, results of the ground water flow model and a Pit Lake geochemical model (Condition 85) will be incorporated into the DSM. The DSM will incorporate all important aspects of the site hydrologic/geochemical system including climate, surface water, ground water, and geochemical components. The DSM will provide an efficient modeling platform to assess the environmental effects of site operation and eventual closure.

1.1 Background

The *Baseline Characterization of the Hydrology, Geology, and Geochemistry of the Proposed Continental Mine Expansion Project* (SMI, 1999), referred to herein as the Baseline Report, included ground water flow and water quality predictions for the Continental Pit. The report described an analytical ground water flow model that was used to assess impacts associated with the proposed Continental Mine expansion. The NMED commented on the flow and water quality predictions made in the Baseline Characterization. It was NMED's opinion that there were uncertainties in the predicted conditions of the final Continental Pit and associated pit lake. The purpose of DP-1403 Condition 84 is to address these uncertainties.

1.2 Objectives

The overall purpose of this Plan is to describe work tasks that will provide a technically defensible evaluation of hydrologic and geochemical conditions within and adjacent to the Continental Mine Facility. Specific objectives include the following:

- Develop a numerical ground water flow model to evaluate hydrologic conditions within and adjacent to the mine area.
- Compile results of the Condition 85 pit lake geochemical model
- Develop a dynamic systems model (DSM) that combines characteristics of the flow model and the geochemical model, along with relevant aspects of climate, surface water, and possible closure alternatives.
- Using the DSM, perform a series of simulations to evaluate the probable range of environmental effects associated with facilities at the Continental Mine. This will include environmental evaluations of the pit lake (Condition 85), the Ground Water Abatement Plan (Condition 32), and proposed closure

alternatives to the extent that they achieve (or do not achieve) requirements of the Water Quality Act and the Water Quality Control Commission.

- Provide a detailed report describing the ground water flow model and a separate report describing the DSM and results of the impact evaluation.

2.0 SCOPE OF WORK

To achieve the goals and objectives of this Work Plan, the following tasks are proposed:

- Task 1 - Data Compilation and Review
- Task 2 - Conceptual Ground Water Model Update
- Task 3 - Numerical Ground Water Flow Model Development
- Task 4 - Ground Water Model Third Party Review
- Task 5 - Ground Water Model Predictive Simulations and Sensitivity Analysis
- Task 6 - Supplemental Ground Water Study Report
- Task 7 - DSM Update and Development
- Task 8 - DSM Third Party Review
- Task 9 - DSM Predictive Simulations
- Task 10 - DSM Report

These tasks are described in the following subsections. Note that Tasks 1, 2, and 3 have been initiated or completed by Telesto. The write-ups for these tasks are presented in Appendix A, which is a partially-completed draft version of the Supplemental Ground Water Study Report required by Condition 84.

2.1 Task 1 – Data Compilation and Review

A review of existing studies will be performed to update and refine the understanding of the site ground water system. The review will include compiling hydraulic heads and hydraulic property estimates for the various rock types present at the site. The horizontal and vertical directions of ground water flow will also be evaluated. Water budget information will be compiled and reviewed, including potential sources of recharge, discharge, pit inflows, inflows to underground workings, evaporation and ground water extraction.

An important component of the review will be to evaluate the site geology in three dimensions. This includes delineation of major geologic units and structures that may have a bearing on ground water hydraulics. Geologic maps will be reviewed in detail. Depth projections of geologic contacts and structural features will be performed to develop a three-dimensional picture of the site hydrogeology.

2.2 Task 2 – Conceptual Ground Water Model Update

The information compiled for Task 1 will be used to update the conceptual model that was previously presented in the Baseline Characterization Report (SMI, 1999). This will include delineation of major hydrogeologic units (HGUs), geologic structures having hydrologic significance, sources of recharge/discharge, and hydrologic boundaries. The HGUs will generally consolidate sequences of geologic units that are considered to have similar hydraulic properties and significance with regard to ground water flow. Hydrologic boundaries will typically be defined as no-flow along ground water divides and strong flow paths, or prescribed head along perennial (or nearly perennial) streams. Geologic structures will generally be classified as "low-permeablity" features that impede ground water flow or "high-permeability" features that act as regional drains and enhance ground water flow. Distributed recharge will be specified as a percent of mean annual precipitation and enhanced recharge may occur below certain types of mining facilities (e.g., uncovered waste rock stockpiles). Ground water discharge will occur along perennial streams, by pumping of water supply wells, dewatering of the mine workings, and evaporation from the future Continental Pit Lake. In updating the conceptual model, hand calculations will be performed to verify that the modified HGUs, boundaries, and recharge/discharge relationships are reasonable for the site conditions.

2.3 Task 3 – Numerical Ground Water Flow Model Development

A numerical ground water flow model will be developed to evaluate the hydrologic conditions beneath the Continental Mine Facility. Modflow-Surfact (Hydrogeologic, Inc. 1996), an enhanced version the MODFLOW ground water flow model (McDonald & Harbaugh, 1988), has been chosen as the numerical code used to perform the groundwater flow simulations. Enhancements in Modflow-Surfact allow for explicit simulation of variable ground water recharge and better representation of ground water discharge at seepage faces, which makes it suitable for evaluating pit-wall inflow (e.g. at the Continental Pit).

The flow model will provide a three-dimensional representation of the conceptual model developed under Task 2. This will involve a three-dimensional finite difference mesh incorporating the geometry of HGUs and important geologic structures. Each HGU will comprise a material type within the model that can be assigned unique hydraulic properties. Additional materials will be specified to account for mine facilities and the Continental Pit. Within the mesh, will be internal hydraulic boundaries conforming to ground water divides (no-flow features) and perennial streams (prescribed head features). Finite difference elements outside these boundaries will be inactive. The Continential Pit walls will be specified as seepage faces that allow outflow if situated below the phreatic surface and no-flow if situated above the phreatic surface.

The model will be calibrated to measured water levels in different HGUs and flow rates associated with water supply wells (if present), historical mine inflow, and baseflows in perennial streams. Calibration will generally involve reasonable adjustments of hydraulic properties and boundary conditions in the model so that it adequately simulates these known hydraulic heads and flow rates. Attempts will be made to calibrate the ground water model to: (1) steady-state pre-mining conditions and (2) steady-state operational conditions when the underground mine was fully dewatered. A transient calibration to intermediate dewatering conditions will be considered if there are sufficient temporal data on mine inflow rates during historical operations.

2.4 Task 4 – Ground Water Model Third-Party Review

Model development and the results of calibration will be documented in outline format along with appropriate tables and graphics. This documentation will be submitted to a qualified third party for review and comment. It is anticipated that direct communications between Telesto and the third-party reviewer will also occur via conference calls and emails. The third-party reviewer will provide comments and suggestions for improving the ground water model in a brief letter report. Telesto will respond to the review comments and modify the model as appropriate to improve its predictive capability and credibility with regulators and the public. This may involve redefinition of certain boundary conditions, changes in the lateral/vertical extent of materials (i.e., HGUs), modification of material properties, and additional calibration activities. The project will not proceed to Task 5 until Telesto, Phelps Dodge, and the third-party reviewer agree that the numerical model is adequate for predictive ground water flow simulations.

2.5 Task 5 – Ground Water Model Predictive Simulations and Sensitivity Analysis

A series of predictive simulations will be performed to evaluate potential Continental Mine post-closure scenarios. The focus of the predictive simulations will be post-mining conditions at the Continental Pit and underground workings. Issues to be investigated will include: (1) the time required to refill the pit and the underground workings, (2) the ultimate pit lake water level, (3) whether the pit lake will be a ground water flow-through feature or operate as a terminal sink, and (4) the extent of the ground water capture zone for both open and partial backfill pits. The model will be used to generate analytical response functions that relate: (1) underground mine inflow rate to mine water level, (2) pit inflow rate to pit water level, and (3) induced seepage into or out of Hanover Creek to head conditions in the mine area. These analytical response functions will be used in the DSM to simulate the mine area ground water flow conditions.

The sensitivity of model results to physical properties and boundary conditions will be evaluated. The general procedure is to vary the model inputs within probable ranges and evaluate the extent to which these variations affect model results and conclusions. Inputs to be investigated may include hydraulic conductivity, storativity/specific yield, natural recharge rates, stockpile seepage rates, and the nature of hydrologic boundaries. Sensitivity analysis is considered one of the key outcomes of the modeling effort, in that it provides a measure of the degree of certainty regarding model prediction and can identify important data gaps. An important part of sensitivity analysis is to determine how model sensitivity affects the response functions used in the DSM.

2.6 Task 6 – Supplemental Ground Water Study Report

Tasks 1 through 5 of this work plan will be fully documented in the Supplemental Ground Water Study Report. This will include compilation of existing data, development of the conceptual model, development of the numerical model, predictive simulations, and sensitivity analysis. Also presented will be the flow response functions carried over to the DSM. The report will provide all model input and results in tabular and graphical format. Also included will be a disk containing the model input/output files. A draft report will be submitted to Cobre and the third party reviewer. After incorporation of comments from these parties, the final report will be submitted to the agencies.

2.7 Task 7 – DSM Development

Telesto will develop a DSM to provide a means of simulating the ground water and geochemical systems in an efficient manner. The model will be based on ground water flow response functions developed from the ground water numerical model and chemical response functions developed from Condition 85 geochemical models. Use of response functions allows the DSM to be run for a wide range of closure scenarios without having to re-run the ground water and geochemical models.

DSM modeling will be performed using the publicly available computer codes, GOLDSIM (2004). The DSM will contain tabulated data or analytical functions that incorporate all relevant aspects of the site hydrochemical system. With regard to water balance, the DSM will contain the following components:

- Climate (rainfall, storm events, mean daily temperature)
- Lake evaporation
- Evapotranspiration
- Recharge
- Ground water discharge to streams
- Pit lake inflow (including seepage faces) and pit lake storage
- Inflow to underground workings
- Surface water runoff

Geochemical functions in the DSM will include:

- Chemical mass mixing balance
- Integrated equilibrium chemistry (adsorption to solids and other precipitates, precipitation/dissolution reactions)
- Evapoconcentration.

The DSM will also contain options to simulate different types of mine closure scenarios including:

- Open pit lake
- Partial or completely backfilled pit

- Vegetation/soil covers on mine facilities
- Water recycling between mine facilities
- Spray evaporation
- Evaporation ponds and wetlands
- Ground water pump-and-treat schemes

2.8 Task 8 – DSM Third-Party Review

After initial development of the DSM, relevant documentation will be submitted for third-party review. Based on comments and suggestions from the third-party reviewer, the DSM will be refined and modified as appropriate.

2.9 Task 9 – DSM Predictive Simulations

DSM simulations will be used to evaluate the Continental Pit Lake formation and water quality changes in the pit lake over time. Simulations will be projected 100 years into the future. The simulations will consider different closure alternatives for handling mine waters after the site has moved into closure and will be integrated into the Feasibility Work for Condition 89. Results of DSM simulations will provide support for the Ground Water Abatement Plan (Condition 32) and evaluate if the proposed closure alternatives will achieve the requirements of the Water Quality Act and the Water Quality Control Commission. Selected sensitivity analyses will be performed to evaluate model sensitivities to the input parameters.

2.10 Task 10 – DSM Report

The DSM Report will provide complete documentation of the DSM including: model setup, analytical flow functions, chemical functions and relationships, climate data, and other mathematical formulations used for internal computations. Simulation results for different types of closure scenarios will also be provided. These results will include predicted water levels in the pit lake and concentrations of chemical constituents in the pit lake water. The report will be submitted in draft to Cobre, NMED, and MMD. After incorporation of comments from all parties, a final report will be submitted.

3.0 SCHEDULES AND DELIVERABLES

Table 1 presents the deliverables and schedule for completion of the Condition 84 studies proposed by Telesto.

4.0 REFERENCES

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