ANNEXURE N13: TAILINGS STORAGE FACILITY MODELING STUDY BY AQUATERRA

RPS Aquaterra

RÖSSING - PREDICTION OF GROUNDWATER SEEPAGE MOVEMENT

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1. INTRODUCTION

Evaluation of the potential impacts that mining might have on the regional hydrogeology, makes up part of the full environmental impact assessment for the development of the Rössing mine. RPS Aquaterra have been involved in assisting Rössing Uranium Limited (RUL) with the assessment of the mine site hydrogeology and potential impacts that the mine could have on local and regional surface and groundwater resources for nearly 10 years. Parts of these assessments have involved the evaluation of impacts caused by mine dewatering and also impacts that this dewatering has on groundwater flow. Of particular importance, have been the assessment of seepage flow and seepage chemistry from the tailings storage facility and any other sources of seepage. This assessment has been undertaken using numerical models that have been developed, based on the conceptual understanding of the mine site hydrogeology.

1.1 Background

The development of the Rössing Groundwater Model has been incremental since the original model was developed in 2001/2002. The model was designed to assist in the assessment of operational strategies for the TSF and the prediction of impacts of long term closure strategies. Since the first model was developed, the model boundaries have been extended, with the final extension including the entire Dome Gorge catchment and the Khan River downstream to its confluence with the Swakop River.

In 2009, the groundwater flow model was converted to Modflow Surfact to include some important model features such as a more rigorous handling of near surface water tables and rising groundwater levels. The 2009 model was used to assess the likely flow paths associated with proposed tailings storage in the Dome Gorge area and a combined ripios/heap leach facility over the existing TSF. Results suggested that for the proposed tailings management strategy, all flow paths originating from below the Dome Gorge TSF and the expanded existing TSF were toward the open pit. No groundwater originating from the TSFs was predicted to reach the Khan River over a period of 500 years.

1.2 Project Objectives

As part of the current work, the Rössing groundwater model developed in 2009 was updated to include:

- The latest geological information available from RUL staff that suggests that the Karibib marble, located on the northern side of the existing TSF, is more permeable than previously thought.
- An Amphibolite schist layer of greater permeability than the surrounding bedrock.
- The latest DTEM elevation data available for the mine area.
- Recharge to groundwater from existing waste rock dumps.
- Calibration to data from the period 1990 to 2007, including TSF deposition and seepage at the toe of the dam, groundwater pumping from bores within the TSF and surrounding recovery systems, dewatering of the open pit and groundwater monitoring data.

The calibrated model was then used to predict the likely flow paths of seepage from two further mine operation scenarios, namely:

- The proposed extension of the existing TSF (Base Case(Mine Plan V9.3)).
- Use of the current TSF, with a heap leach facility on the north-eastern extent of the current TSF and ripios disposal in the Dome Gorge area (Expansion Case).

The modelling assumes that the open pit is dewatered consistent with mine development and remains a local groundwater sink after mining is complete.

2. MODEL DESIGN

As outlined above, the current work involved updates to the geological model and extension of the calibration data set. The model set up remains largely unchanged. However, details of the model setup and current updates are provided in the following sections, to allow this document to provide a convenient reference to these details.

2.1 Model Approach

The groundwater flow model was developed using Modflow Surfact operating under the Groundwater Vistas graphical user interface (Version 5, Rumbaugh and Rumbaugh, 1996 to 2010). The transient calibration was run over the period 1990 to 2007. This period was chosen as it represents the period with the most comprehensive monitoring data, including both groundwater and operational TSF data. The calibration includes yearly increments from 1990 to 2000 and monthly increments from 2000 onwards (to 2007). The data varied over these increments includes:

- Recharge to groundwater from operation of the existing TSF and rainfall.
- Groundwater pumping from recovery bores and trenches.

2.2 Model Extent and Grid

The model grid and extent is shown in Figure 1. Coordinates for the four corners of the model domain are detailed in Table 2.1. The model grid was rotated 45 degrees from the local mine grid such that the model grid was aligned with the inferred predominant flow direction (north west to south east). Model cell size ranges from a minimum of 25 metres close to the open pit area, up to 100 metres close to model boundaries. The reduced grid size of 25 metres was adopted to provide better resolution in hydrogeological formations of interest. This results in a total of 213 rows and 449 columns representing 198,300 active cells over the five model layers.

Table 2.1: Model Domain

Grid Position	Easting*	Northing*
North East	10371	-36380
North West	-21377	-68129
South West	-11053	-78454
South East	20695	-46704

* Local Mine Coordinates

2.3 Model Geometry

The current model configuration remains mostly unchanged from earlier models which included five layers. The two upper layers represent the current TSF, while the remaining three layers represent the underlying aquifer/aquitard systems. Details of model layers are summarised below.

- Layer 1 represents the upper coarse tailings and is active only in the area of the current TSF.
- Layer 2 represents the underlying coarse, medium and fine tailings material and is active only in the area of the current TSF.
- Layer 3 represents alluvium of the numerous gorges (Khan Mine, Panner, Pinnacle and Dome Gorges) and the Khan River and shallow weathered basement over the entire Khan River catchment area.
- Layer 4 represents faults underlying the Khan River and the Gorges and weathered basement in all other areas of the model, and has a uniform thickness of 25m over the entire Khan River catchment.
- Layer 5 represents faults underlying the Khan River and Gorges and fresh basement over the remainder of the Khan River catchment.

The modelled ground surface has been updated to include the latest available DTEM data.

2.4 Groundwater Inflow and Outflow

2.4.1 Groundwater Throughflow

The general groundwater flow direction within the catchment is from northwest to southeast. The model boundaries extend southwest as far as the confluence with the Swakop River and include the following:

- The entire extent of Khan Mine, Panner, Pinnacle, Bolder and Dome Gorges.
- The open pit.
- The Khan River and underlying Khan River aquifer.
- An area immediately south of the Khan River.

The northern most inflow boundary is specified as a constant flux boundary across the Khan River alluvium where it crosses the model boundary (refer Figure 1). In practice, groundwater inflow to the model domain via Khan River aquifer will vary in response to surface water flows upstream in the Khan River catchment. This variation has not been incorporated into the model at this time, however a constant inflow of 500kL/day has been included consistent with average groundwater inflow estimates.

On the south west boundary, outflow from the Khan River aquifer is achieved by a fixed head outflow boundary (refer Figure 1). The water levels at this boundary are set 5 meters below the surface elevation at 203mASL.

All other model boundaries are specified as the no flow type, as they are aligned with groundwater divides inferred from surface topography.

2.4.2 Rainfall Recharge

Rainfall recharge to the groundwater model is applied as described below:

- When annual rainfall exceeds 20mm, 1% of incident rainfall recharges the basement rocks and 10% of incident rainfall recharges the alluvium areas of the Gorges and the Khan River.
- When annual rainfall does not exceed 20mm, no rainfall recharge is assigned.

Available rainfall data suggests that the long term average annual rainfall is around 30mm. The distribution of recharge is shown in Figure 2.

2.4.3 Recharge from the Tailings Storage Facility

Recharge to groundwater from the TSF is assigned consistent with the previous approach. Data for the TSF water balance was provided by RUL staff on a monthly basis that allowed the derivation of recharge to groundwater, R, based on measured and derived values for the other components of the balance. This includes:

- Measured water discharge to the dam with tailings (W).
- Measured decant water recovered from the surface of the tailings (i.e. decant recovery from paddock ponds, D).
- Measured recovery from the seepage dam, and other downstream recovery systems (S).
- Estimated evaporation losses based on measured paddock pond sizes (Ev).
- Calculated entrainment in the saturated and unsaturated saturated tailings mass) based on an unsaturated moisture content (or specific retention) as measured in laboratory tests of 12% wt:wt (Etr).

The water balance for the tailings mass can be expressed as:

R = W – D – S – Ev - Etr

This information was also used to derive a relationship between dry tonnes milled and the annual volume of water exiting the tailings mass as seepage. During this and the previous phase of work completed in 2005, more detailed TSF water balance data was available for the years 1990 to 2007, and recharge from the tailings facility was updated accordingly.

The distribution of recharge to the tailings storage facility is varied monthly and assigned to different area of the dam according to deposition history.

2.4.4 Recharge from Rock Waste Dumps

It is understood that there may be enhanced infiltration of incident rainfall recharge under existing waste rock dumps. For the model calibration, rainfall recharge is assigned at a rate of 5.0% of the long term average rainfall of 30mm per annum or 6.02×10^{-6}m/day under waste rock dumps (O'Kane Consultants Inc., 2010). The distribution of recharge to the rock waste dumps is shown in Figure 2.

2.4.5 Drainage Features

Seepage at the toe of the TSF and to areas immediately downstream of the tailings dam, was simulated by the use of Drain cells (with a drain conductance of 1,000m^2/d). In layer 2 (the lower tailings layer) drains were set consistent with ground level to simulate the seepage that occurs at the toe of the dam. Immediately downstream of the tailings dam, drain cells were also set in layer 3, at ground level or known trench elevations, to simulate groundwater seepage to the surface or to trenches.

Drain cells were also assigned along Khan Mine, Panner, Bolder, Pinnacle, Khan Mine and Dome Gorges to simulate potential groundwater baseflow to the gorges and subsequent loss from the system as surface water flow. The drain bed conductance was set at 1,000m^2/day, with drain levels set consistent with ground level elevations (based on data derived from the latest DTEM). Generally, groundwater does not report to these areas as the predicted groundwater levels were below the assigned drain elevations. In some areas (at some times), groundwater does report to some of these cells. However, the volumes were so small compared to the cell size, that the entire volume would be lost to evaporation (i.e. these are not significant flows). The distribution of drain cells is show in Figure 3.

2.4.6 Evapotranspiration

Evapotranspiration (ET) from the shallow water table underlying the Khan River has been incorporated in the latest model using the Evapotranspiration package in Modflow Surfact Modflow Surfact uses a depth dependent relationship such that if aquifer water levels are at or above a specified evaporation surface ET occurs at the maximum specified rate. If the aquifer water levels decrease below the specified ET surface, the ET rate decreases linearly to zero as the predicted water level reaches an elevation equal to the ET surface minus the extinction depth. The ET rate is also set to zero wherever the aquifer water level is below the elevation equal to the ET surface minus the extinction depth. This is illustrated schematically in Figure 4.

The average annual evaporation in the area is approximately 2.81 metres per year or 7.7mm per day, consistent with average daily evaporation measured on site. The evapotranspiration surface is set consistent with available topographic data for the Khan River area with an extinction depth of 5 metres. The distribution of modelled ET is shown in Figure 3.

2.4.7 Open Pit

The open pit was simulated by constant head outflow cells, set at levels consistent with the pit floor level. It was assumed for the calibration period, that the pit was at its current depth since 1990. For model predictions, the pit depths are set based on the projected mine development plans.

2.4.8 Groundwater Pumping

Pumping from recovery wells along the southwest corner of the TSF (referred to as the TDDS system) and the south east corner of the TSF (referred to as the TDDX system) and surrounding weathered basement aquifers was simulated by the Well package within Modflow Surfact. Groundwater pumping rates were set consistent with information provided by RUL.

2.5 Model Calibration

2.5.1 Approach

Model calibration is the process of demonstrating that a groundwater model replicates historical monitoring data. As the current model includes only minor updates and is primarily based on an already calibrated model, no significant changes were required to aquifer parameters and boundary conditions to achieve model calibration described in the following sections.

Model calibration performance was checked in qualitative (water level matches) and quantitative (pattern-matching) terms against a range of targets, including:

- Groundwater level targets, i.e. time-series hydrographs of modelled / measured levels at selected monitoring bores.
- Seepage flux from the tailing facility against measured volumes.
- Groundwater inflow to the pit.
- Other water balance components over time.

2.5.2 Calibration to Observed Heads

The calibration to transient or time varying conditions was completed for the groundwater model for the period of 1990 to 2007. Observed and modelled water levels for the end of the calibration period (end of 2007) are shown in Figure 5. The scaled root mean square (SRMS) error for this time is 4.60%. This is consistent with the best practice for a developed catchment that suggests that the SRMS error should be less than 5% (MDBC, 2000). Calibration plots for selected monitoring bores and TSF piezometers are presented in Figures 6 to 17. The location of observation bores are shown in Figure 17 and 17a. Generally, the model calibration is good and measured groundwater level trends inside and outside the TSF are well replicated by the groundwater model.

For the January 1990 to December 2007 period, the following groundwater level trends are apparent:

- At piezometers located at the downstream end of the TSF, within the assigned starter wall zone, the magnitude of the predicted water levels is well matched (Figures 5 and 18). The magnitude of the predicted response to tailings deposition, however, varies more than the measured data. This may be related to localised features or behaviour in the starter wall material which is not currently represented in the model as the starter wall material is assigned a uniform horizontal hydraulic conductivity. Conversely it may be related to limitations of the current TSF recharge model described in Section 2.4.3.
- To the immediate west and south west of the TSF, predicted water levels are matched at bores X12 (Figure 9), B (Figure 10) and G (Figure 11) although at some locations measured values are over predicted by the model (Bores DW8 (Figure 9), DW26, E and G27122 (Figure 10)).
- In the area to the north west of the TSF, predicted water levels are well matched (G27124 (Figure 9) and under predicted at bores (X13, DW10 (Figure 9)).
- Further west of the TSF, water levels are over predicted by up to 16 metres. At bores X8 (Figure 10), L6 and L7 (Figure 11) water levels are over predicted by between 8 and 16 metres. Predicted water levels at Bore L10 (Figure 10) and M (Figure 11) are replicated by the model.
- In the Panner Gorge area, water levels are well matched by the model. At bore L9 (Figure 11) however, the measured recharge response in years 1996, 1999 and 2005 are not replicated by the model.
- To the east of the TSF water levels are well matched at bores N1A, N2 and N3 (Figure 12), and slightly under predicted at N4 (Figure 12) and N5 (Figure 16).
- North of the TSF water level elevation is well matched at bore L4 (Figure 12) however the decreasing observed water level trend is not replicated by the model.

- North west of the TSF measured water levels are well matched at L1 (Figure 12) and N7 (Figure 16).
- South east of the TSF and north of the open pit, measured water levels are under predicted by 6 metres at bore RGTP46 (Figure 13).
- Close to the open pit measured water levels are over predicted at RGTP4 (Figure 14) however the decreasing observed water level trend is matched by the model. Water levels are under predicted at RGTP28 and RGTP9 (Figure 14) however the overall trend is predicted by the model. At RGTP9 and RGTP45 (Figure 14) both the water level elevation and measured trend are not replicated by the model. The observed mismatches are consistent with piezometers in this area reflecting flow conditions close the pit which are not represent in the current model set up.
- Interactions between groundwater inflow, and groundwater abstraction in the Khan River aquifer are well replicated at DG1, BH6, BH4, 1.6A, 1.4A, K (Figure 14) and DBH2, KEM3 and UK4B (Figure 16). Water levels at TR5A (Figure 16) are over-predicted by up to 30 metres. There is no clear reason for this on the basis of the current hydrogeological understanding.

Predicted groundwater contours and measured spot heights for the end of the calibration period, i.e. the end of 2007, for layers 5 is presented in Figure 18.

2.5.3 Calibration to Seepage from the Tailings Storage Facility

Measured seepage dam pumping, predicted inflow to the seepage dam and applied TSF recharge rates are presented in Figure 8. Generally, the predicted seepage is consistent with the measured rate of seepage dam pumping. The model is not however able to replicate short term variations in measured seepage dam pumping rates. The model does however, represent average seepage dam pumping and replicate the general increasing and decreasing measured trends in seepage dam pumping.

2.5.4 Calibration to Pit Inflow Flux

Groundwater inflow into the pit is predicted at 1,000kL/day at the end of the calibration period which is consistent with the current dry nature of the open pit, when subject to evaporative losses.

2.5.5 Overall Model Budget

The model predicted water balance at the end of the calibration period (end of 2007) is presented in Table 2.2.

Table 2.2: Water Balance at the end of Calibration

Flux feature	Flux in (kL/d)	Flux out (kL/d)
Groundwater Inflow (Khan River)	500	
Recharge (TSF and Rainfall)	8,000	
Storage In (storage decrease associated with water level decline)	6,200	
Groundwater Outflow (Downstream boundary and Open pit)		1,200
Groundwater Pumping (trenches and recovery bores)		950
Seepage Dam Pumping		5,200
Evaporation		1,550
Storage Out (storage increase associated with predicted water level increase)		5,800
Total	14,700	14,700

The predicted water balance suggests that the largest inflows into the model are recharge from the TSF and aquifer storage changes associated with predicted water level decreases. The largest outflows from the model are seepage dam inflows and storage increases associated with predicted water level increases.

2.5.6 Aquifer Parameters

The distribution of aquifer parameters assigned in the calibrated model are shown in Figures 19 to 23. Calibrated aquifer parameters assigned to each formation are summarised in Tables 2.3 to 2.7.

Table 2.3: Summary of Adopted Calibrated Aquifer Parameters-Layer 1

Zone	Hydrogeological Unit	Horizontal Hydraulic Conductivity Kh (m/d)	Vertical Hydraulic Conductivity Kv (m/d)	Sy	S
Zone 1	Medium Tailings	10	0.1	0.25	0.0001
Zone 2	Coarse Tailings	4	0.5	0.25	0.0001
Zone 3	Starter wall	2	2	0.25	0.0001

Table 2.4: Summary of Adopted Calibrated Aquifer Parameters-Layer 2

Zone	Hydrogeological Unit	Horizontal Hydraulic Conductivity Kh (m/d)	Vertical Hydraulic Conductivity Kv (m/d)	Sy	S
Zone 3	Starter wall	2	2	0.25	0.0001
Zone 4	Fine Tailings	0.5	0.5	0.25	0.0001
Zone 5	Coarse Tailings	1	0.01	0.25	0.0001
Zone 6	Medium Tailings	0.1	0.001	0.01	0.0001

Table 2.5: Summary of Adopted Calibrated Aquifer Parameters-Layer 3

Zone	Hydrogeological Unit	Horizontal Hydraulic Conductivity Kh (m/d)	Vertical Hydraulic Conductivity Kv (m/d)	Sy	S
Zone 7	Khan & Etusis Fm	0.005	0.001	0.001	0.00001
Zone 8	Kuiseb, Karibib and Chuos	0.015	0.0001	0.001	0.00001
Zone 9	Quaternary Cover	0.04	0.0001	0.01	0.0001
Zone 10	Karibib	0.1	0.01	0.01	0.0001
Zone 11	Rössing Marble	0.1	0.0001	0.01	0.0001
Zone 12	Amphibole Schist - High K Zone	0.05	0.005	0.005	0.00001
Zone 13	Gorge Alluvium	10	0.1	0.1	0.0001
Zone 14	Panner Gorge Alluvium	20	0.1	0.1	0.0001
Zone 15	Gorge Alluvium	10	0.1	0.1	0.0001
Zone 16	Faults	0.4	0.1	0.02	0.0001
Zone 17	Rössing Fm Alaskites	0.001	0.0001	0.005	0.00001
Zone 18	Rössing Marble	0.1	0.0001	0.01	0.0001
Zone 19	Khan River Alluvium	40	20	0.1	0.0001
Zone 20	Gorge alluvium	0.5	0.1	0.001	0.00001
Zone 21	Faults	0.2	0.1	0.02	0.0001

Table 2.6: Summary of Adopted Calibrated Aquifer Parameters-Layer 4

Zone	Hydrogeological Unit	Horizontal Hydraulic Conductivity Kh (m/d)	Vertical Hydraulic Conductivity Kv (m/d)	Sy	S
Zone 7	Khan & Etusis Fm	0.005	0.001	0.001	0.00001
Zone 8	Kuiseb, Chuos, and Karibib	0.015	0.0001	0.001	0.00001
Zone 9	Quaternary Cover	0.04	0.0001	0.01	0.0001
Zone 10	Karibib	0.1	0.01	0.01	0.0001
Zone 11	Rössing Marble	0.1	0.0001	0.01	0.0001
Zone 12	Amphibole Schist - High K Zone	0.2	0.02	0.005	0.00001
Zone 13	Gorge Alluvium	10	0.1	0.1	0.0001
Zone 16	Faults	0.4	0.1	0.02	0.0001
Zone 17	Rössing Fm Alaskites	0.001	0.0001	0.005	0.00001
Zone 18	Rössing Marble	0.1	0.0001	0.01	0.0001
Zone 19	Gorge Alluvium	40	20	0.1	0.0001
Zone 20	Fault under Panner Gorge (downstream)	0.5	0.1	0.001	0.00001
Zone 21	Faults	0.4	0.1	0.02	0.0001
Zone 22	Gorge Faults	1	0.1	0.1	0.0001
Zone 23	Khan River Alluvium	6	0.1	0.001	0.00001

Table 2.7: Summary of Adopted Calibrated Aquifer Parameters-Layer 5

Zone	Hydrogeological Unit	Horizontal Hydraulic Conductivity Kh (m/d)	Vertical Hydraulic Conductivity Kv (m/d)	Sy	S
Zone 12	Amphibole Schist	0.2	0.02	0.005	0.00001
Zone 13	Gorge Alluvium	10	0.1	0.1	0.0001
Zone 21	Faults	0.4	0.1	0.02	0.0001
Zone 24	Rössing Fm Alaskite	0.001	0.0001	0.0001	0.00001
Zone 25	Rössing marble	0.1	0.0001	0.0001	0.00001
Zone 26	Rössing marble	0.1	0.0001	0.001	0.00001
Zone 27	Fault under Khan River	2	0.1	0.0002	0.00001
Zone 28	Khan & Etusis Fm	0.005	0.001	0.0001	0.00001
Zone 29	Faults Gorges	0.1	0.01	0.0002	0.00001
Zone 30	Kuiseb, Chuos, and Karibib Fm	0.0015	0.0001	0.0001	0.00001
Zone 31	Kuiseb, Chuos, and Karibib Fm	0.0015	0.0001	0.0001	0.00001

3. MODEL PREDICTIONS

3.1 Prediction set up

The calibrated groundwater flow model has been used to assess:

- Potential flow paths from the expanded TSF, including heap leach pads developed on the existing TSF, Ripios disposal in the Dome Gorge area and waste rock dumps.
- Long term flow paths resulting form the interactions of decommissioned tailings facilities and the open pit.
- Concentrations of sulphate plumes developed with time as seepage moves away from the facilities mentioned above.

Two different scenarios have been assessed, namely

- Base Case – the prediction was based on the use of the existing TSF for a 16 year period (2009 – 2025).
- Expansion Case - the prediction assumed that the existing TSF will be operational between 2009 and 2024 and include heap leach facilities and that there will be a new ripios facility in the Dome Gorge area. These facilities will be decommissioned in 2024.

To predict the impact of the operational TSFs and long term closure impacts, the model was run from 2009 to 2024, and then for a period of a further 1000 years. Other key model assumptions and constraints are described in Table 3.1.

Particle tracking was completed using Modpath. This program predicts the flow paths associated with the conditions outlined above. To complete the predictions, a number of particles, or flow origin points were assigned in the area of the existing TSF, the proposed Dome Gorge TSF and waste rock dumps near the Open Pit and their movement away from these locations was simulated.

Table 3.1: Assumptions and Constraints Applied in the Prediction Runs

Feature	Start Date	Finish Date	Quantities	Comments
Existing TSF	2009	2024	5200 kL/d over 12 ha, plus rainfall recharge	The seepage from TSF has been applied in the western parts of existing TSF and has been rotated through the paddock areas (as shown in Figure 3.1) each year.
Heap Leach Pad (on existing TSF area)	2013	2023	4.32×10^{-4} kL/d	The seepage from the heap leach pad is simulated at the rate of 10^{-8} m/sec with only 50% of the pad area actively recharging the groundwater system. The area under heap leach is progressively increased from an area of 0.64 km2 in 2013 to a maximum area of 1.47 km^2 by 2019.
Ripios on Dome Gorge	2013	2023	1.6×10^{-6} KL/d	Seepage from the ripios is simulated at a rate of 0.6mm/year. The area under ripios is increased from 0.33 km2 in 2013 reaching a maximum area of 1.78 km2 in 2017.
Waste Rock Dumps	2009	Ongoing, post closure of TSF facilities	0.3 mm/yr	Seepage from waste rock dumps is simulated at a rate of 8.20×10^{-7}m/day (5% of average annual rainfall of (0.30mm).
Rainfall	2009	Ongoing, post closure of TSF facilities		10% of average annual rainfall (30mm) to Gorges, 1% to other areas.
TDDS Borefield	2009	Ongoing, post closure of TSF facilities	Maximum Pumping	Groundwater levels are set consistent with minimum achievable at pumping locations
TDX borefield	2009	Ongoing, post closure of TSF facilities	Maximum Pumping	Groundwater levels are set consistent with minimum achievable at pumping locations
WDW borefield pumping	2009	Ongoing, post closure of TSF facilities	Maximum Pumping	Groundwater levels are set consistent with minimum achievable at pumping locations
NTSC borefield pumping	2009	Ongoing, post closure of TSF facilities	Maximum Pumping	Groundwater levels are set consistent with minimum achievable at pumping locations
Pumping from Trenches B, C, E and H	2009	Ongoing after operational period, for remainder of prediction.	Maximum Pumping	Trench elevations are set consistent with the base of the alluvium. Trench G (Upper Dome Gorge) is activated at beginning of post-closure period, even though the trench always remains dry.
Khan River Aquifer pumping	2009	2023	Maximum Pumping rate as per licensed abstraction (2000kL/day)	Groundwater levels are set consistent with minimum achievable at pumping locations
Seepage Dam Operation	2009	ongoing		The seepage dam continues to operate throughout the whole simulation period, even though seepage into the dam is balanced by evaporation out of the dam after 40 years.
Groundwater inflow to the Open Pit	2009	ongoing		Ongoing pit development simulated consistent with LOM Plan V9.3 during operational period. During the post-closure period, Open Pit left open to form a long term groundwater sink (ie all groundwater flow towards the pit with little to no groundwater flow away from the pit)

4. BASE CASE SCENARIO

The Base Case Scenario (Mine Plan V9.3) involves conventional tailings spread over entire footprint of the existing TSF, with associated seepage to the underlying groundwater from the TSF and from rainfall percolating through the rock dumps. The layout of the rock dumps is as per Figure 25. Although this layout differs slightly from more recently proposed rock dump layouts, this layout was utilized since data on sulphate concentrations only exist for each of the different rock dumps in this layout. A schedule for rotation of the paddocks in the TSF over the 16 years mine life covered in this scenario, was obtained from Metago (see Appendix A).

4.1 Base Case Prediction Results

4.1.1 Seepage Movement

The calibrated model was run for the Base Case scenario to predict the movement of seepage from the TSF and the rock dumps.

The majority of the seepage moves down Pinnacle Gorge and is captured by the cone of depression formed by dewatering of the pit, ultimately ending up in the pit. Some seepage moves down Panner Gorge and ends up in the Khan River, at a period between 50 and 100 years after mining stops. The only other seepage that enters the Khan River emanates from the rock dumps south of the pit which moves very slowly through the bedrock and the bottom end of Dome Gorge, entering the Khan River 500 to 1000 years after the mine closes. Although not a quantitative indication of seepage rates, only two of the particles "released" from the TSF end up in the Khan River. It should be clearly understood, that even though the particle tracking suggests that some seepage enters the Khan River, this does not suggest that the seepage will have any impact on the water quality in the Khan River. The contaminant transport modelling (below) provides a better understanding of the impact that this seepage has on water quality.

4.1.2 Contaminant Transport Modelling

As an initial assessment of contaminant migration, modelling of concentrations in sulphate levels was undertaken, assessing the movement of sulphate away from the source areas (the TSF and the rock dumps). Sulphate was utilised, since information was available on concentrations in the seepage emanating from the TSF and the rock dumps, and since sulphate is "non-reactive" parameter which would show limited attenuation during seepage.

Information presented by RUL indicates that the sulphate concentration leaving the TSF would be 14,000mg/L, while the variability in concentrations of seepage leaving the rock dumps concentration was based on data provided by SRK (2011). A single concentration of 1,995mg/L SO4 was used for the entire area for the duration of the operational and closure periods.

The changes in the sulphate concentrations in the groundwater (above the current conditions) are shown for 10, 20, 50, 100, 500 and 1000 years after the start of the modelling simulation (Appendix B). The highest concentrations of sulphate, spread over the greatest area, occur 20 years after the start of the prediction. Thereafter, the extent of the sulphate plume remains relatively static. The worst quality "finger" of sulphate movement occurs along the Pinnacle Gorge, towards the open pit. The increase in sulphate concentrations adjacent to the open pit, in Pinnacle Gorge are ~ 2100mg/L, while there is no increase in sulphate levels of any seepage leaving Pinnacle Gorge and entering the Khan River. Seepage from the rocks dumps adjacent to the bottom end of Dome Gorge does enter the Khan River through the Dome Gorge fracture system, at a sulphate concentration of ~70mg/L. The current sulphate levels at Bore 1.6 (in the Khan River alluvium, just downstream of Panner Gorge) have varied between 600-800mg/L since 1986. The limited seepage from the rock dumps at 70mg/L is unlikely to significantly increase the sulphate levels in the Khan river any further, since the seepage volumes are very low compared to the throughflow in the Khan River aquifer system. The modelling suggests the increased sulphate concentrations will be below 1mg/L.

5. EXPANSION CASE SCENARIO

The Expansion Scenario involves conventional tailings spread over the central footprint of the existing TSF, with a heap leach pad over the north-eastern end of the current TSF, Ripios disposal in the Dome area and rock dumps (as laid out in Figure 25). Although this layout differs slightly from more recently proposed rock dump layouts, this layout was utilised since data on sulphate concentrations only exist for each of the different rock dumps in this layout.

From each of these areas, seepage to the underlying groundwater system would take place.

5.1 Expansion Case Prediction Results

5.1.1 Seepage Movement

The calibrated model was run for the Expansion Case scenario to predict the movement of seepage from the TSF, the heap leach pad, the ripios disposal area and the rock dumps. The movement of the seepage from these different areas in shown in Appendix C, showing the paths that particles would follow for 10, 20, 50, 100, 500 and 1000 years after the start of the modelling simulation. The predictions show that:

- The majority of the seepage from the TSF and Heap Leach pad moves down Pinnacle Gorge and is captured by the cone of depression formed by dewatering of the pit, ultimately ending up in the pit. Some seepage moves down Panner Gorge and ends up in the Khan River, at a period between 50 and 100 years after the start of the model prediction.
- All of the seepage from the Ripios dump in the Dome area moves down the Dome George and ends up in the open pit.
- Some very limited seepage is predicted to enter the Khan River – this seepage emanates from the rock dumps south of the pit and would move very slowly through the bedrock and the bottom end of Dome Gorge, predicted to enter the Khan River 500 to 1000 years after the mine closes in the Dome George area.

Once again, even though the particle tracking suggests that some seepage does enter the Khan river, the particle tracking does not quantify the amount of seepage entering the river and as a result, no conclusion can be drawn that this seepage will negatively impact the water quality in the river. The contaminant transport modelling results (below) provides a better understanding of the impact that this seepage is predicted to have on water quality around the mine.

5.1.2 Contaminant Transport Modelling

As an initial assessment of contaminant migration, modelling of concentrations in sulphate levels was undertaken, assessing the movement of sulphate away from the different seepage source areas listed above. Information presented by RUL indicates that the sulphate concentration leaving the different areas would be:

- TSF - 14,000 mg/L.
- Heap Leach pad – 50,000mg/L.
- Ripios dump – concentrations were based on Mintek's drain down testwork (Mintek, 2009). For the first 2 years of operation - 10,900mg/L SO4 was used, for the rest of the operational period 2,900mg/L SO4 was used, while 1,470mg/L SO4 was used post-closure.
- Rock dump seepage – concentration was based on data provided by SRK (2011). A single concentration of 1,995mg/L SO4 was used for the entire area for the duration of the operational and closure periods

The changes in the predicted increase in sulphate concentrations in the groundwater (above the current conditions) are shown for periods of 10, 20, 50, 100, 500 and 1000 years after the start of the modelling simulation (Appendix B). The highest concentrations of sulphate, spread over the greatest area, occur 20 years after the start of the prediction. Thereafter, the extent of the sulphate plume does not change significantly. The overall plume extent does continue to increase after 20 years, but only at very low concentrations, while the central high concentration areas are predicted to decrease after 20 years. The worst quality "finger" of sulphate movement occurs along Pinnacle Gorge, towards the Open Pit. The highest sulphate concentrations adjacent to the open pit, in Pinnacle Gorge are approximately 1950mg/L, while there is no increase in predicted sulphate concentrations of any seepage leaving Pinnacle Gorge and entering the Khan River. The increase in sulphate concentration at the downstream end of the Panner Gorge (at it's furthest extent after 100 years) is only 1mg/L. Seepage from the rock dumps adjacent to the bottom end of Dome Gorge does enter the Khan River through the Dome Gorge fracture system, with a sulphate concentration of 60mg/L. The current sulphate levels at Bore 1.6 (in the Khan River alluvium, just downstream of Panner Gorge) have varied between 600-800mg/L since 1986. The limited seepage from the rock dumps at 60mg/L, is unlikely to significantly increase the sulphate levels in the Khan River any further. The current sulphate levels at Bore 1.6 (in the Khan River alluvium, just downstream of Panner Gorge) have varied between 600-800mg/L since 1986. The limited seepage from the rock dumps is unlikely to significantly increase the sulphate levels in the Khan river any further, since the seepage volumes are very low compared to the throughflow in the Khan river aquifer system. The modelling suggests the increased sulphate concentrations will be below 1mg/L.

6. CONCLUSIONS

Results of modelling completed to date suggest that predicted groundwater flow paths associated with the operation and closure of the exiting TSF, rock dump, heap leach or ripios facilities proposed for the Base and Expansion Cases are ultimately towards the open pit. Particle tracking predicts that some limited flow is predicted to reach the Khan River via Panner, Pinnacle and Dome Gorges. The particle tracking is not quantitative, so even though some seepage is predicted to enter the Khan river, this does not suggest that there is any impact on the water quality.

The contaminant transport modelling (using sulphate as a conservative parameter which is not subjected to any chemical attenuation along the flow paths) shows that the seepage not being captured by the inflow to the open pit and entering the Khan River, will have low sulphate concentrations. These low concentrations, coupled with the low seepage rates and the higher flows in the Khan River alluvial aquifer system, will result in exceptionally low increases in sulphate levels in the Khan river alluvium – below 1mg/L.

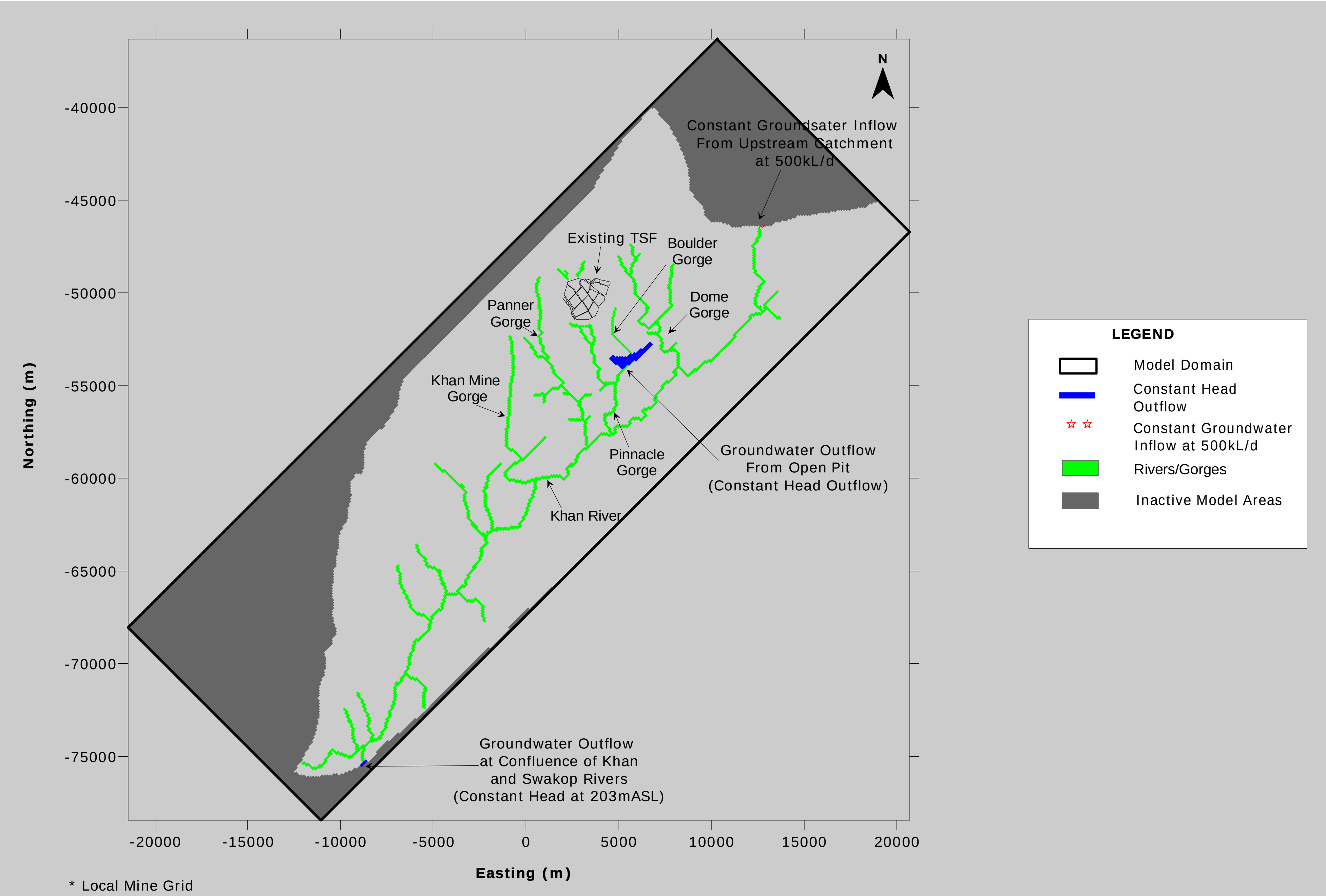
7. REFERENCES

Mintek, 2009, Acid generation and drain-down testwork on Rössing uranium ore, Authors P.J. van Staden, W.W. Robertson & A. Seiedbaghery, 08 January 2009, Report 4995, Randburg, South Africa

Murray Darling Basin Commission, 2000. Groundwater Flow Modelling Guideline, November 2000.

Steffen Robertson and Kirsten, 2011. Unpublished table of results for laboratory seepage tests, provided in an email from James Lake, 15 February 2011.

FIGURES



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MODEL DOMAIN AND BOUNDARY CONDITIONS FIGURE 1

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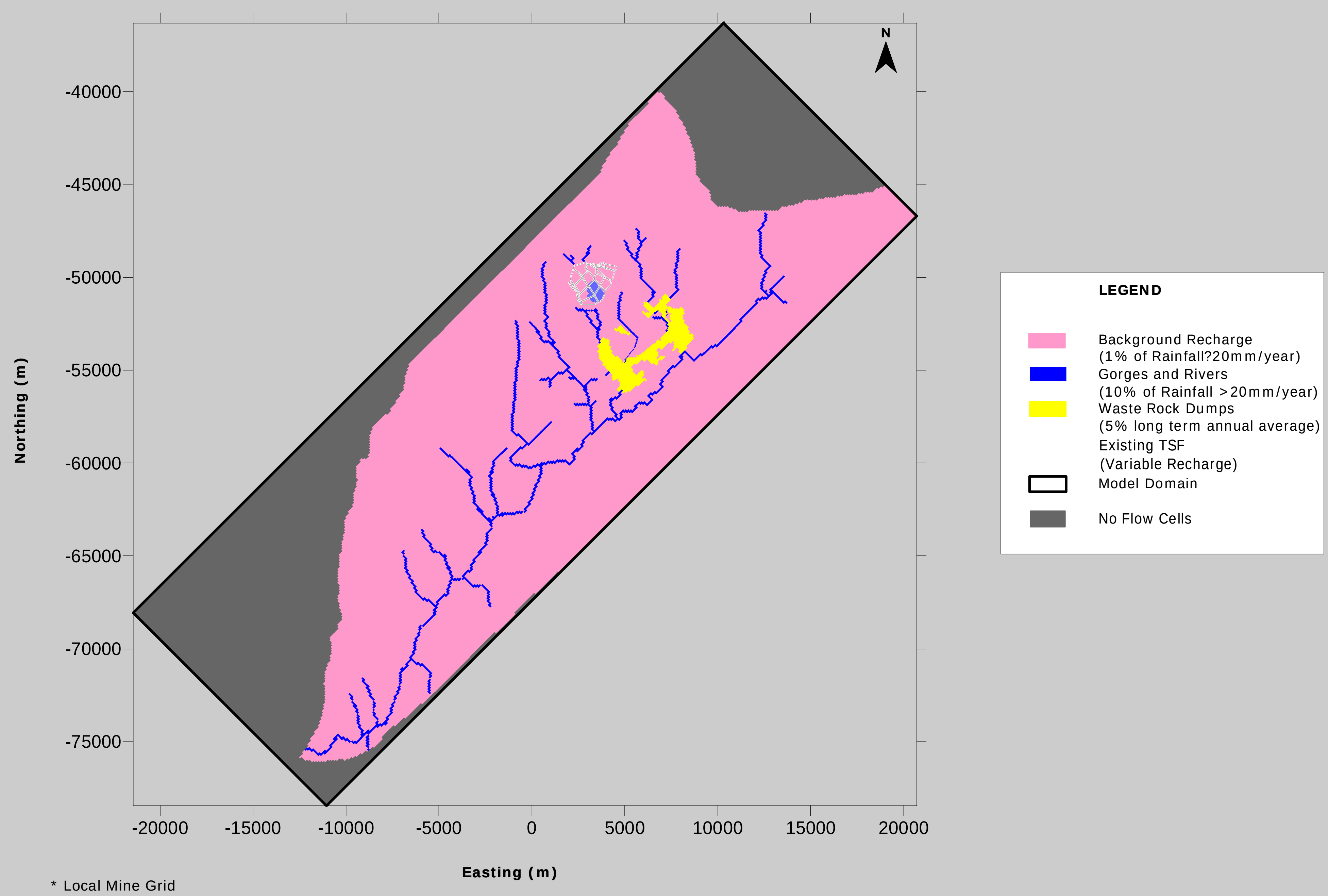

* Local Mine Grid

RPS Aquaterra

MODELLED RECHARGE DISTRIBUTION FIGURE 2

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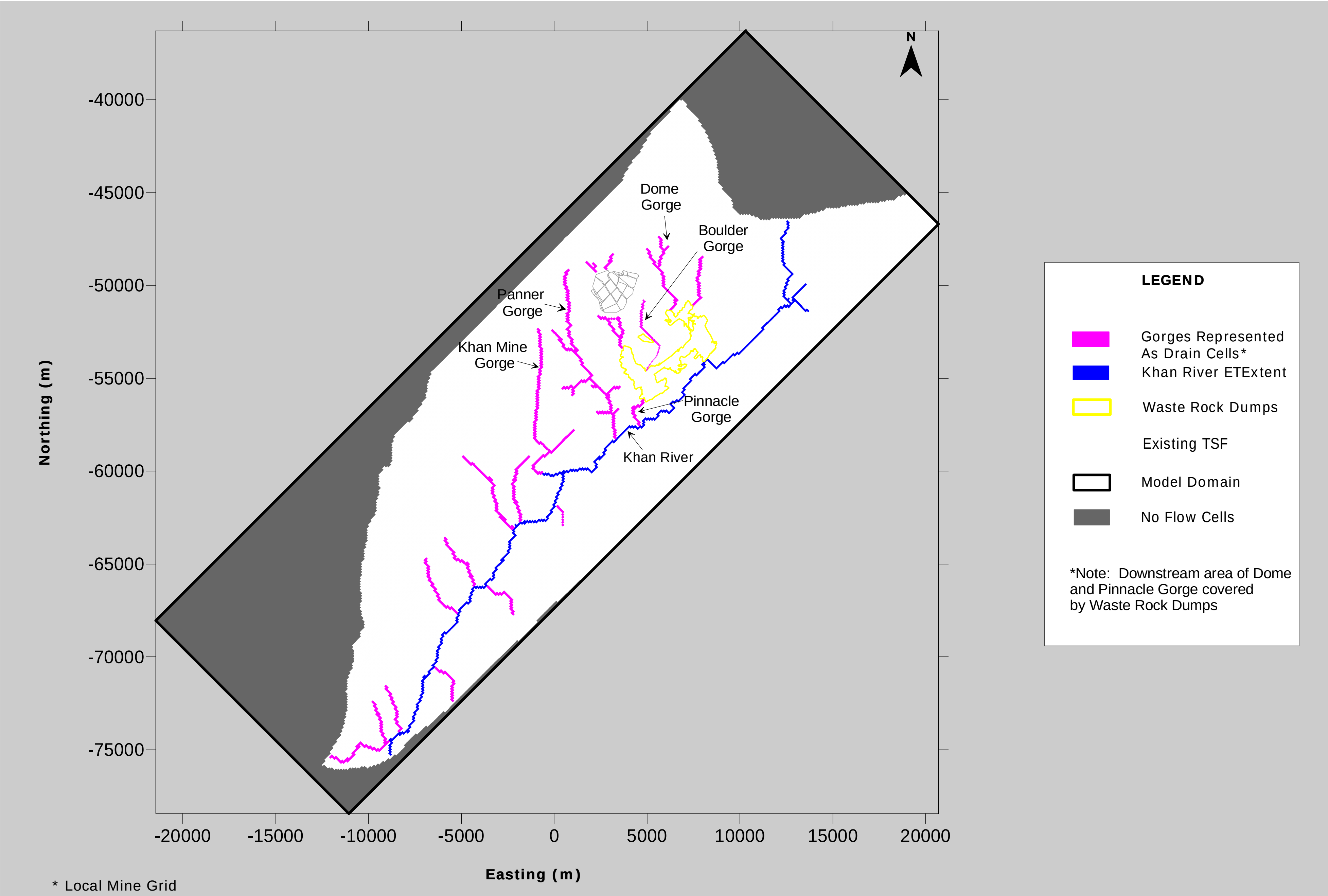

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DRAINAGE FEATURES AND EVAPOTRANSPIRATION DISTRIBUTION FIGURE 3

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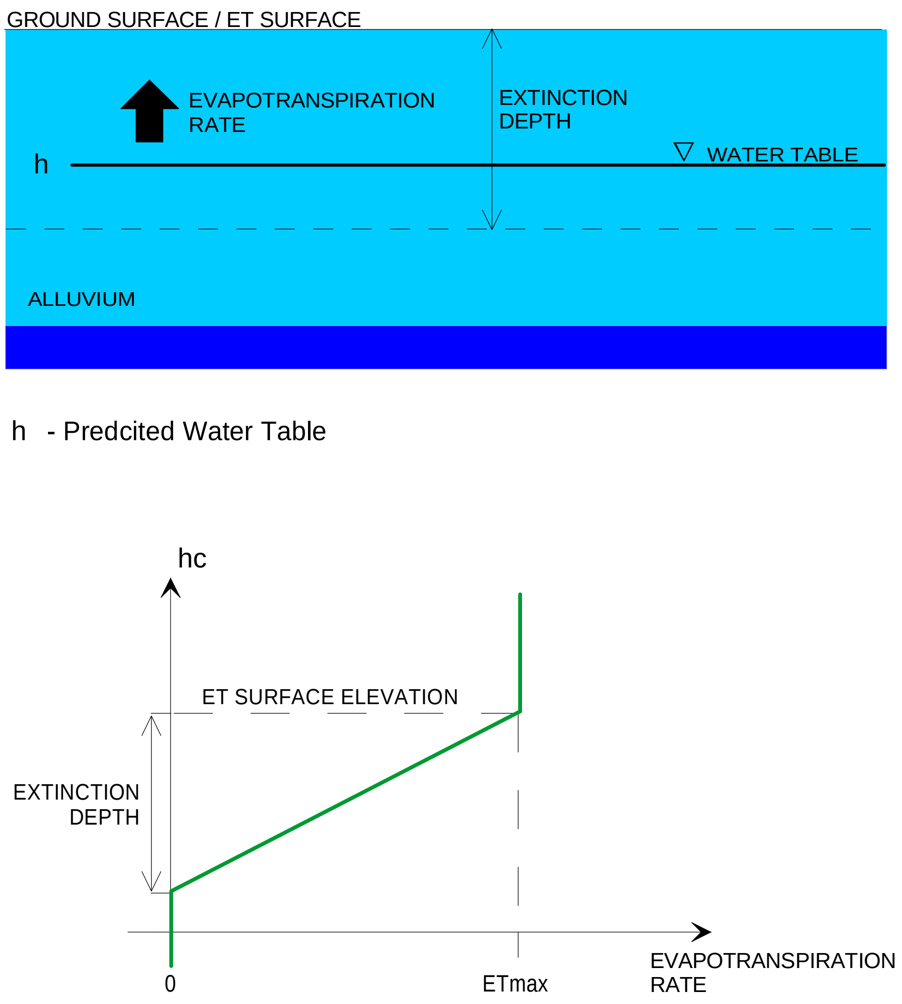
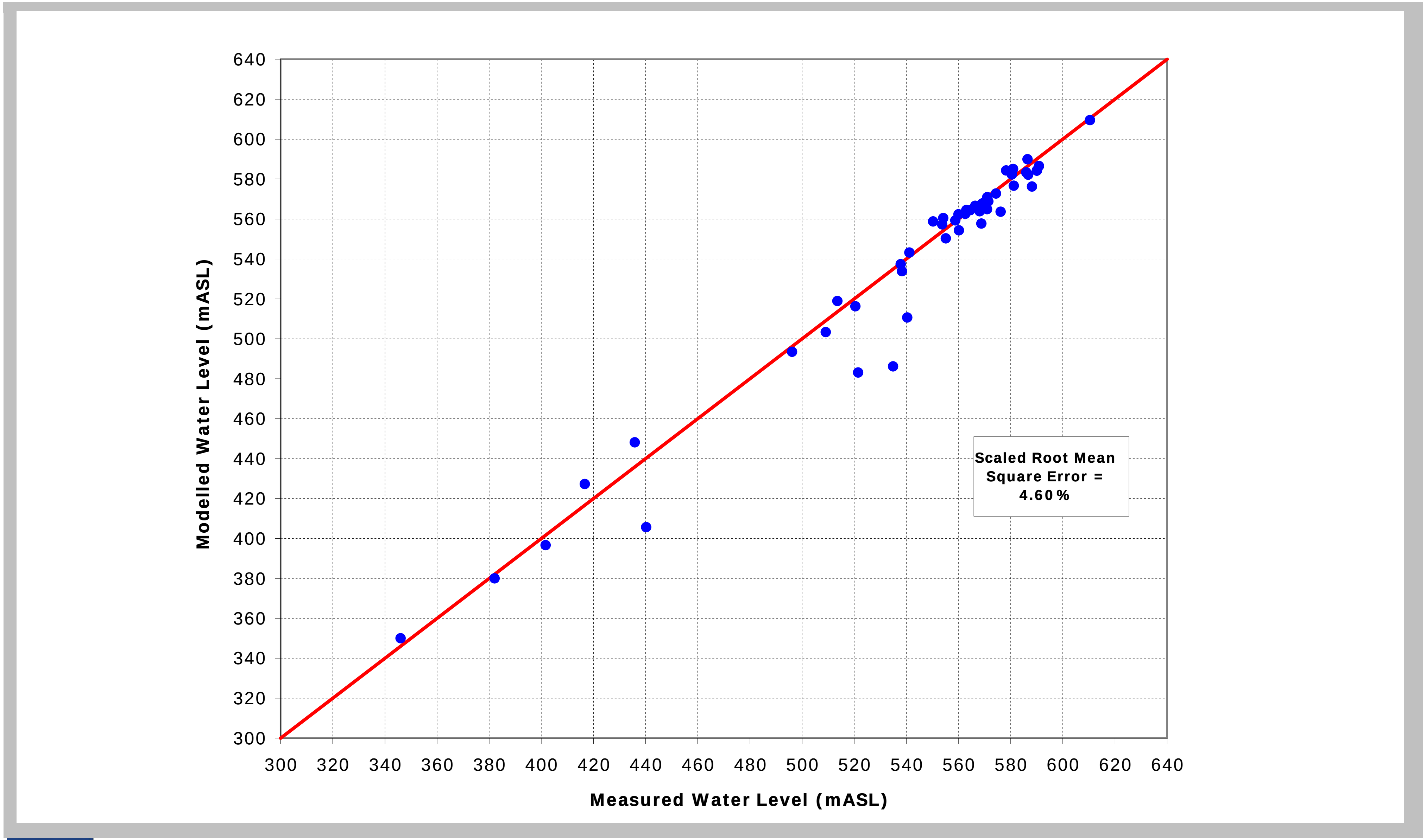

GROUND SURFACE / ET SURFACE
EVAPOTRANSPIRATION RATE
EXTINCTION DEPTH
h
WATER TABLE
ALLUVIUM
h - Predcited Water Table
hc
ET SURFACE ELEVATION
EXTINCTION DEPTH
0
ETmax
EVAPOTRANSPIRATION RATE



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MEASURED VERSUS MODELLED WATER LEVELS FIGURE 5

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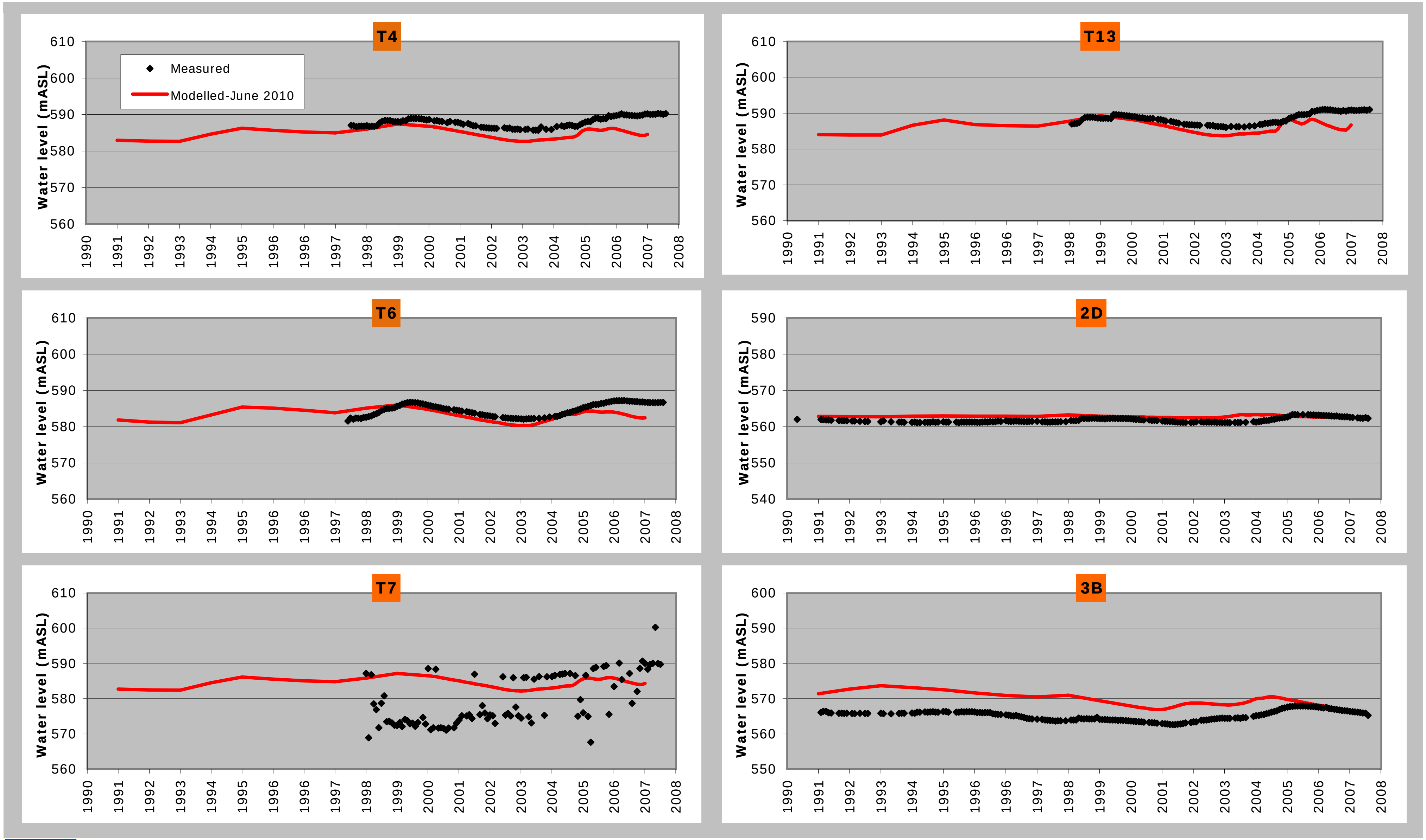

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TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 6

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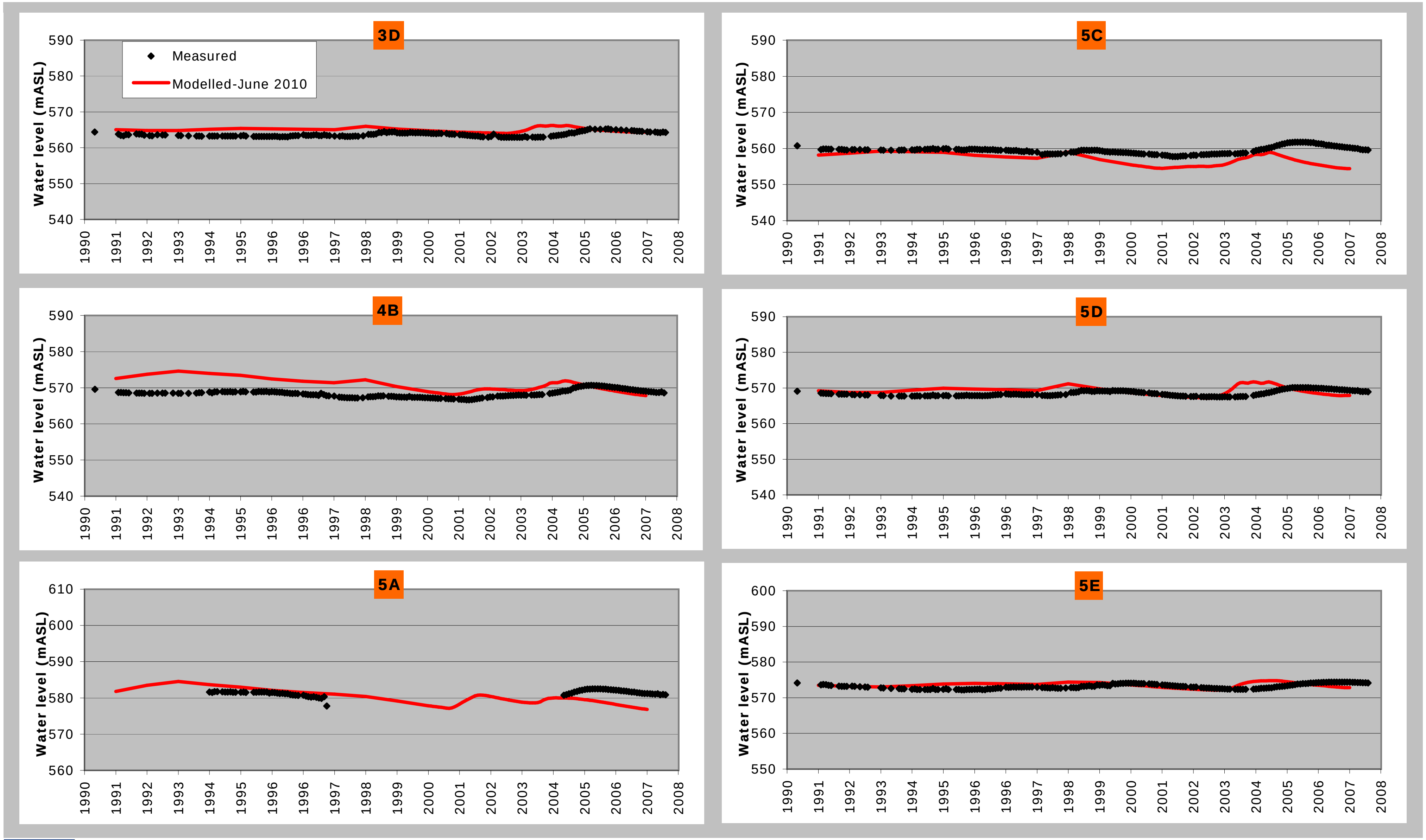
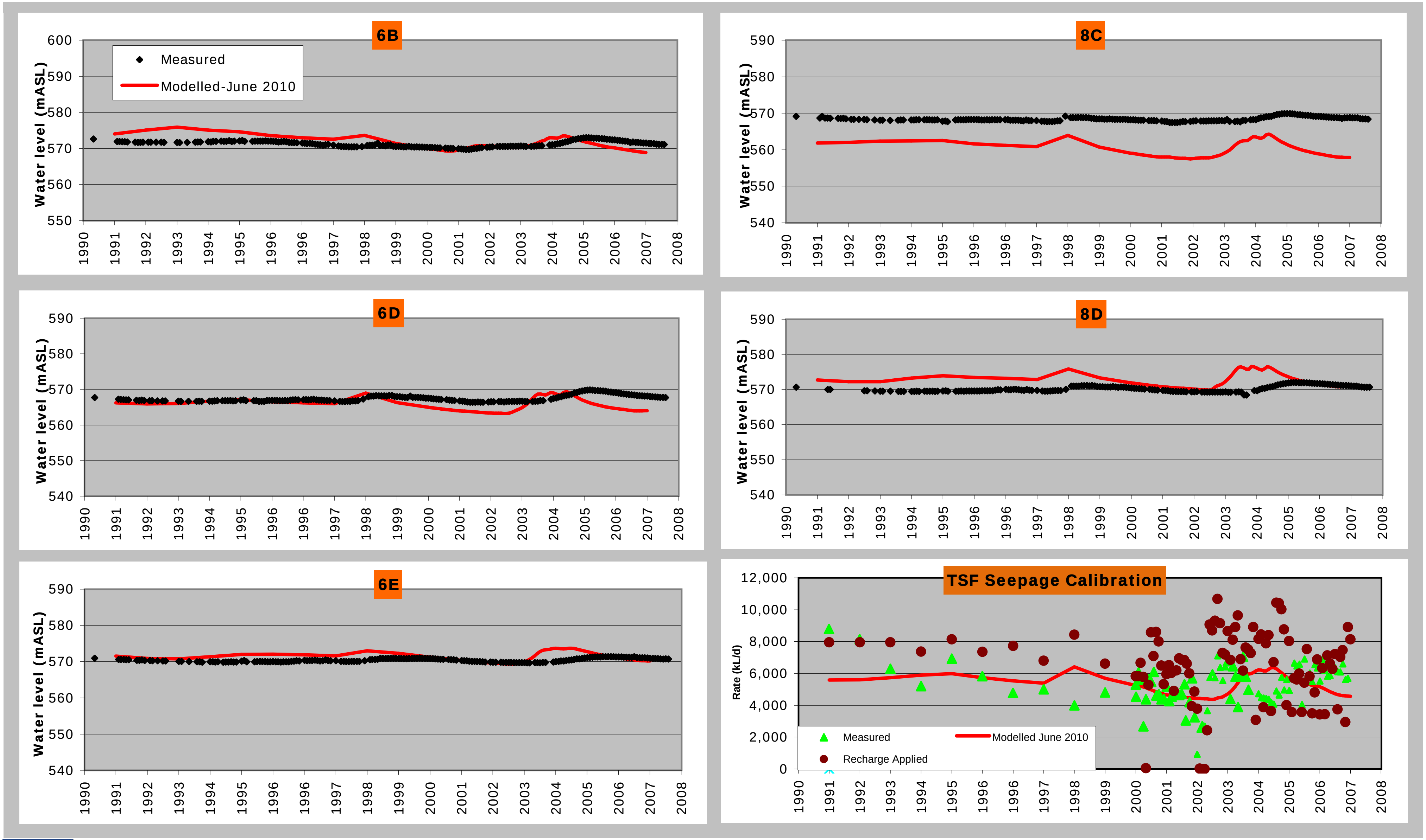


TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 7



TRANSIENT CALIBRATION HYDROGRAPHS AND SEEPAGE DAM CALIBRATION FIGURE 8

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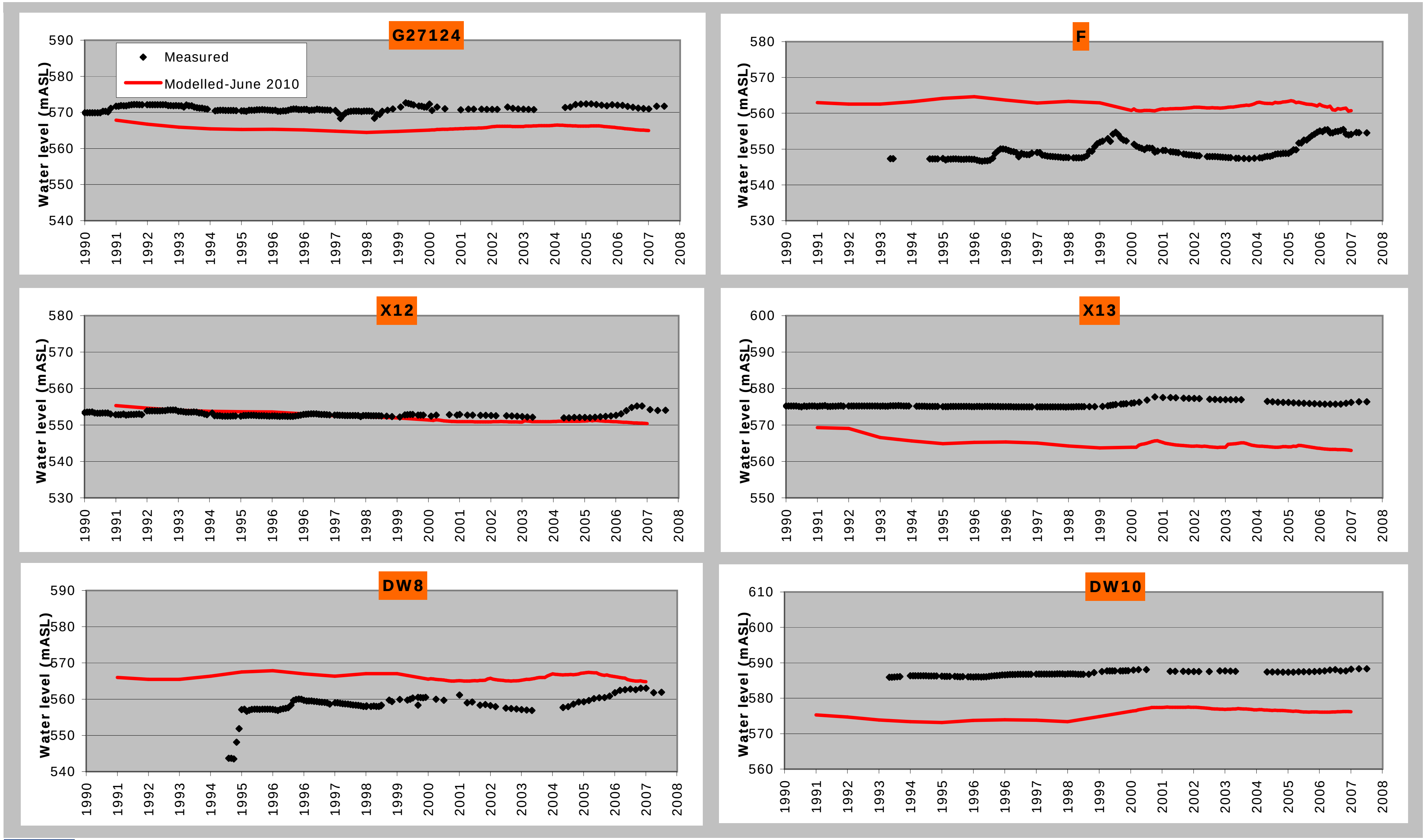

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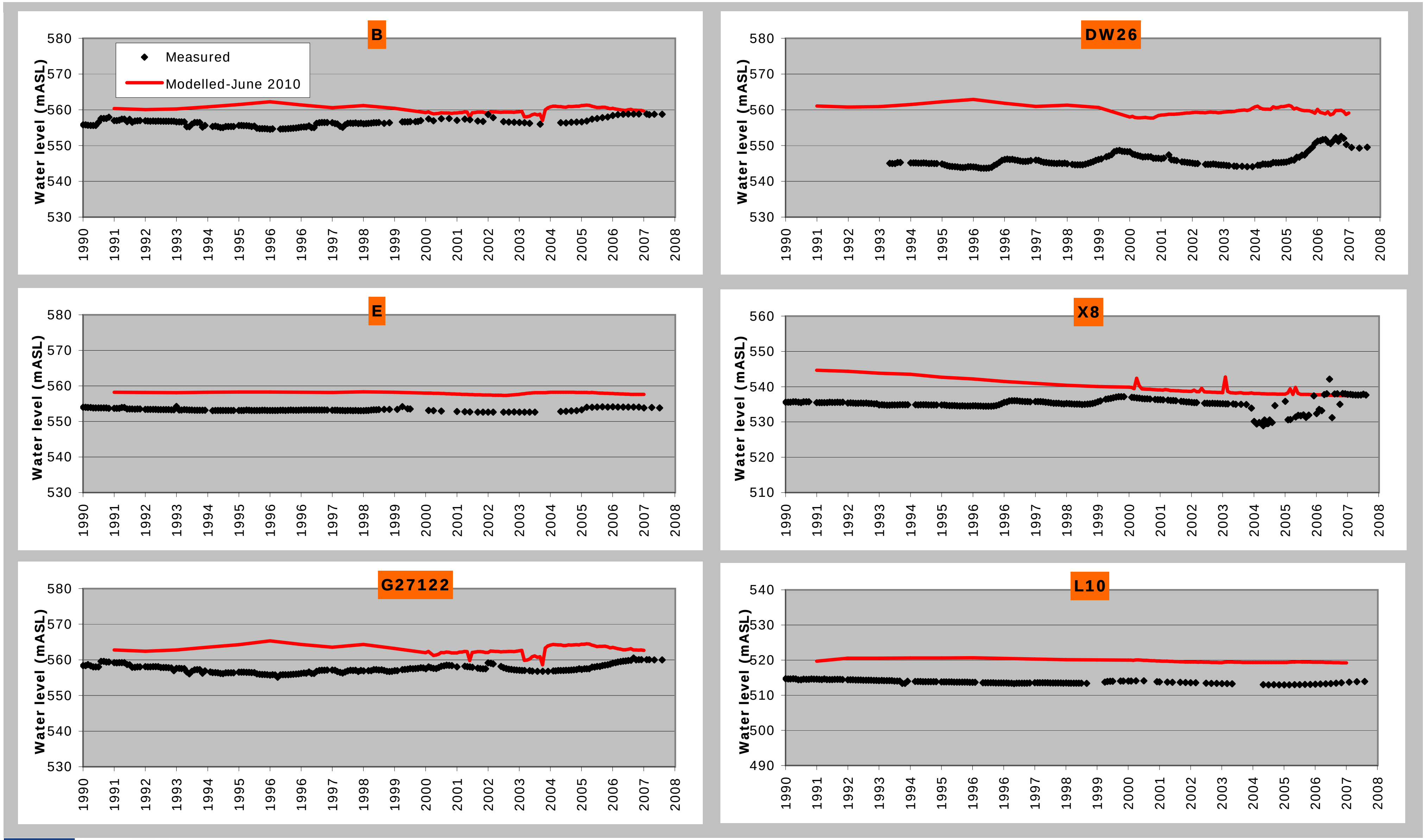
TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 9



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TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 10

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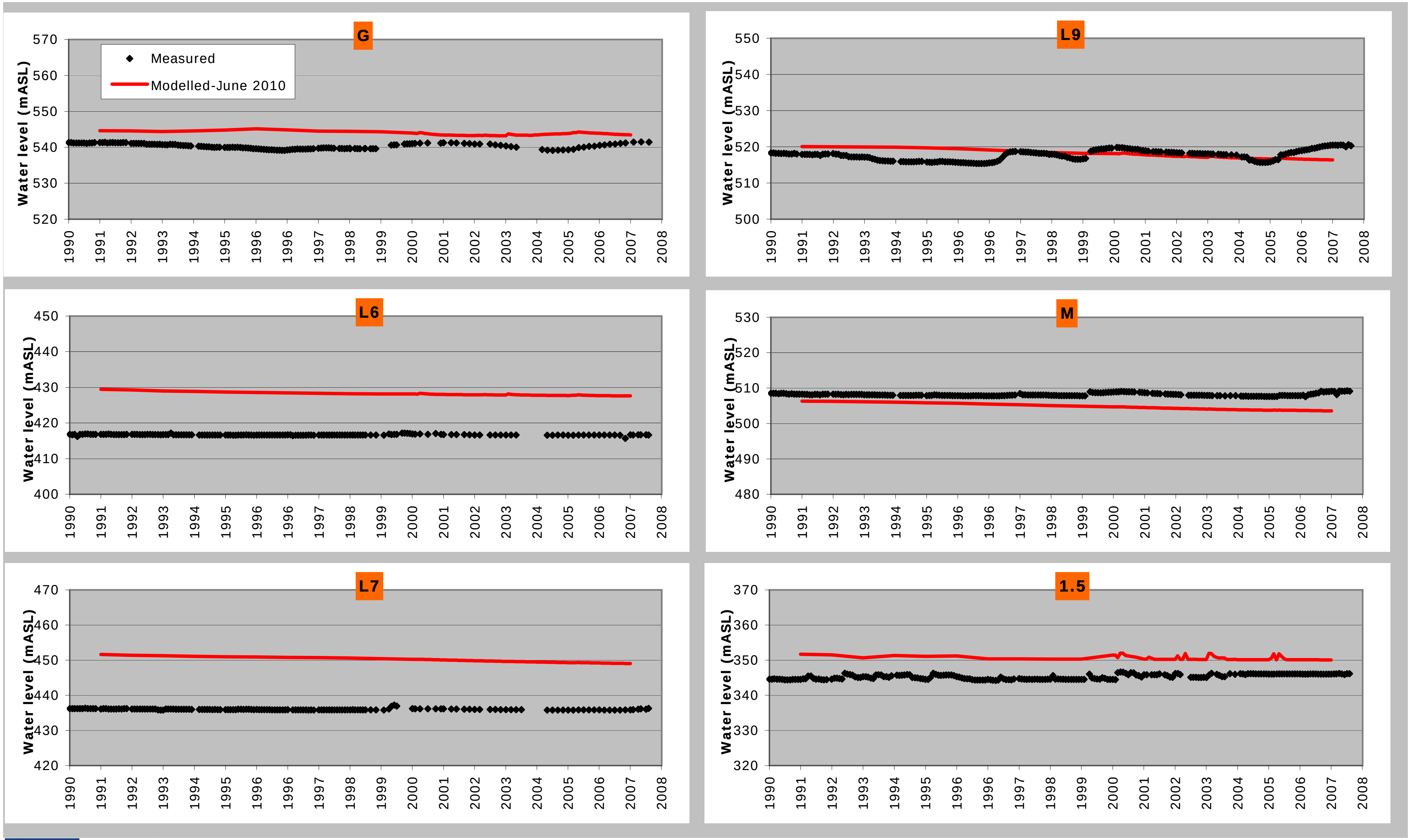

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TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 11

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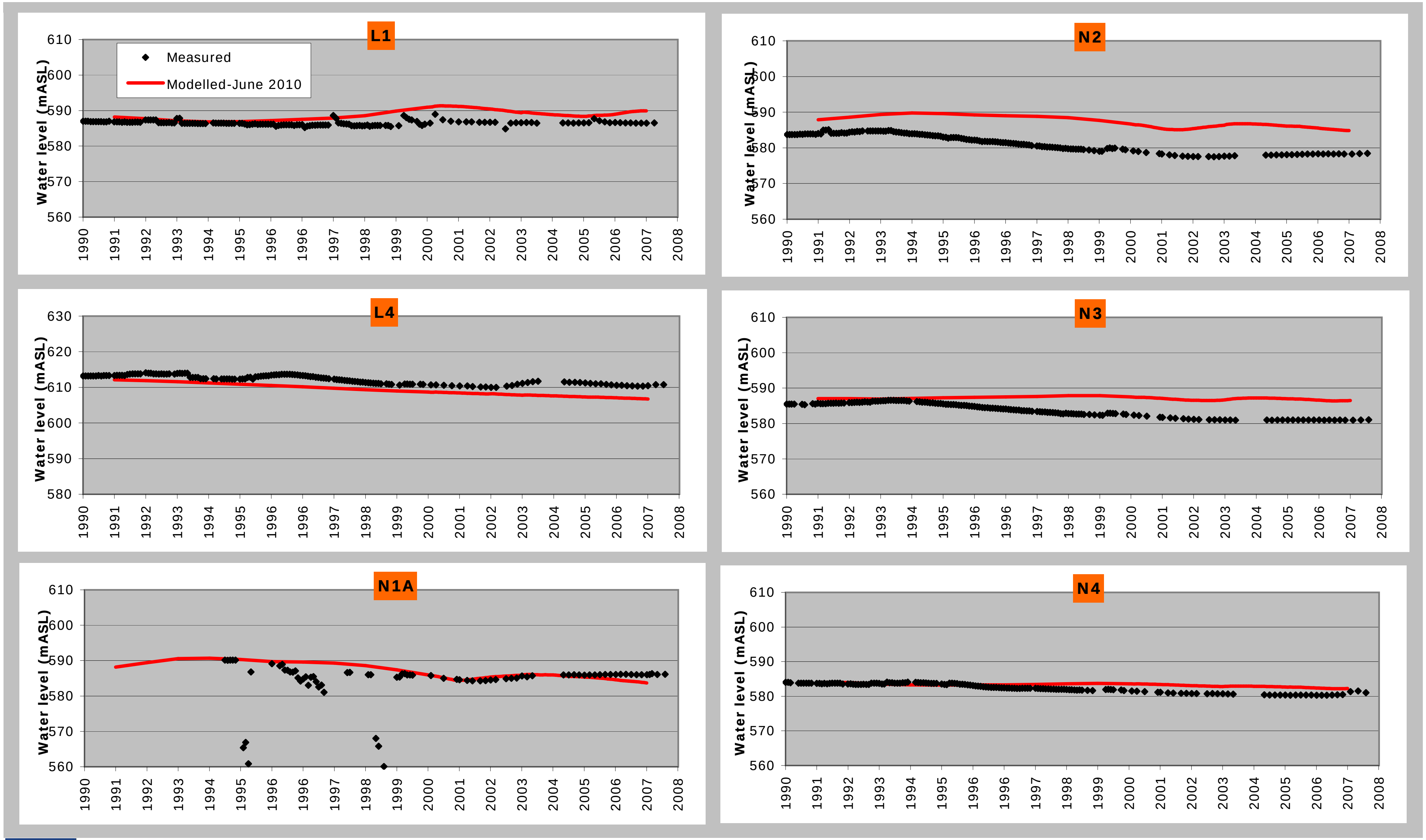

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TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 12

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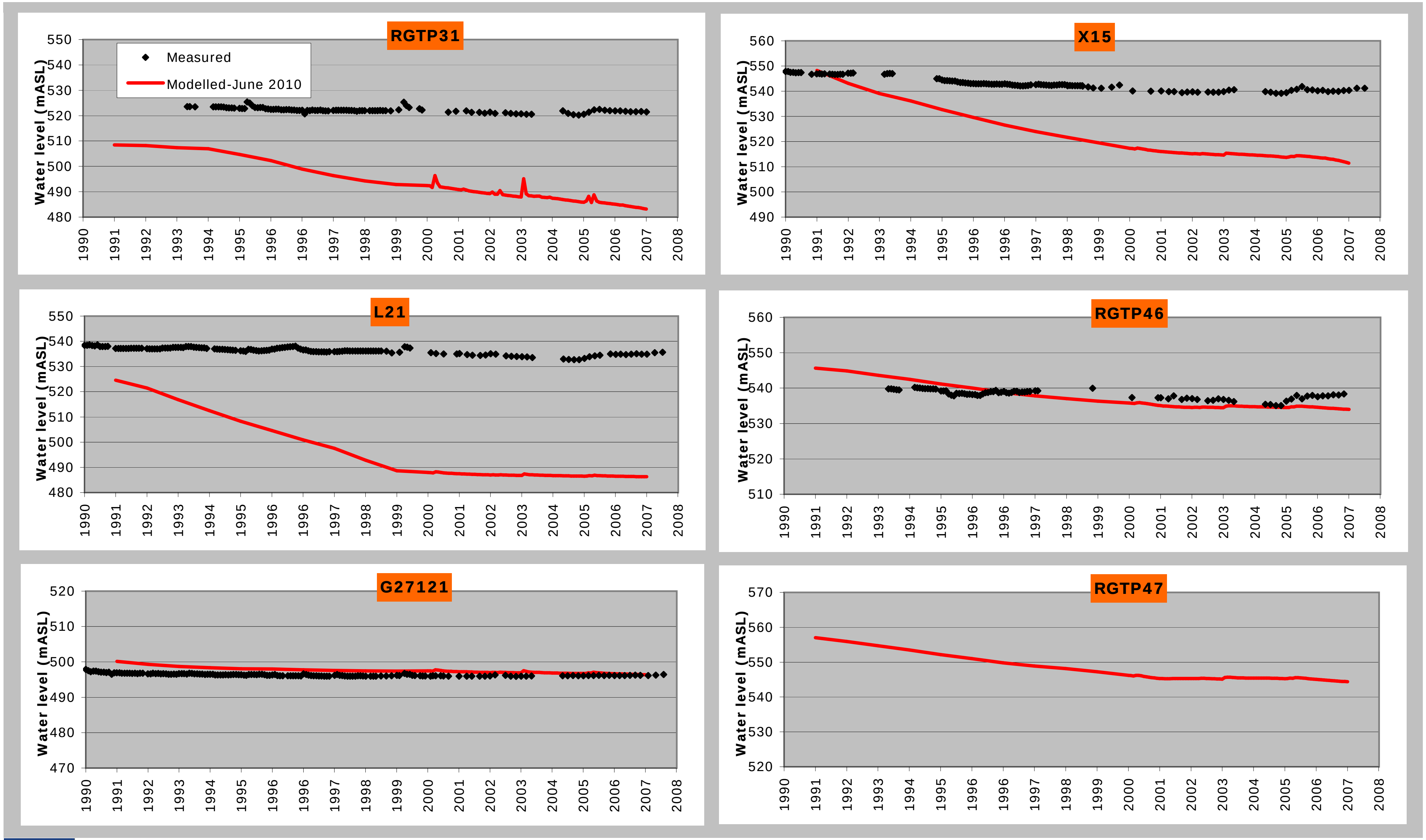

TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 13

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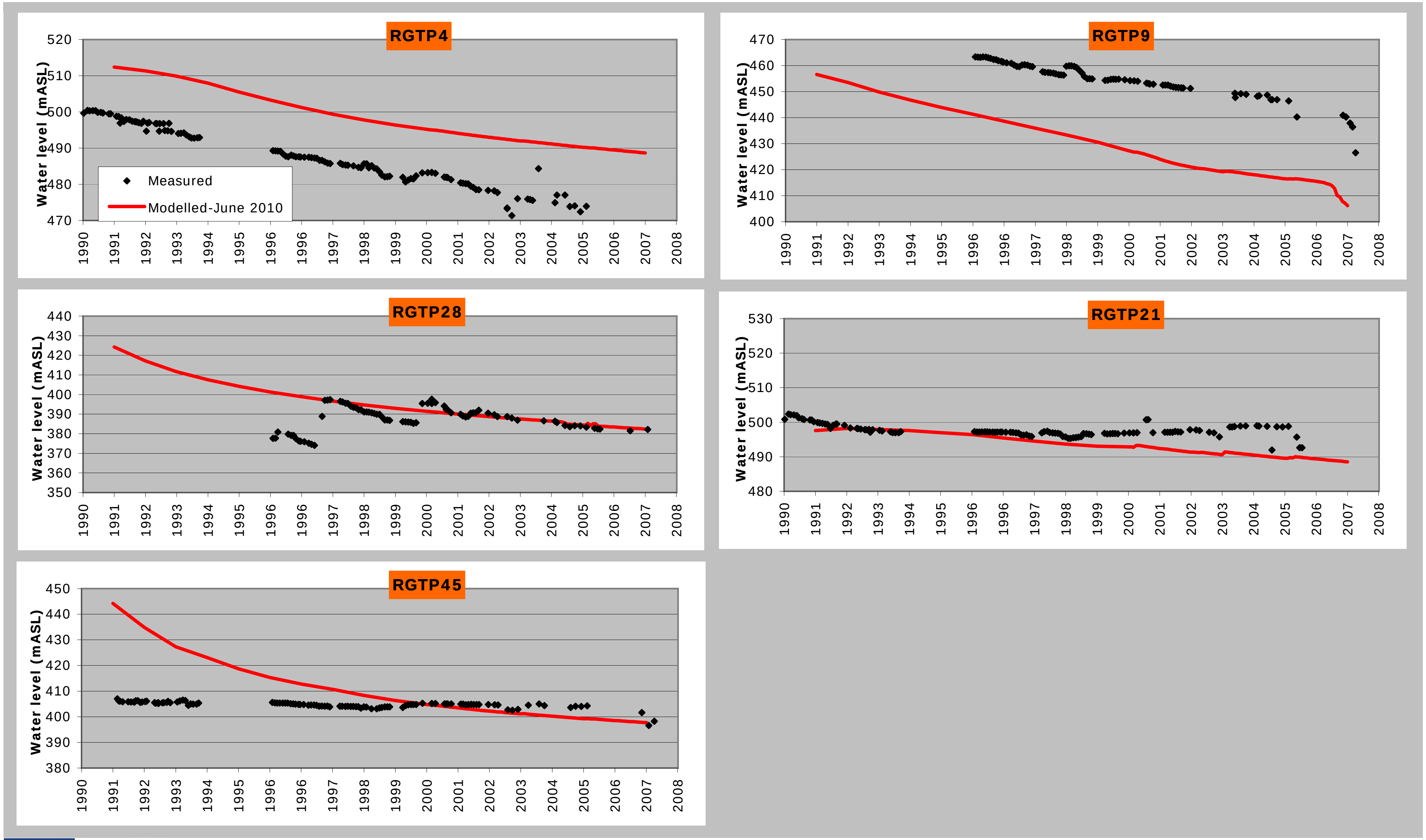

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TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 14

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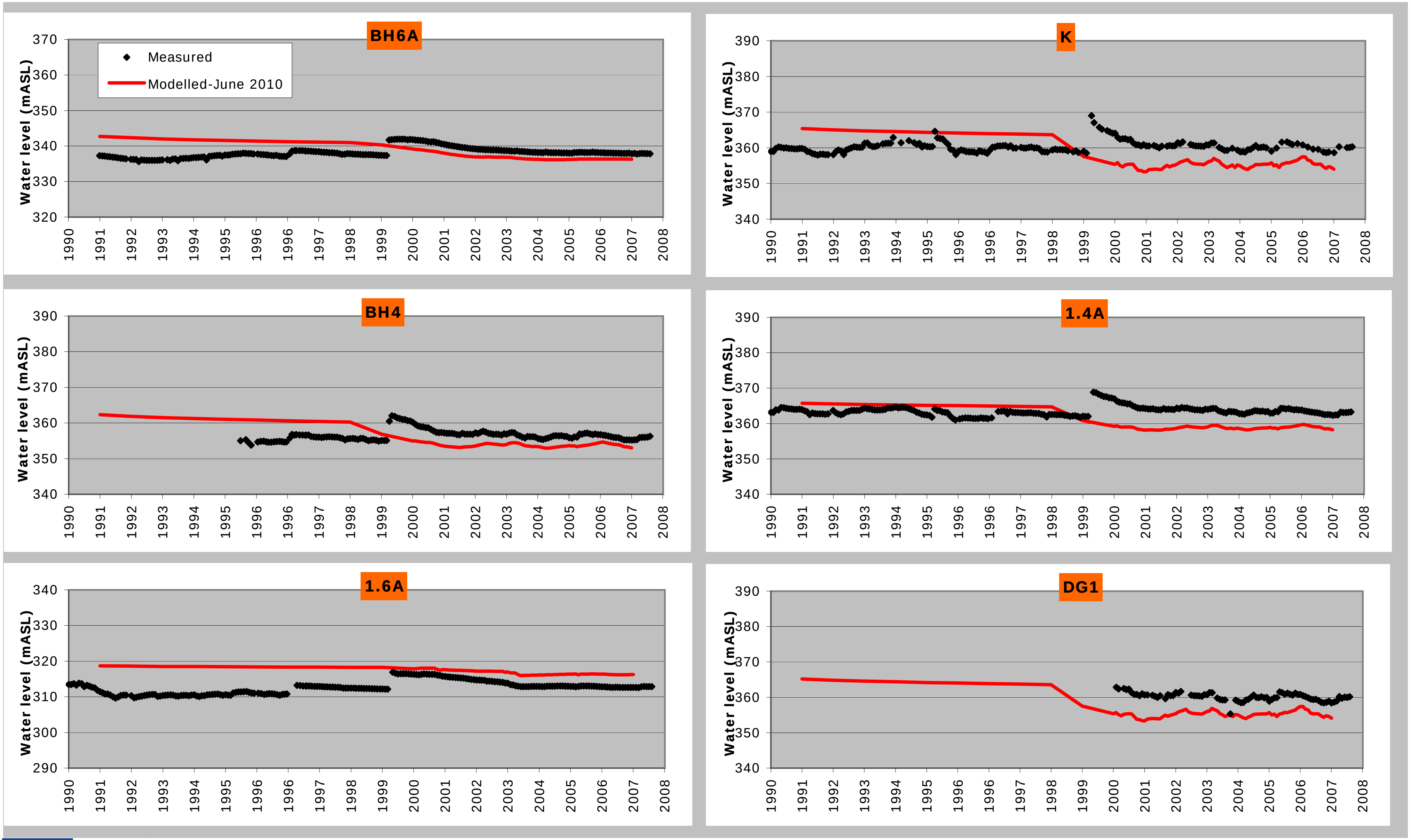

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TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 15

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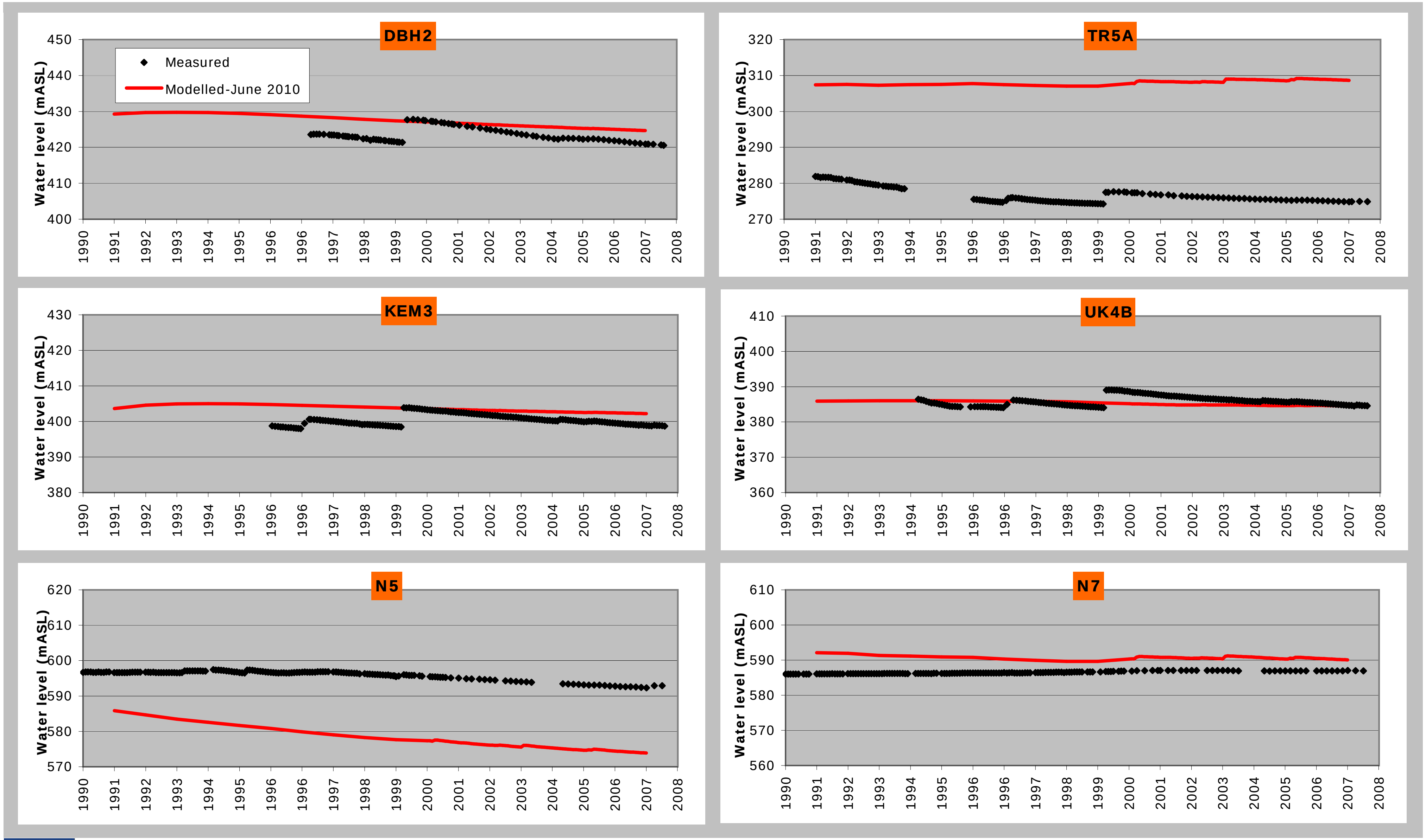

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TRANSIENT CALIBRATION HYDROGRAPHS FIGURE 16

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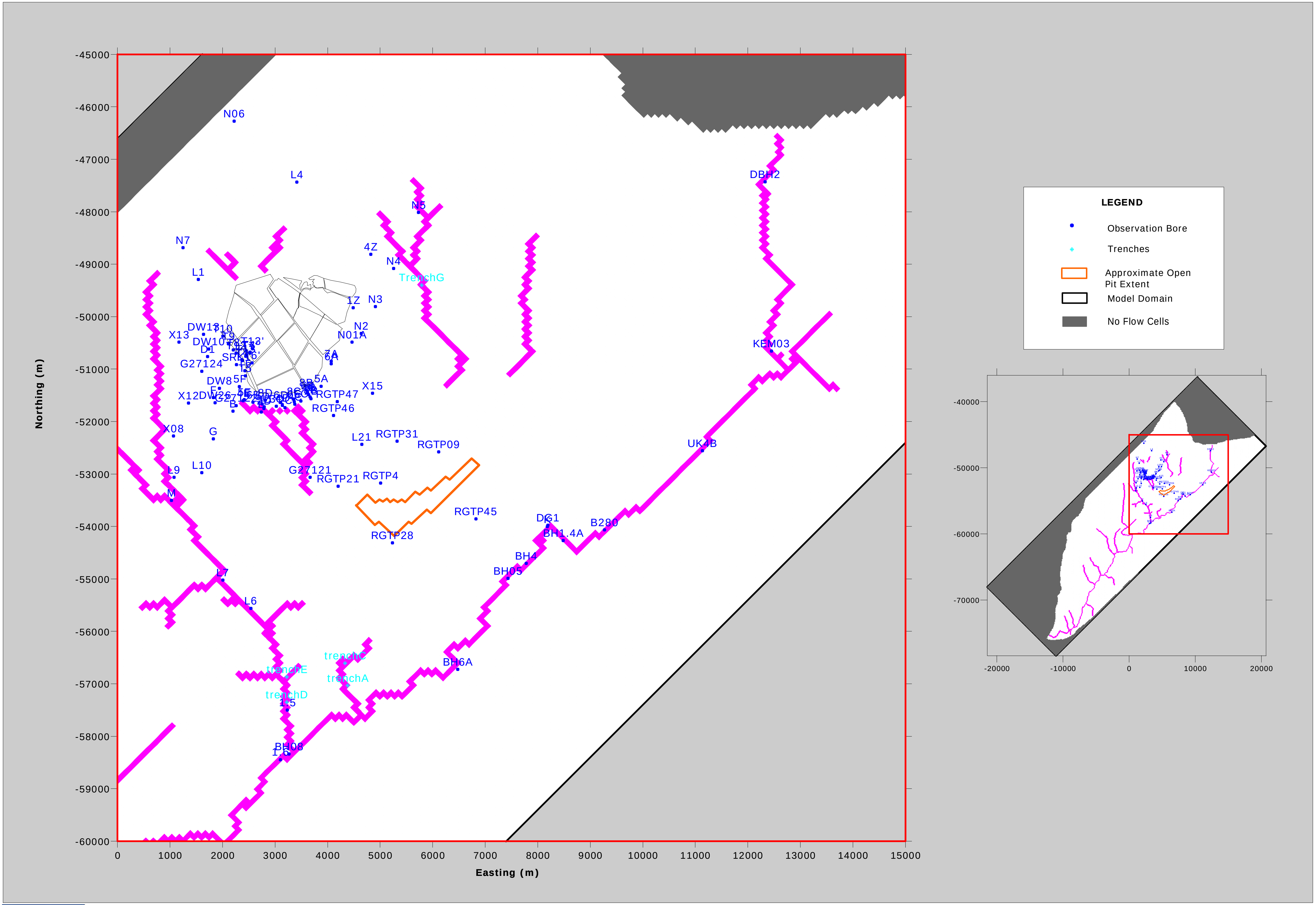

LOCATION OF OBSERVATION BORES USED FOR MODEL CALIBRATION FIGURE 17

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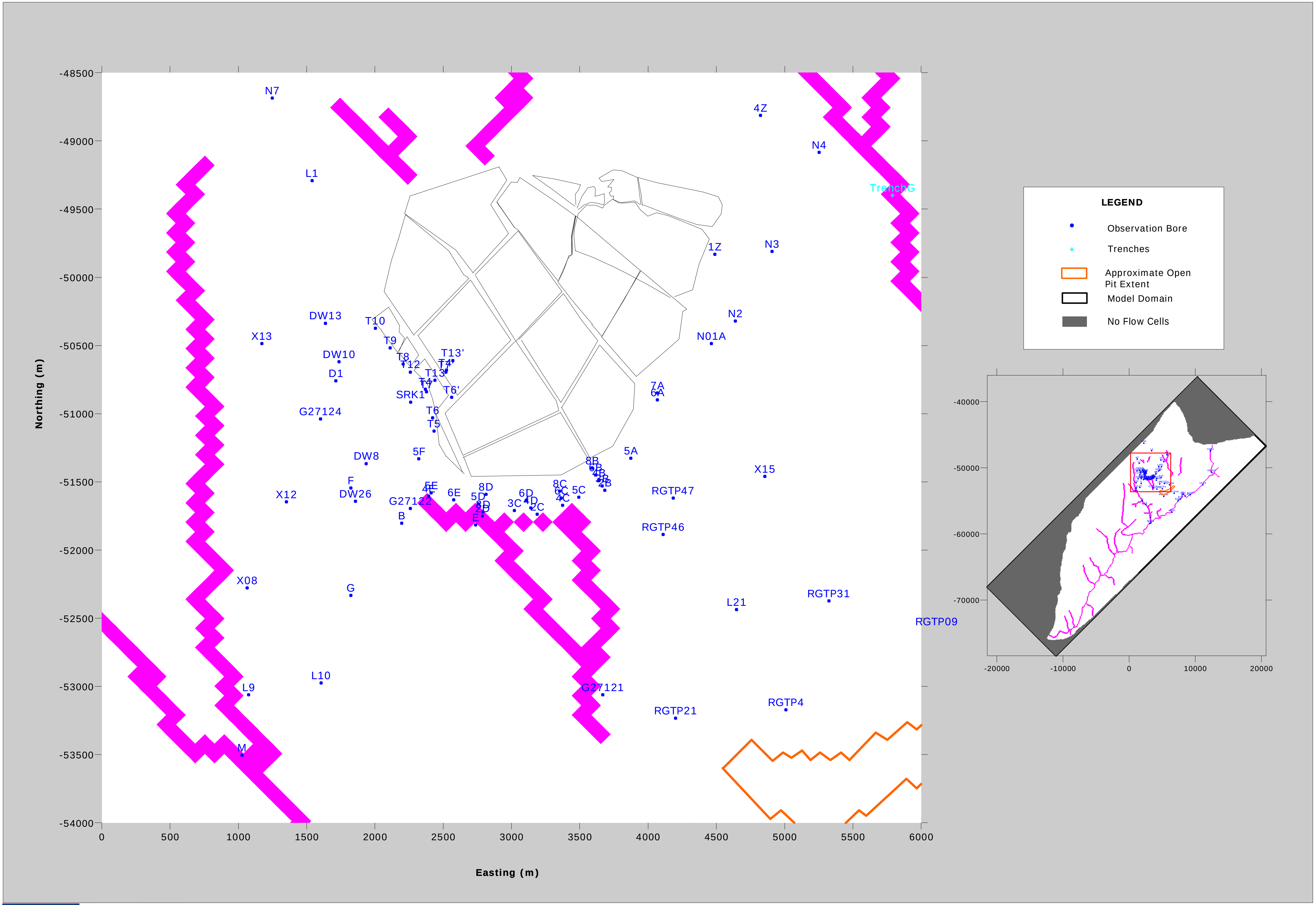

LOCATION OF OBSERVATION BORES USED FOR MODEL CALIBRATION FIGURE 17a

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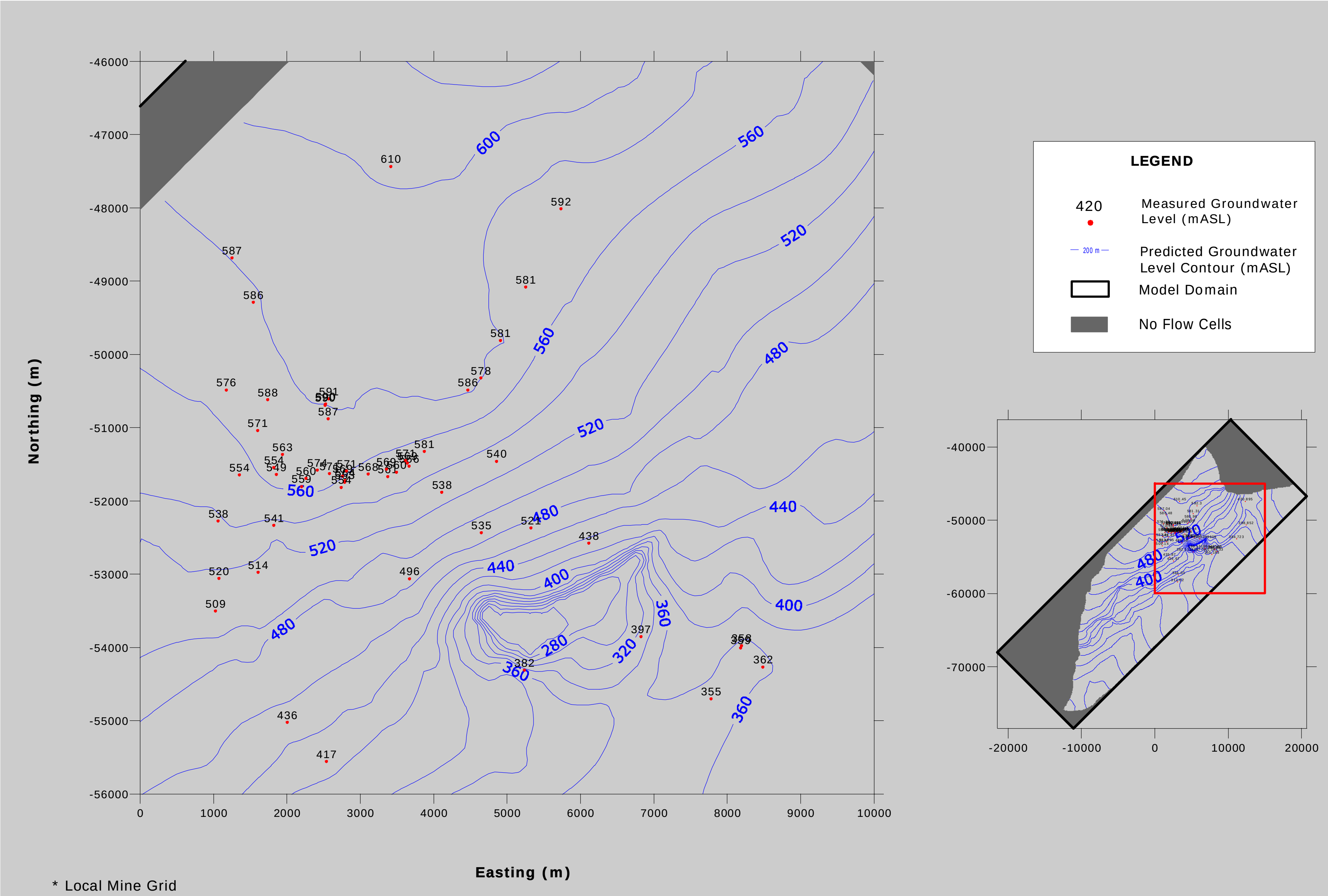
RPS Aquaterra



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MODELLED WATER LEVEL CONTOUR- LAYER 5 FIGURE 18

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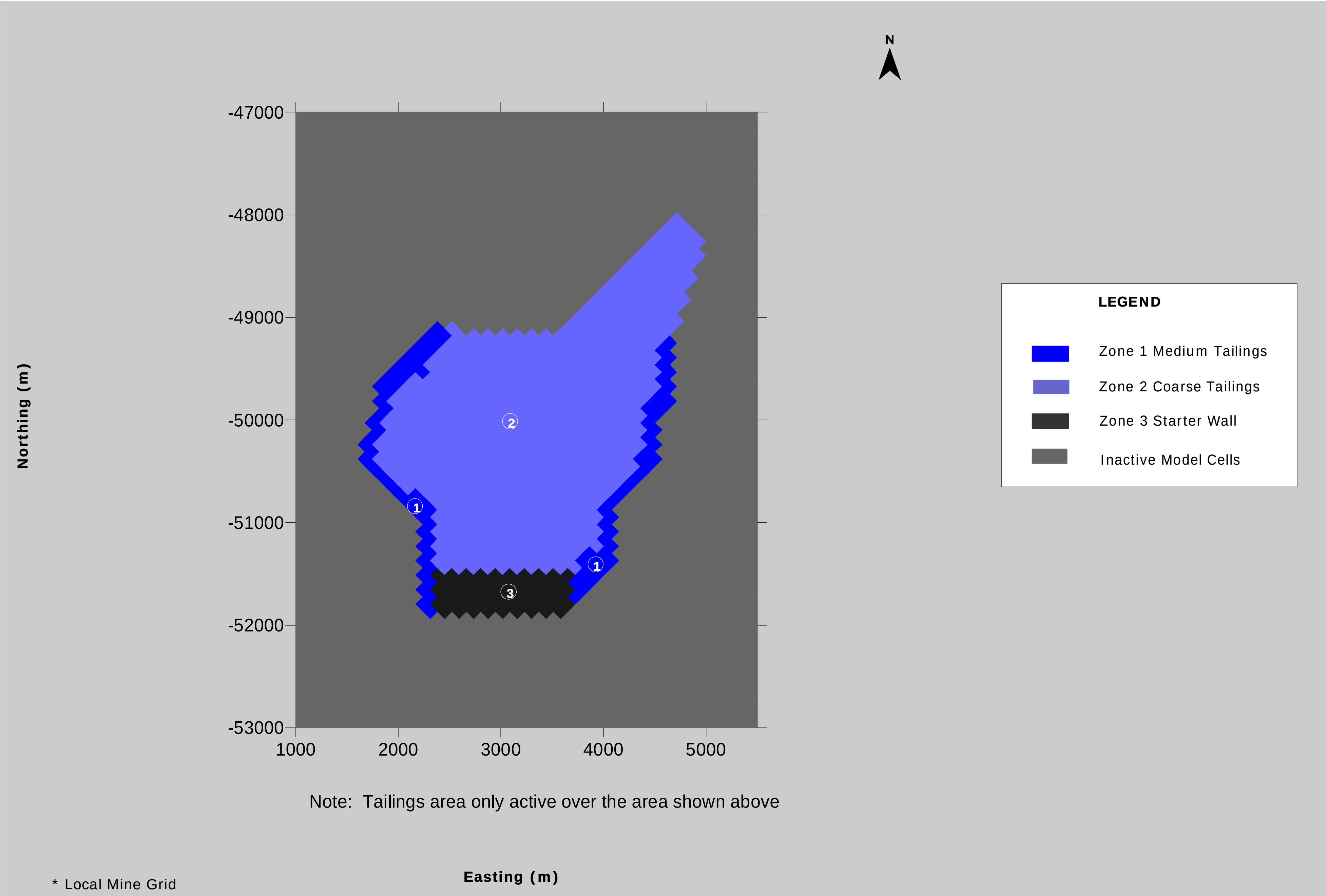

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PARAMETER DISTRIBUTION LAYER 1 FIGURE 19

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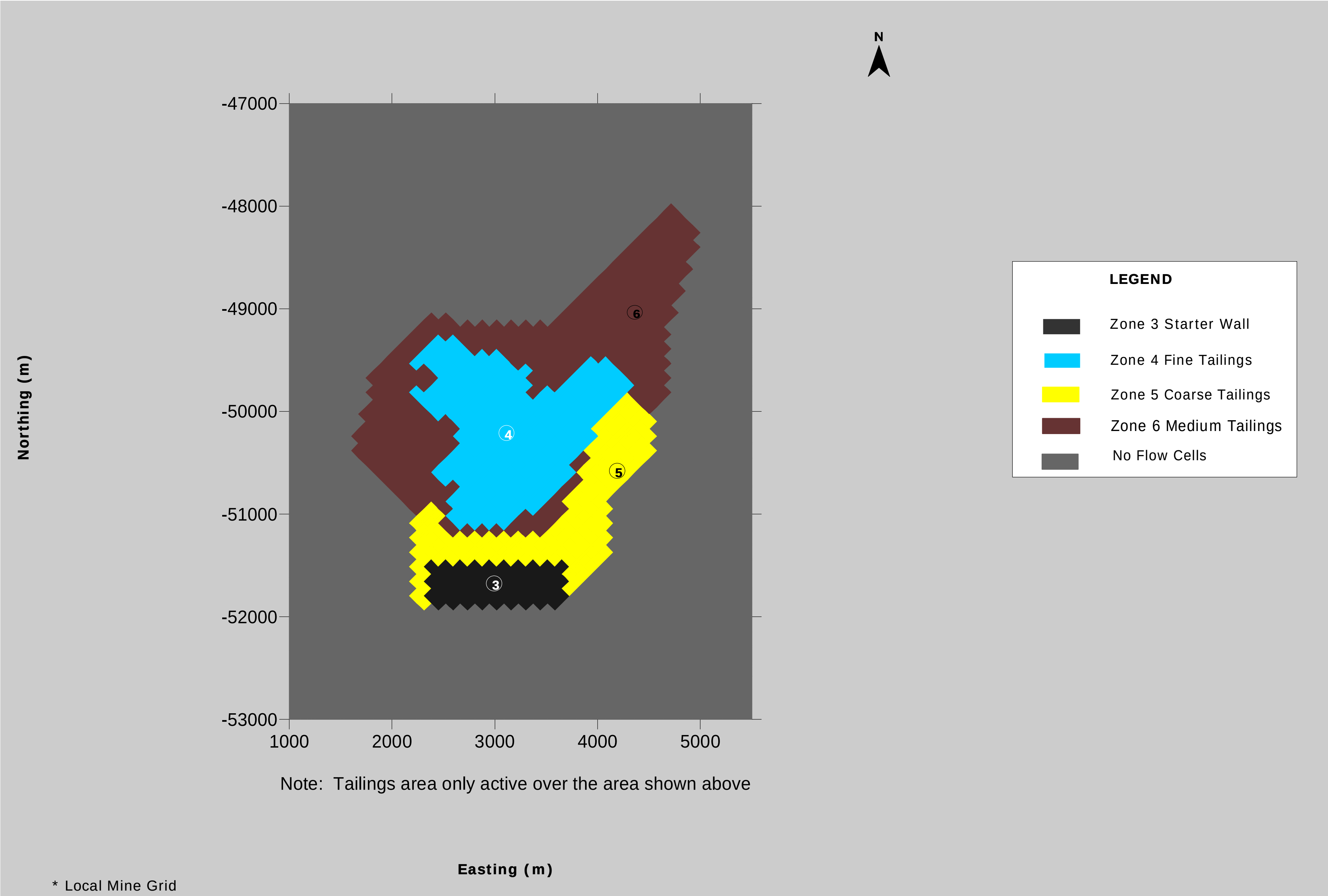

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PARAMETER DISTRIBUTION LAYER 2 FIGURE 20

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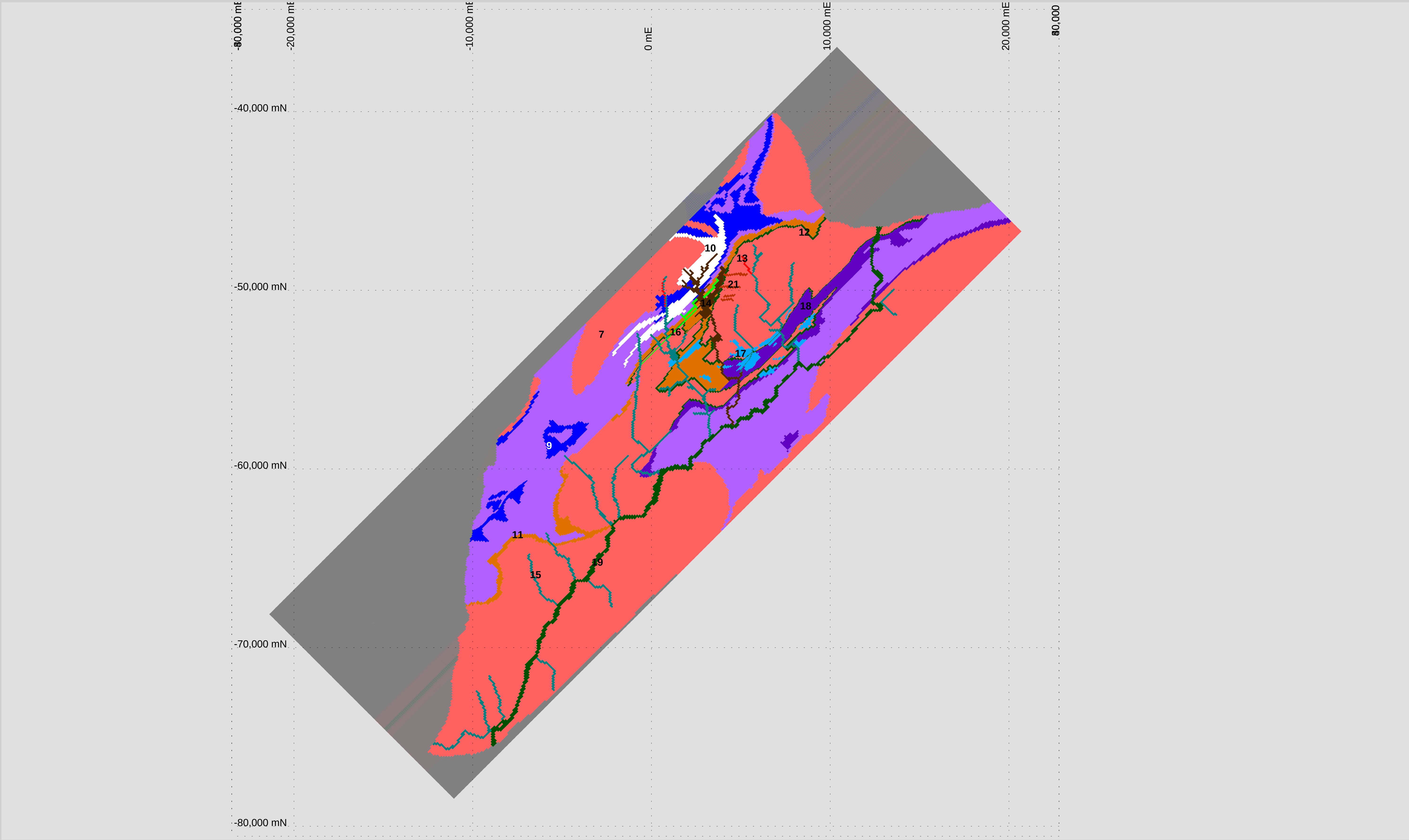

N

0 5 10

Kilometers

Scale 1:200,000 @A3

Local Mine Grid

AUTHOR:	DV	DOC NO:	027a
DRAWN:	MR	REVISION:	-
DATE:	14/07/2011	JOB NO:	1074 /C11

LEGEND

- Zone 7 Khan & Etusis Fm
- Zone 8 Karabib, Kuiseb & Chuos
- Zone 9 Quaternary
- Zone 10 Karabib
- Zone 11 Rossing
- Zone 12 Amphibole Schist - high K Zone
- Zone 13 Gorge Alluvium
- Zone 14 Panner Gorge Alluvium
- Zone 15 Gorge Alluvium
- Zone 16 Faults
- Zone 17 Rossing Fm Alaskites and Granites
- Zone 18 Rossing Marble
- Zone 19 Khan River Alluvium
- Zone 21 Faults
- Model Domain
- No Flow Cells

Refer to table 2.5 for assigned aquifer parameters

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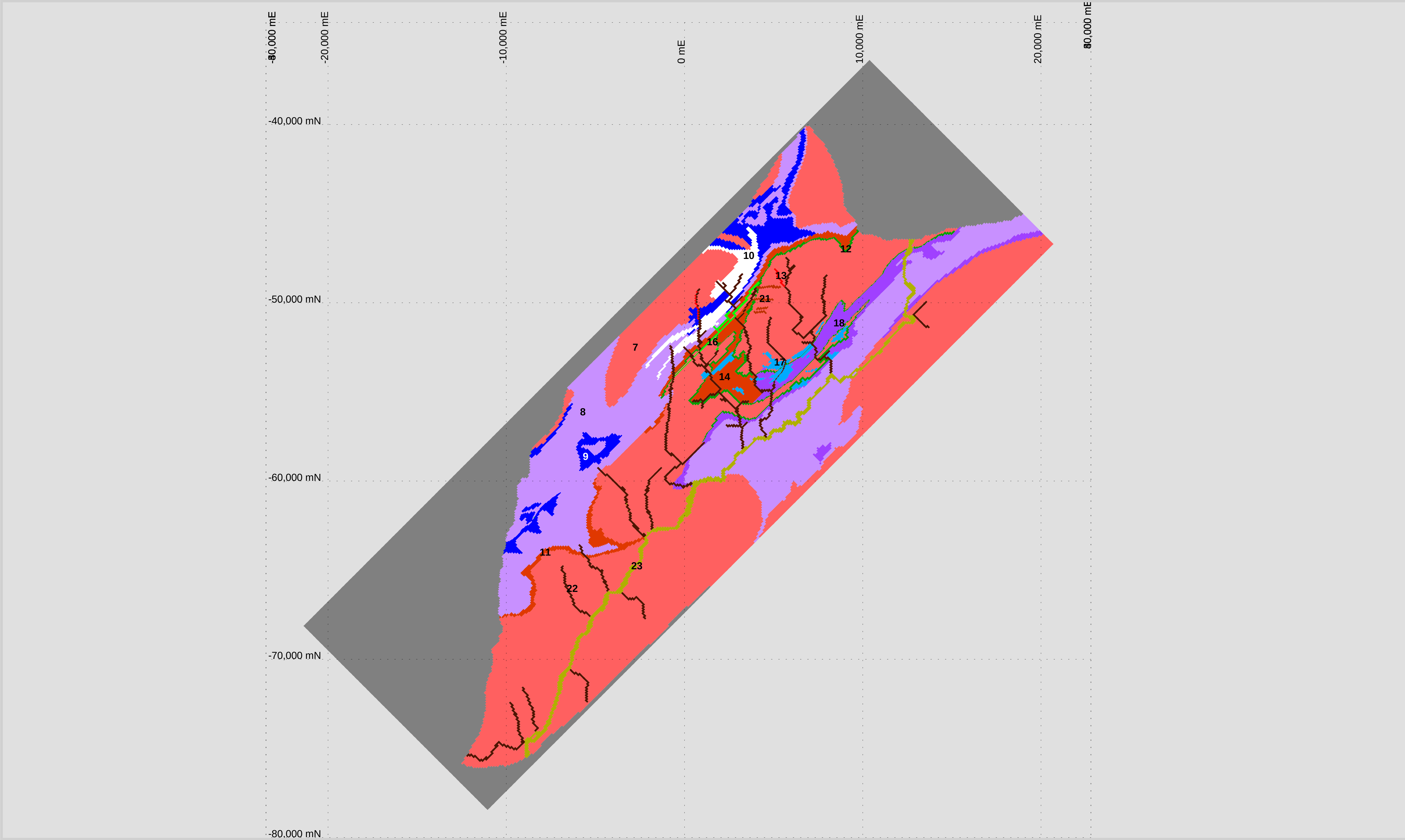
Figure 21

PARAMETER DISTRIBUTION LAYER 3

Location: F:\Jobs\1074C\Map Info\\\rpsperfs02\at1\Jobs\1074C\Map Info\Workspaces\027a Figure 21 - Parameter Distribution Layer 3



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Local Mine Grid

AUTHOR:	DV	DOC NO:	027a
DRAWN:	MR	REVISION:	-
DATE:	14/07/2011	JOB NO:	1074 /C11

LEGEND

- Zone 7 Khan & Etusis Fm
- Zone 8 Kuiseb, Chuos & Karabib
- Zone 9 Quaternary
- Zone 10 Karabib
- Zone 11 Rossing
- Zone 12 Amphibole Schist - High K Zone
- Zone 13 Gorge Alluvium
- Zone 16 Faults
- Zone 17 Rossing Fm Alaskites
- Zone 18 Rossing Marble
- Zone 21 Faults
- Zone 22 Faults Under Gorges
- Zone 23 Khan River Alluvium
- Model Domain
- No Flow Cells

Refer to table 2.6 for assigned aquifer parameters

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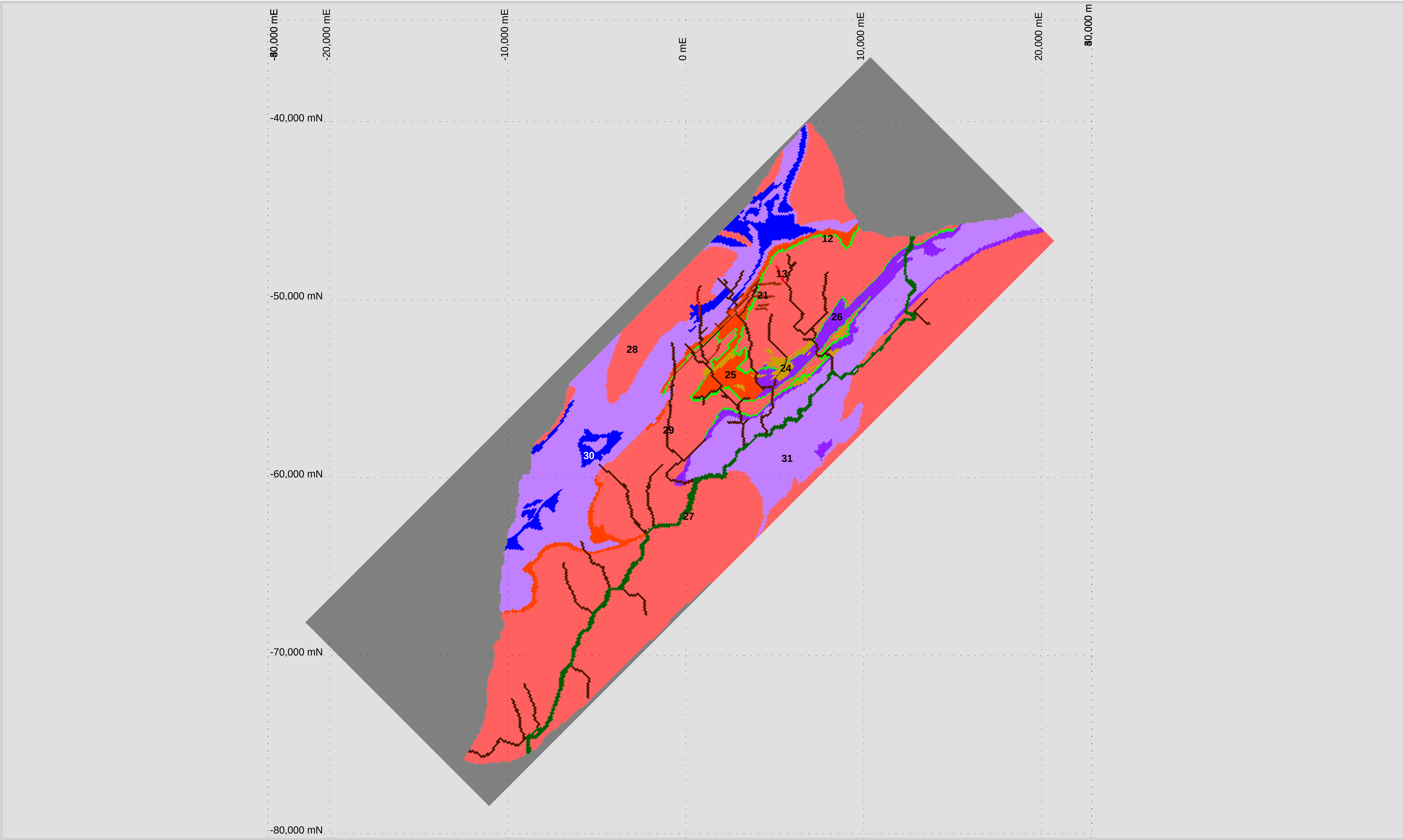
Figure 22

PARAMETER DISTRIBUTION LAYER 4



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Kilometers

Scale 1:200,000 @A3

Non Earth

AUTHOR:	DV	DOC NO:	027a
DRAWN:	MR	REVISION:	-
DATE:	14/07/2011	JOB NO:	1074 /C11

LEGEND

- Zone 12 Amphibole Schist - High K Zone
- Zone 13 Faults Under Gorges
- Zone 21 Faults
- Zone 24 Rossing Fm Alaskite
- Zone 25 Rossing Marble
- Zone 26 Rossing Marble
- Zone 27 Faults Underlying Khan River
- Zone 28 Khan, Etusis
- Zone 29 Faults Underlying Gorges
- Zone 30 Khan & Etusis Fm
- Zone 31 Kuiseb, Chuos & Karabib Fm
- Model Domain
- No Flow Cells

Refer to table 2.7 for assigned aquifer parameters

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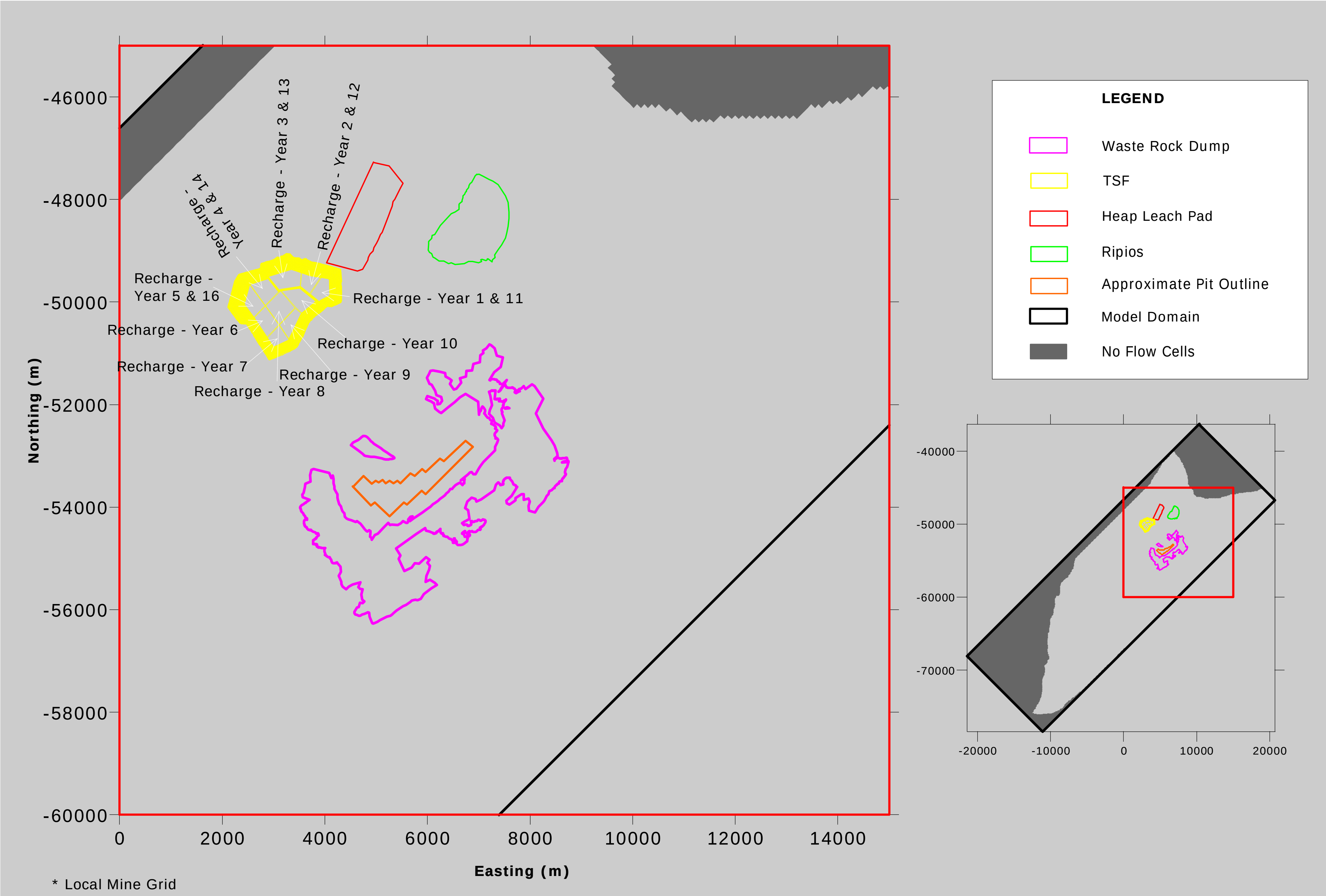
Figure 23

PARAMETER DISTRIBUTION LAYER 5

Location: F:\Jobs\1074C\Map Info\\\rpsperfs02\at1\Jobs\1074C\Map Info\Workspaces\027a Figure 23 - Parameter Distribution Layer 5



RECHARGE DISTRIBUTION - PREDICTION SCENERIO FIGURE 24

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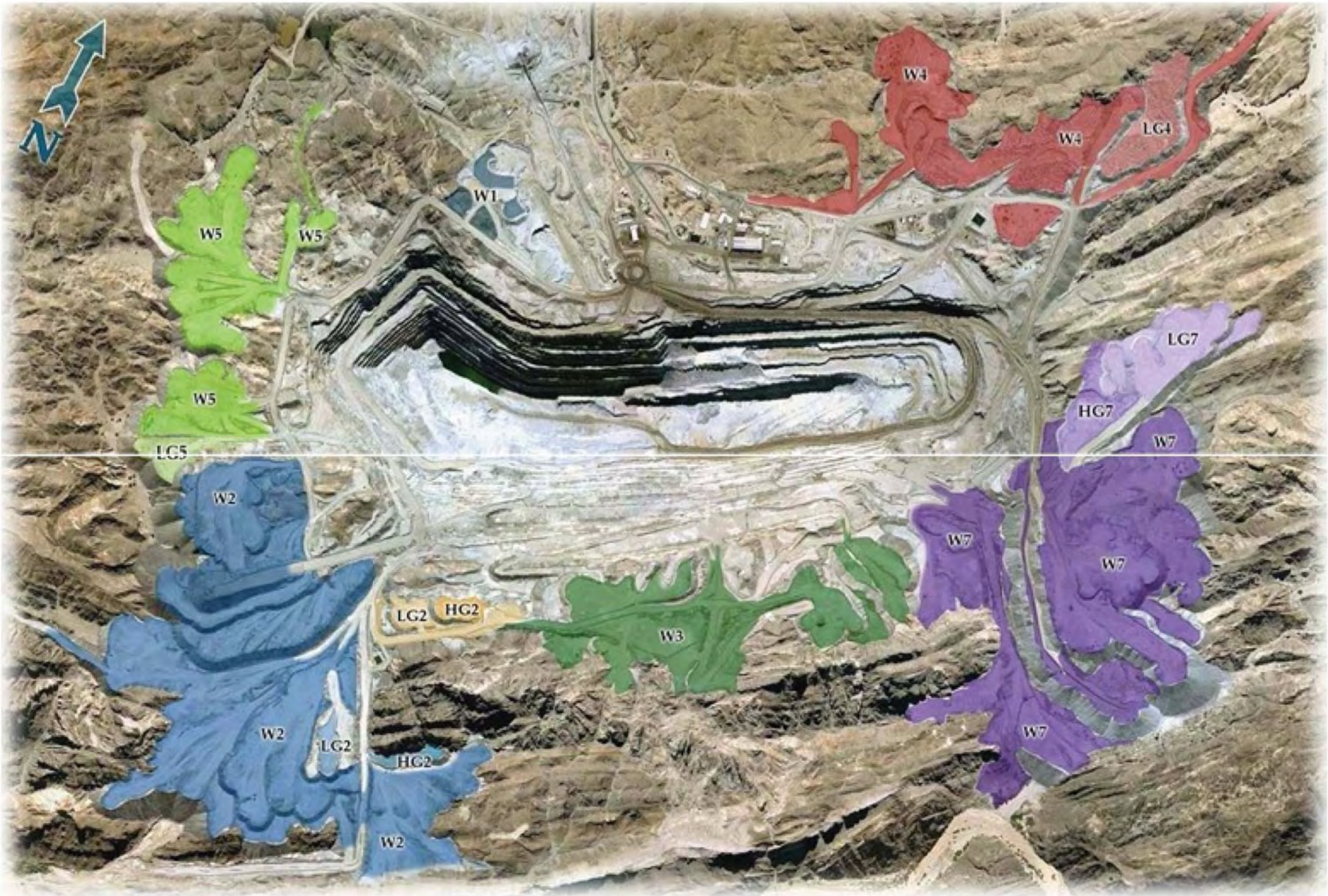


REV.	DESCRIPTION	DATE

DESIGNED:	PROJECT APPROVAL:
DESIGN CHECK:	CAD REFERENCE:
DRAWN: GK	JOB No.: 1074C\C11\027a
DRAWING CHECK:	SCALE: NTS

RPS Aquaterra
38 Station Street
Subiaco, Western Australia 6008
Telephone: (08) 9211 1111
Facsimile: (08) 9211 1122

Rossing Contaminant Transport

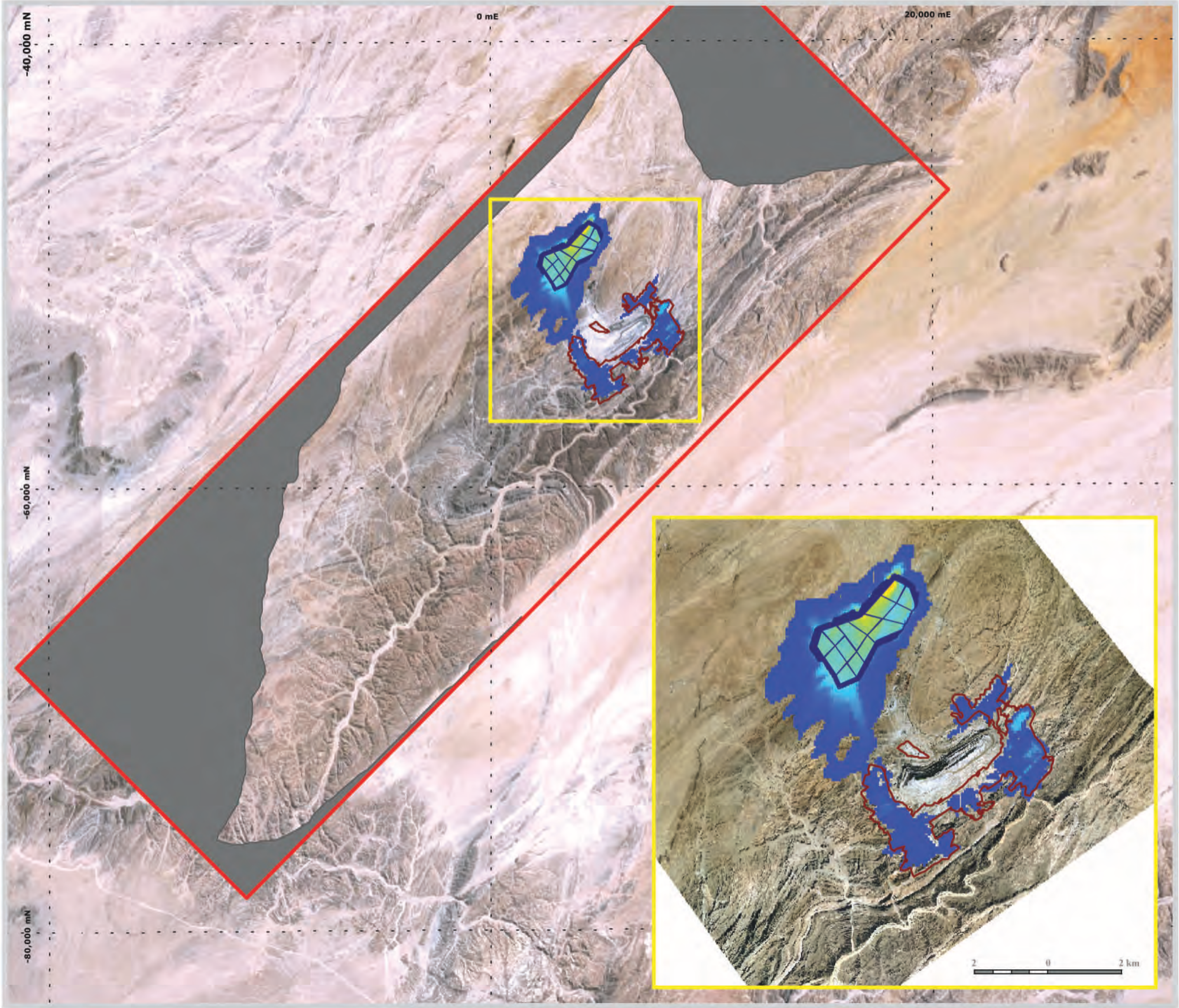
Figure 25: Location of Rock Dumps

SIZE:	SCALE:	JOB No.:	DRAWING No.:	REV.:
A4	N.T.S.	1074C\C11\027a	Figure 25	A

APPENDIX A:
TSF RECHARGE SCHEDULE

TSF Rechareg Schedule		ELEVATIONS mamsl														
Paddock	Date from Jan 2009	X3	Y3	Y2	CD4	AB4	X2	X1	CD2	AB2	CD3	AB3	Z2	Z1	E2	E1
	01-Jan-09	615	615	615	620	625	625	635	635	635	635	635	625	625	615	615
CD4	11-Mar-09				625											
X3	28-Mar-09	620														
Y3	01-Jun-09		620													
Y2	06-Sep-09			620												
X3	22-Sep-09	625														
Y3	25-Nov-09		625													
Y2	04-Mar-10			625												
CD4	08-May-10				630											
AB4	29-Jun-10					630										
X2	29-Aug-10						630									
X1	23-Oct-10							640								
X2	23-Dec-10						635									
X1	14-Feb-11							645								
CD2	09-Apr-11								640							
AB2	26-May-11									640						
CD3	31-Jul-11										640					
AB3	17-Sep-11											640				
CD4	16-Nov-11				635											
AB4	05-Jan-12					635										
Y3	08-Mar-12		630													
Y2	06-Jun-12			630												
Z2	09-Sep-12												630			
Z1	04-Nov-12													630		
E2	31-Jan-13														620	
E1	02-Apr-13															620
X2	02-Jun-13						640									
X1	21-Jul-13							650								
CD2	09-Sep-13								645							
AB2	24-Oct-13									645						
CD3	27-Dec-13										645					
AB3	12-Feb-14											645				
CD4	09-Apr-14				640											
AB4	27-May-14					640										
Y3	28-Jul-14		635													
Y2	20-Oct-14			635												
Z2	20-Jan-15												635			
Z1	17-Mar-15													635		
E2	08-Jun-15														625	
E1	04-Aug-15															630
X2	04-Oct-15						645									
X1	19-Nov-15							655								
CD2	05-Jan-16								650							
AB2	16-Feb-16									650						
CD3	18-Apr-16										650					
AB3	04-Jun-16											650				
CD4	26-Jul-16				645											
AB4	10-Sep-16					645										
Y3	09-Nov-16		640													
Y2	28-Jan-17			640												
Z2	27-Apr-17												640			
Z1	19-Jun-17													640		
E2	05-Sep-17														630	
E1	30-Oct-17															635
X1	12-Dec-17							660								
CD2	24-Jan-18								655							
AB2	06-Mar-18									655						
CD3	03-May-18										655					
AB3	20-Jun-18											655				
CD4	07-Aug-18				650											
AB4	20-Sep-18					650										
X2	30-Nov-18						650									
Y3	27-Jan-19		645													
Y2	16-Apr-19			645												
Z2	09-Jul-19												645			
Z1	29-Aug-19													645		
E2	10-Nov-19														635	
E1	04-Jan-20															640
CD2	12-Feb-20								660							
AB2	22-Mar-20									660						
CD3	17-May-20										660					
AB3	03-Jul-20											660				
CD4	16-Aug-20				655											
AB4	28-Sep-20					655										
X2	06-Dec-20						655									
Y3	31-Jan-21		650													
Y2	18-Apr-21			650												
Z2	08-Jul-21												650			
Z1	26-Aug-21													650		
E2	02-Nov-21														640	
E1	25-Dec-21															645
CD4	03-Feb-22				660											
AB4	15-Mar-22					660										
X2	22-May-22						660									
Y3	16-Jul-22		655													
Y2	28-Sep-22			655												
Z2	14-Dec-22												655			
Z1	30-Jan-23													655		
E2	04-Apr-23														645	
E1	24-May-23															650
Y3	16-Jul-23		660													
Y2	24-Sep-23			660												
Z2	06-Dec-23												660			
Z1	20-Jan-24													660		
E2	20-Mar-24														650	
E1	06-May-24															655
E2	29-Jun-24														655	
E1	12-Aug-24														660	
E2	02-Oct-24															660

APPENDIX B:
BASE CASE TRANSPORT MODELLING RESULTS



LEGEND

15,000
10,000
5,000
1

Particle Concentration 10 Years (mg/L)

Model Extent
No Flow Cells
Rock Dump Waste
TSF

N

4 0 4
Kilometres
Scale: 1:250,000 @A4
Mine Grid

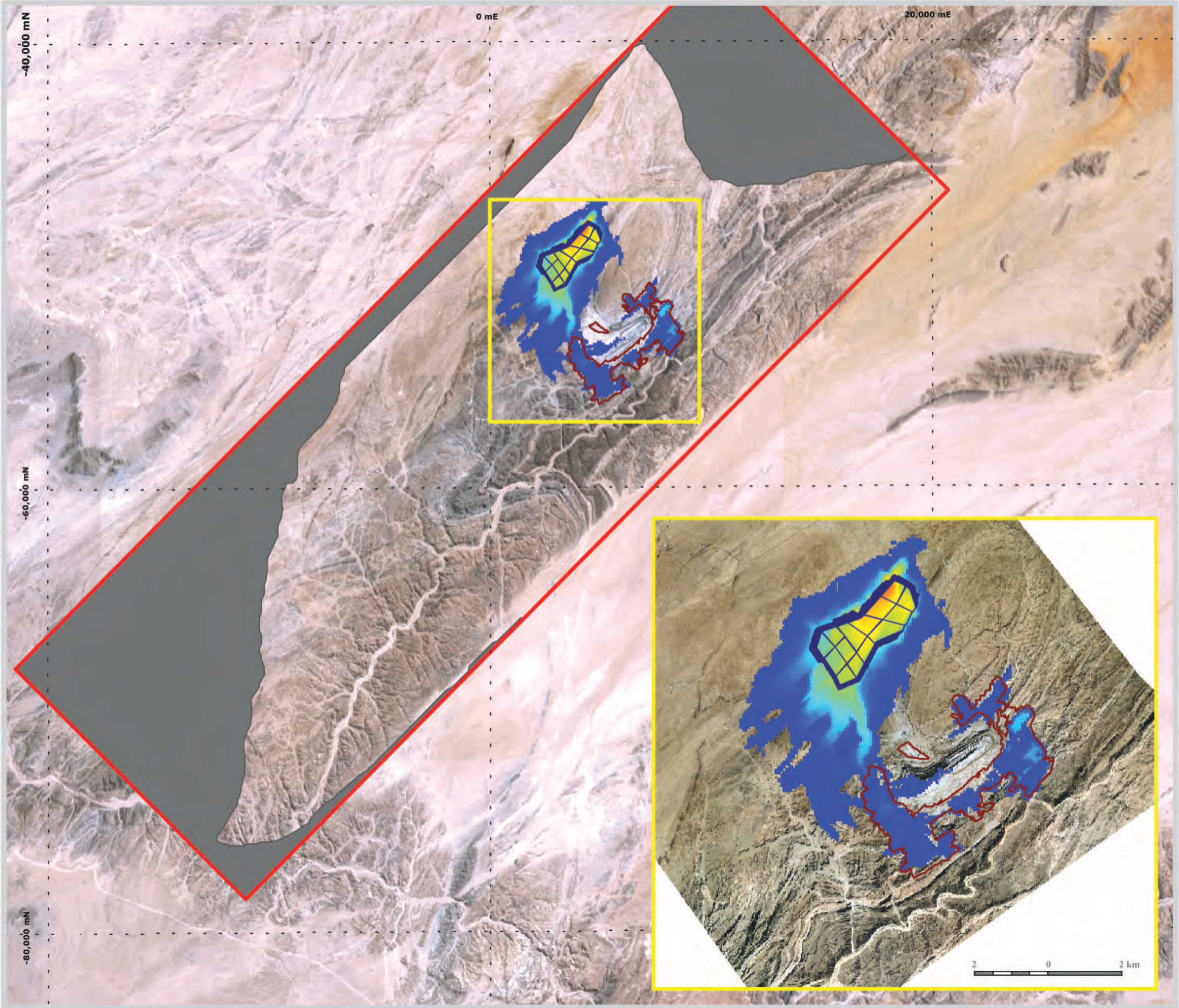
RPS Aquaterra

FIGURE B1

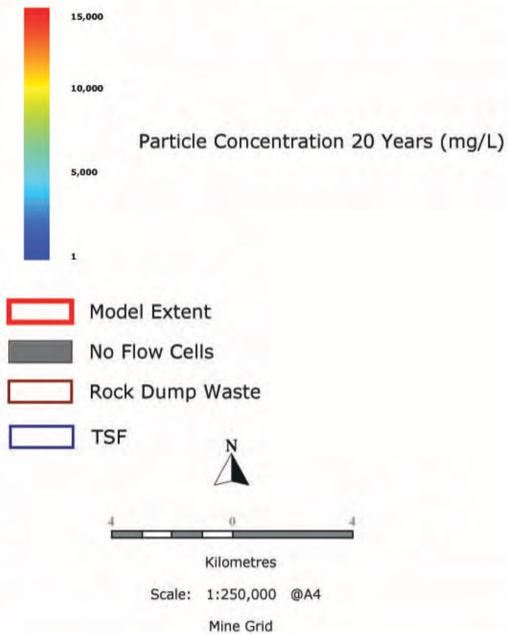
ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 10YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074 C\11

Location: F:\Jobs\1074C\Map Info\F:\Jobs\1074C\Map Info\run14a concentration\Figure B1.wor



LEGEND



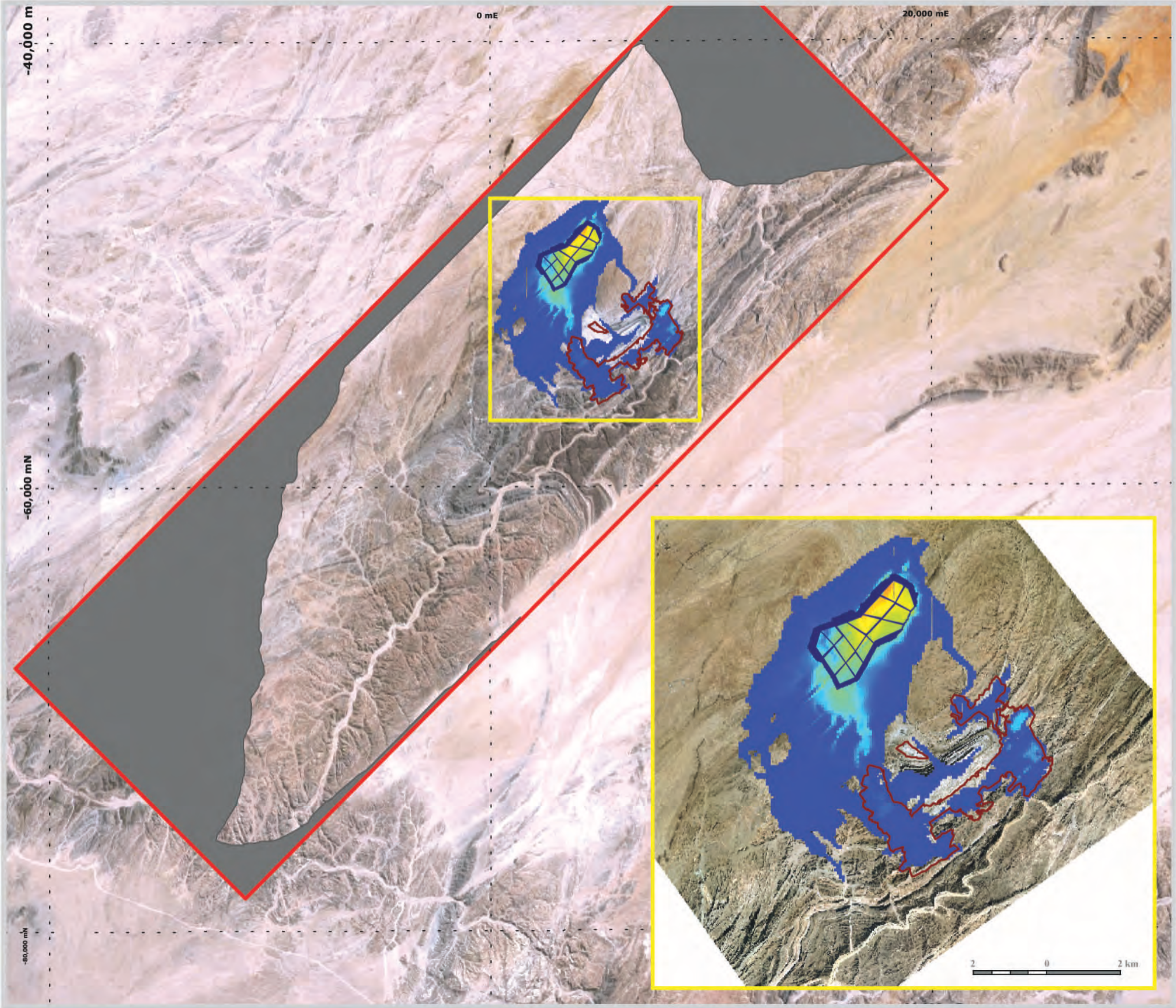
RPS Aquaterra

FIGURE B2

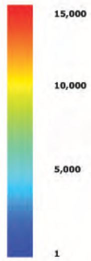
ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 20YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074 C\11

Location: F:\Jobs\1074C\Map Info\F:\Jobs\1074C\Map Info\run14a concentration\Figure B2.wor



LEGEND



Model Extent

No Flow Cells

Rock Dump Waste

TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

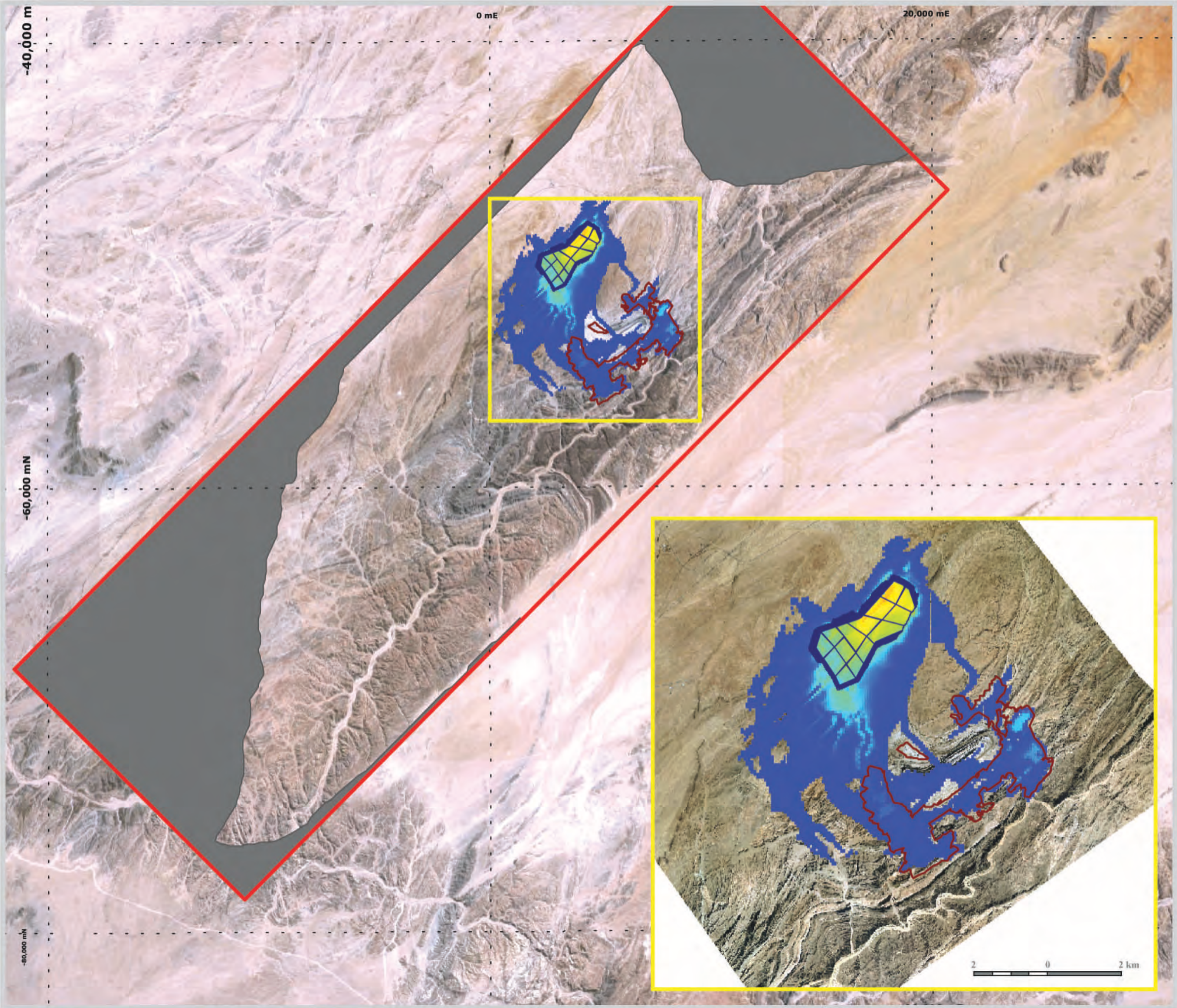
RPS Aquaterra

FIGURE B3

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 50YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074 C\11

Location: F:\Jobs\1074C\Map Info\F:\Jobs\1074C\Map Info\run14a concentration\Figure B3.wor



LEGEND

15,000
10,000
5,000
1

Particle Concentration 100 Years (mg/L)

- Model Extent
- No Flow Cells
- Rock Dump Waste
- TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

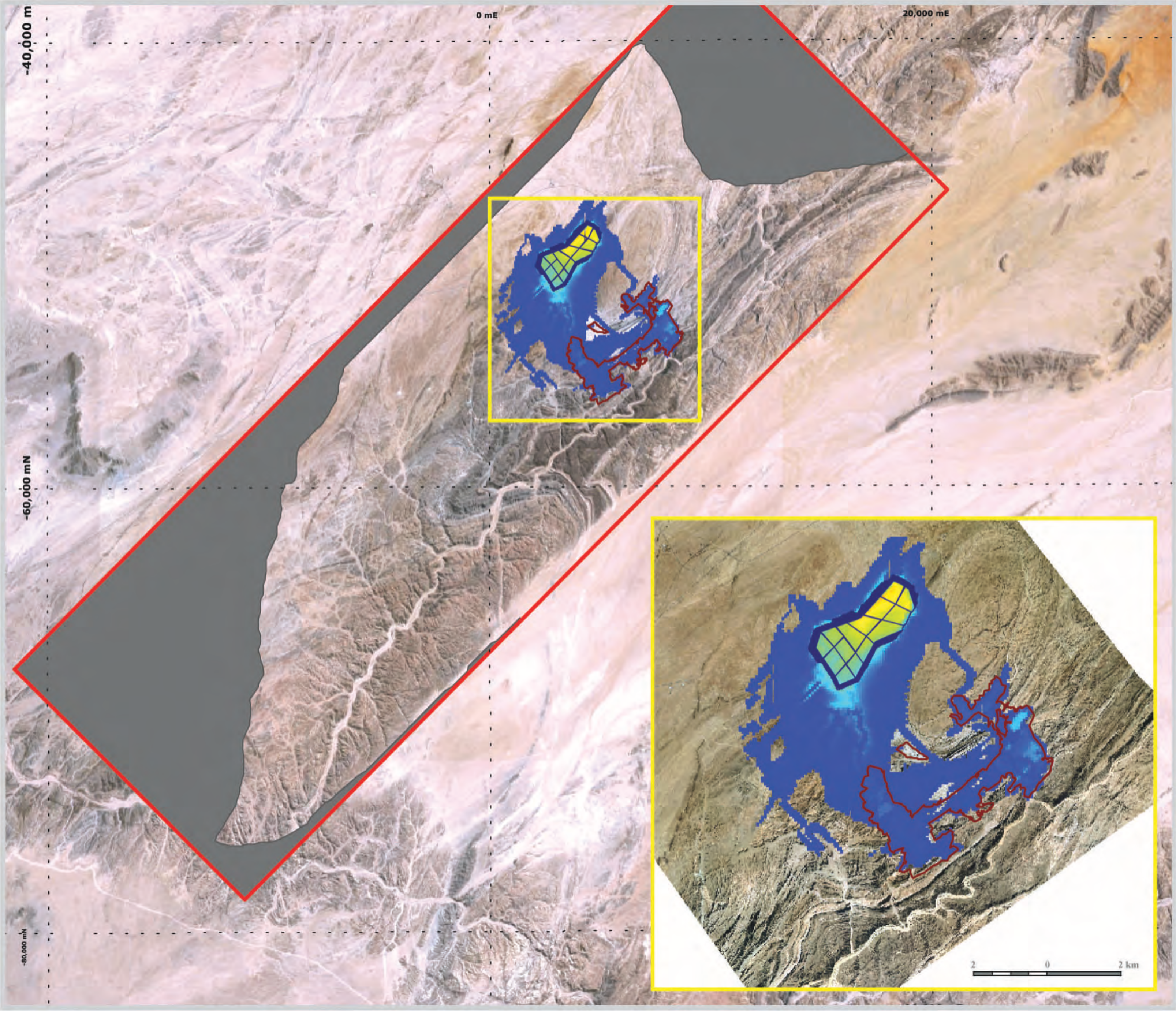
RPS Aquaterra

FIGURE B4

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 100YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074 C\11

Location: F:\Jobs\1074C\Map Info\F:\Jobs\1074C\Map Info\run14a concentration\Figure B4.wor



LEGEND

15,000
10,000
5,000
1

Particle Concentration 500 Years (mg/L)

Model Extent
No Flow Cells
Rock Dump Waste
TSF

N

4 0 4
Kilometres
Scale: 1:250,000 @A4
Mine Grid

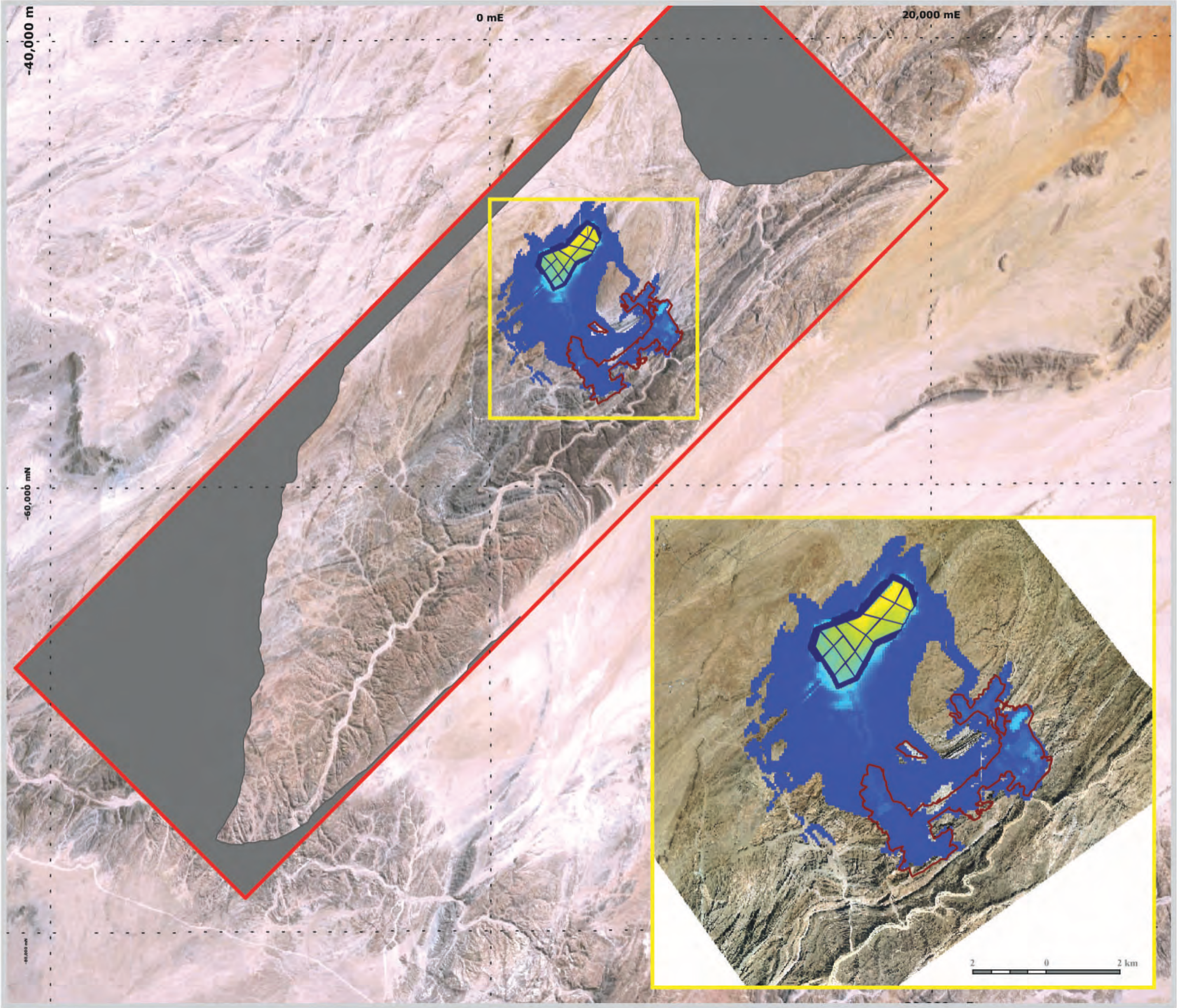
RPS Aquaterra

FIGURE B5

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 500YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074 C\11

Location: F:\Jobs\1074C\Map Info\F:\Jobs\1074C\Map Info\run14a concentration\Figure B5.wor



LEGEND

15,000
10,000
5,000
1

Particle Concentration 1000 Years (mg/L)

- Model Extent
- No Flow Cells
- Rock Dump Waste
- TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

RPS Aquaterra

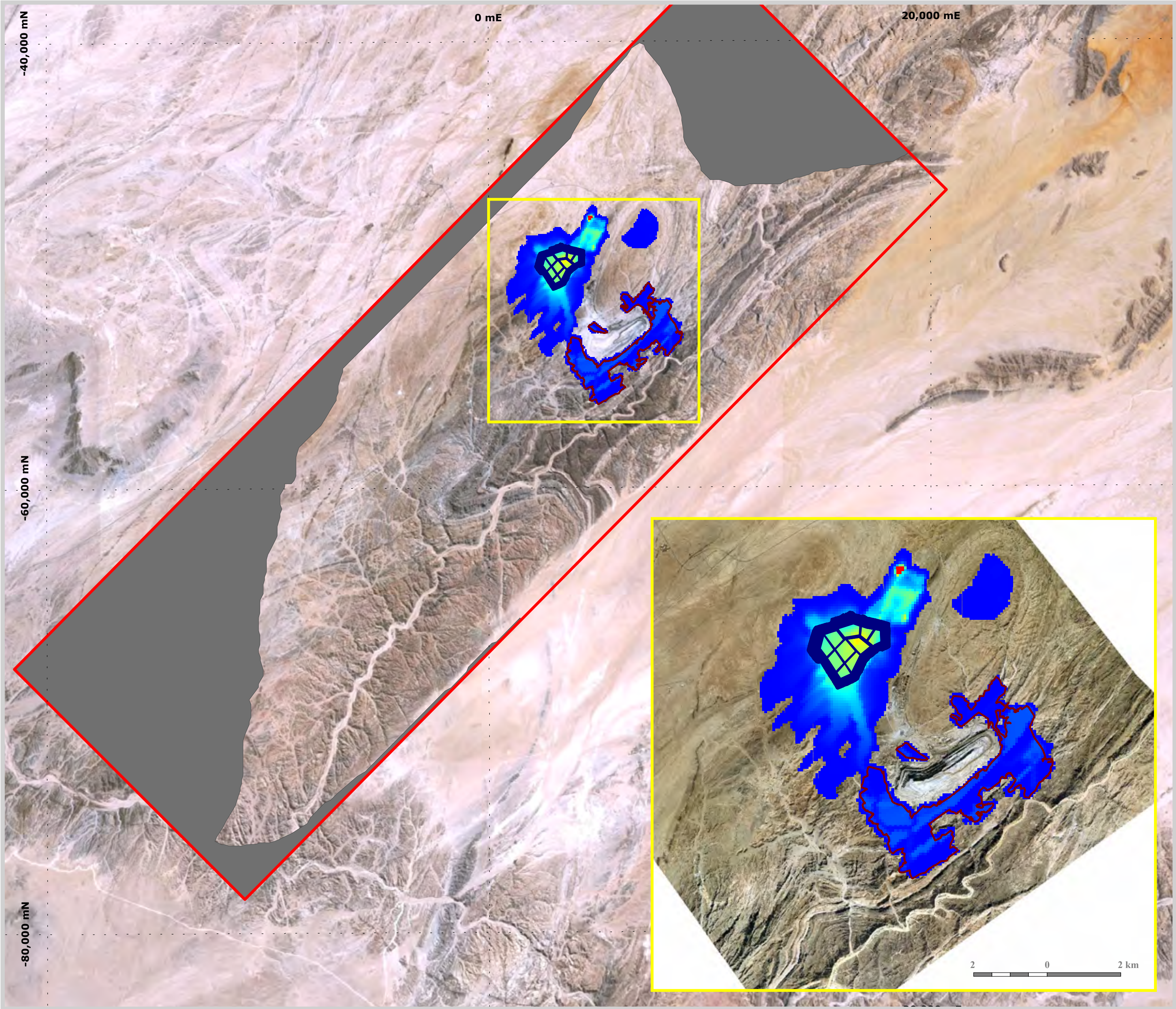
FIGURE B6

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 1000YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074 C\11

Location: F:\Jobs\1074C\Map Info\F:\Jobs\1074C\Map Info\run14a concentration\Figure B6.wor

APPENDIX C:
EXPANSION CASE TRANSPORT MODELLING RESULTS



LEGEND

15,000
10,000
5,000
1

Particle Concentration 10 Years (mg/L)

Model Extent
No Flow Cells
Rock Dump Waste
TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

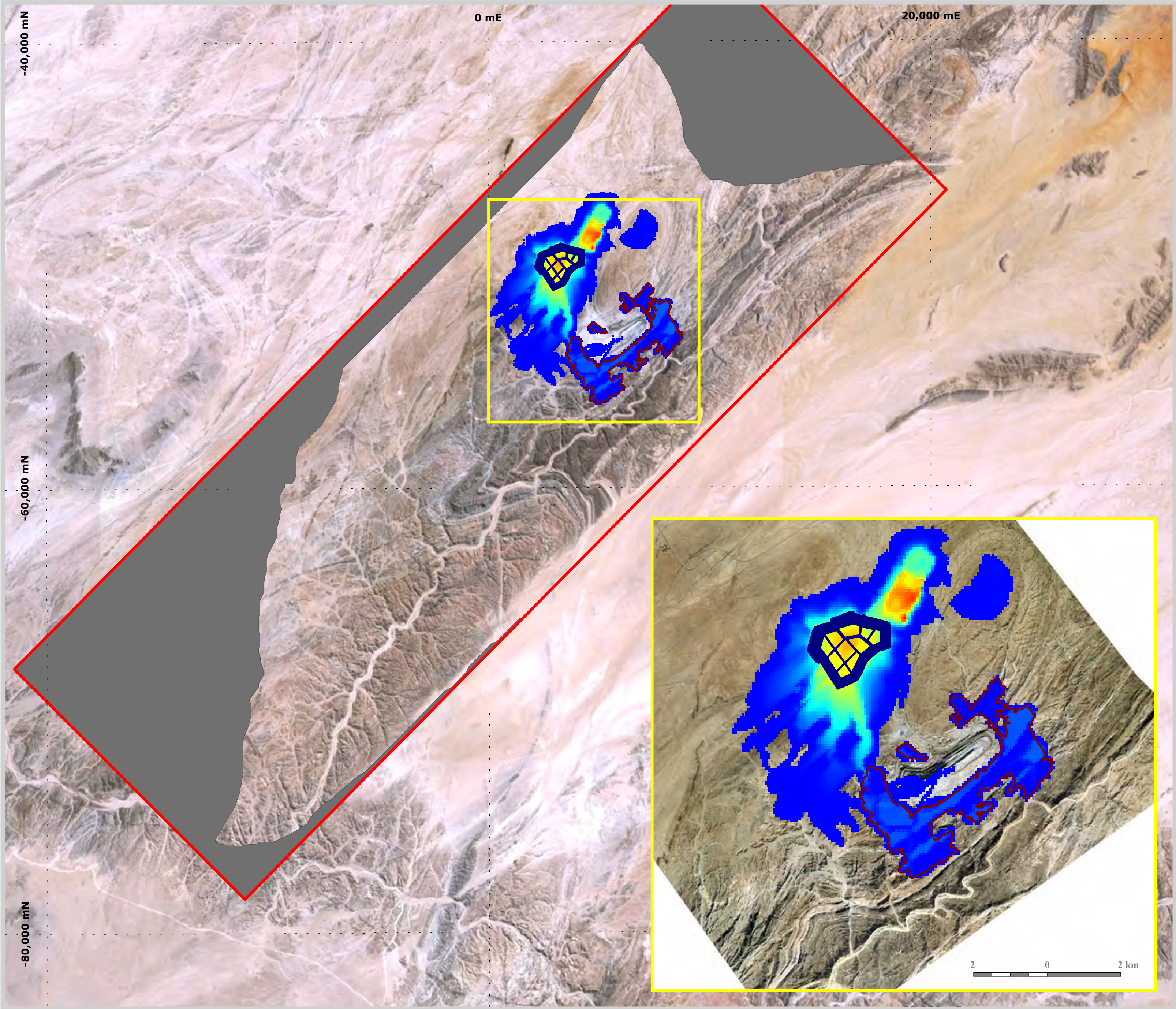
RPS Aquaterra

FIGURE C1

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 10YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074C

Location: F:\Jobs\1074C\Map Info\Workspaces\027b Figure C1.wor



LEGEND

15,000
10,000
5,000
1

Particle Concentration 20 Years (mg/L)

Model Extent

No Flow Cells

Rock Dump Waste

TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

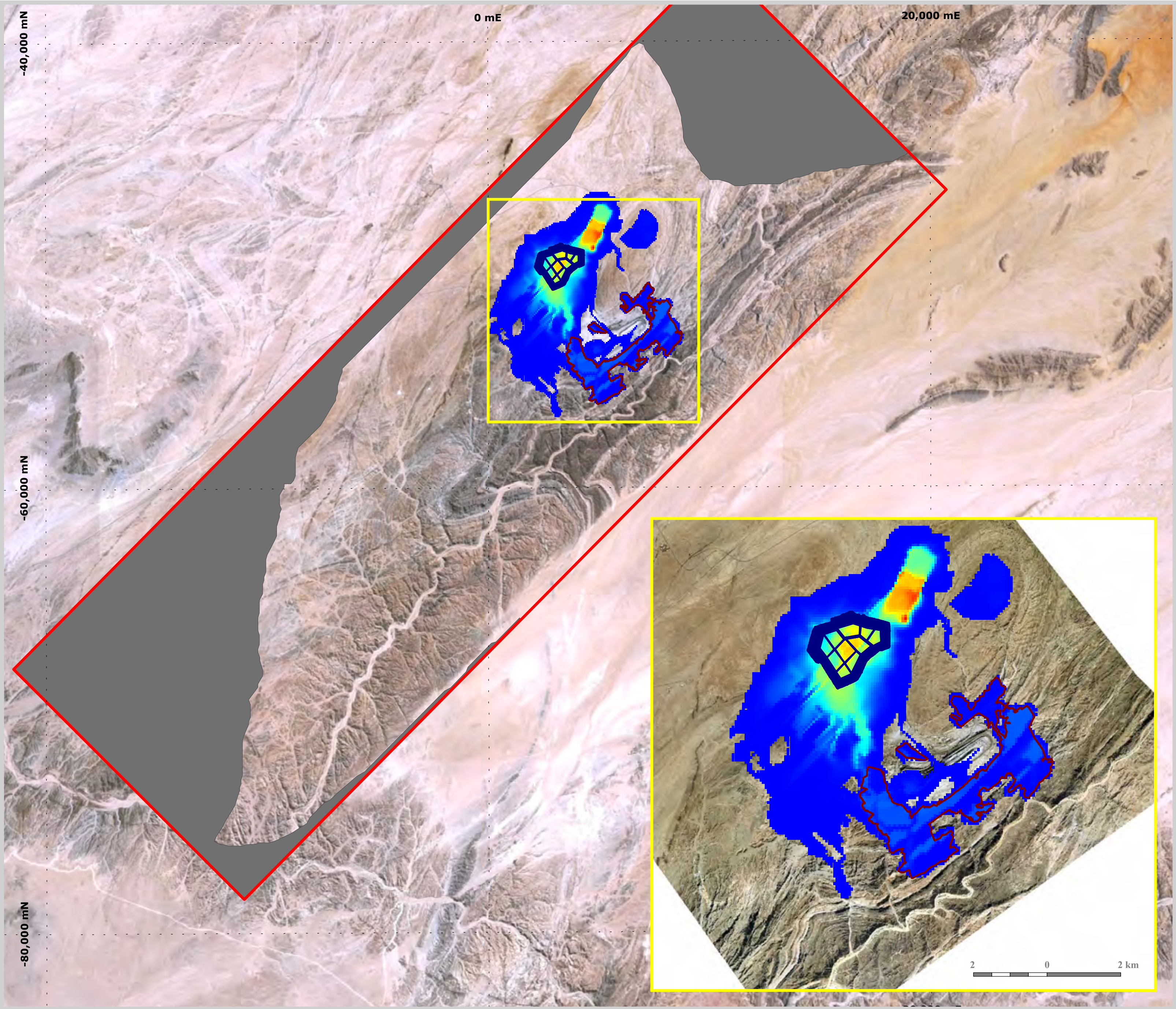
RPS Aquaterra

FIGURE C2

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 20YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074C

Location: F:\Jobs\1074C\Map Info\Workspaces\025C Figure B2.wor



LEGEND

15,000
10,000
5,000
1

Particle Concentration 50 Years (mg/L)

Model Extent

No Flow Cells

Rock Dump Waste

TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

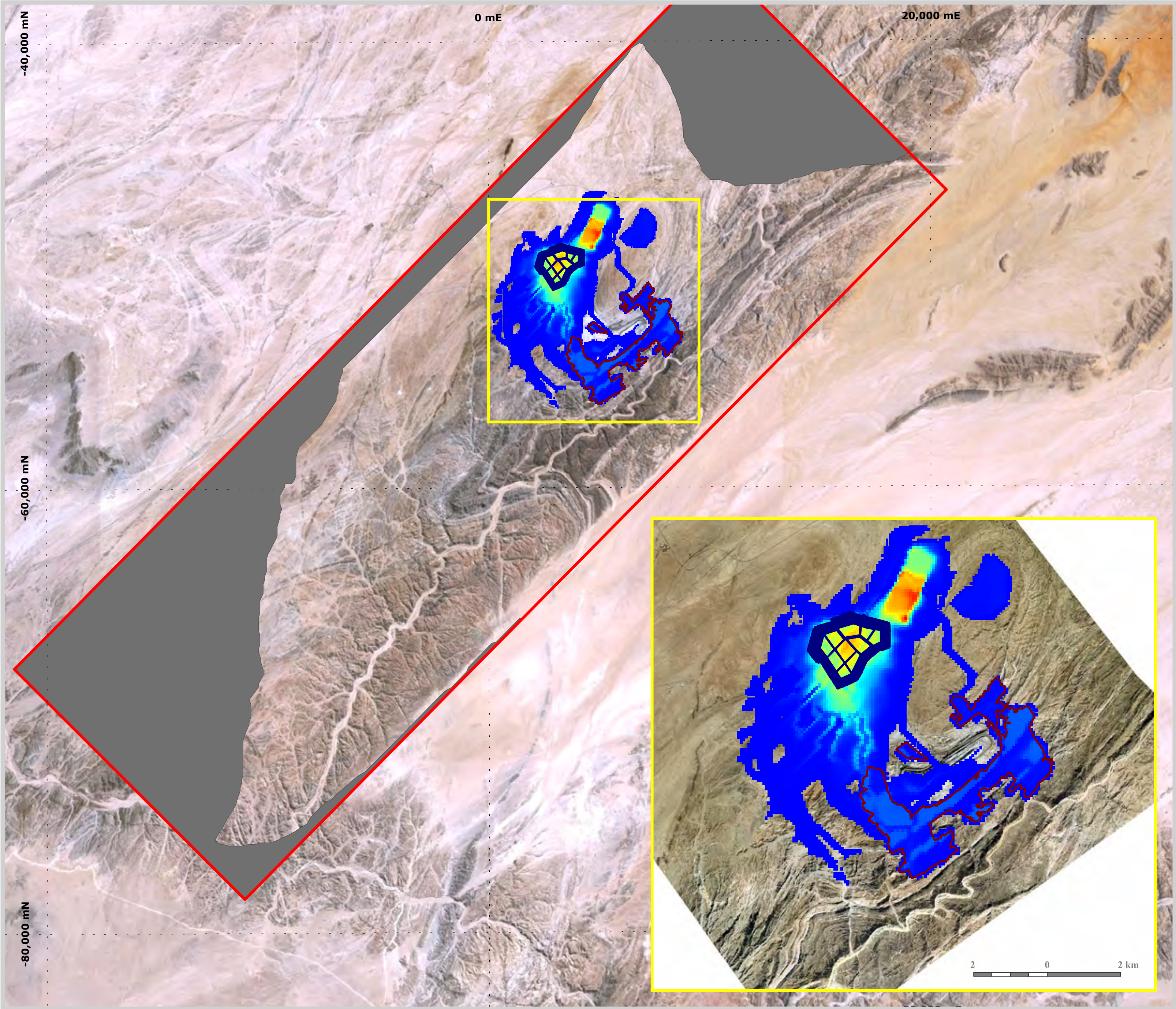
RPS Aquaterra

FIGURE C3

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 50YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074C

Location: F:\Jobs\1074C\Map Info\Workspaces\025C Figure B3.wor



LEGEND

15,000
10,000
5,000
1

Particle Concentration 100 Years (mg/L)

Model Extent

No Flow Cells

Rock Dump Waste

TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

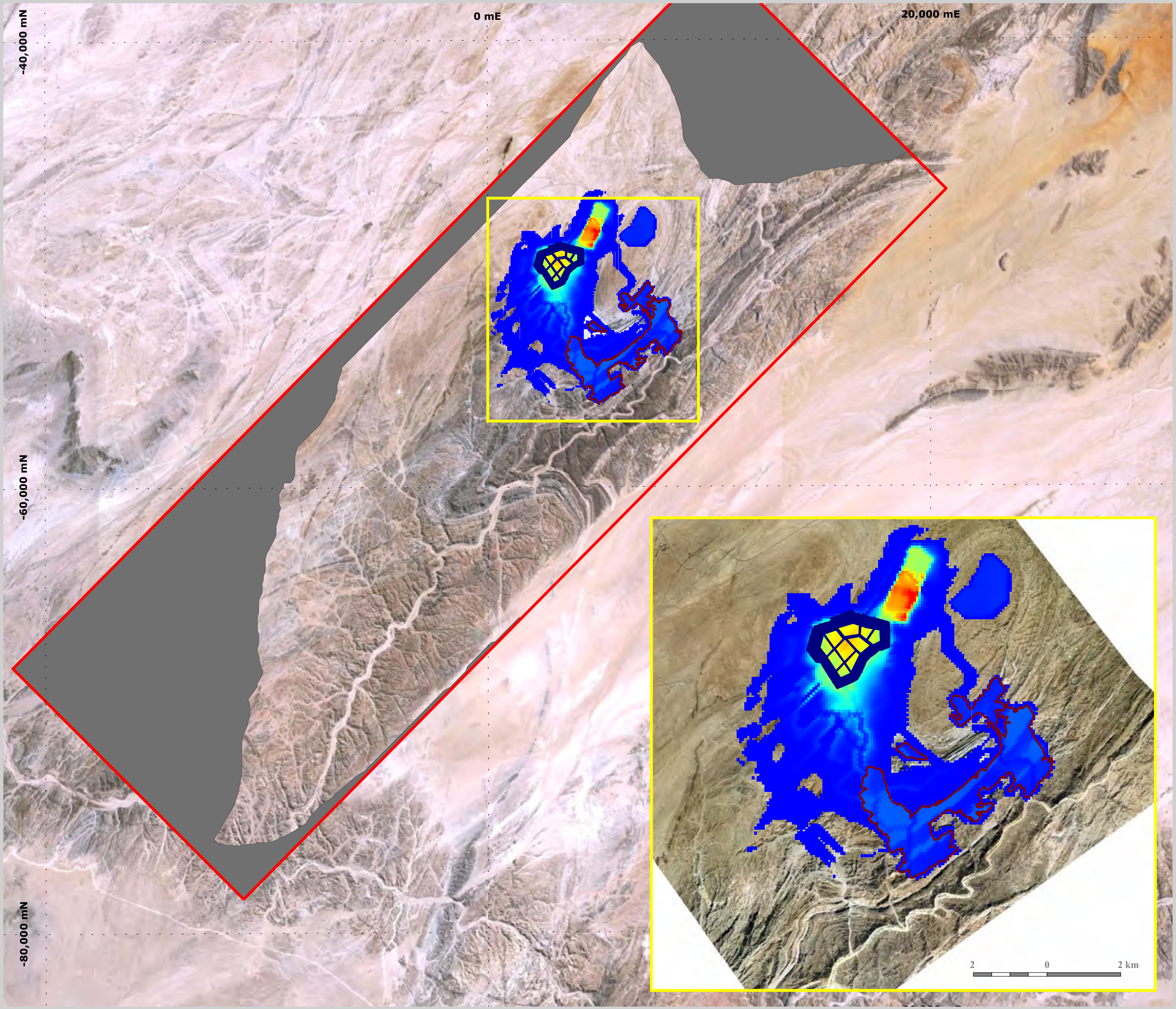
RPS Aquaterra

FIGURE C4

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 100YR CONCENTRATION(SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074C

Location: F:\Jobs\1074C\Map Info\Workspaces\025C Figure B4.wor



LEGEND

15,000
10,000
5,000
1

Particle Concentration 500 Years (mg/L)

Model Extent

No Flow Cells

Rock Dump Waste

TSF

N

4 0 4

Kilometres

Scale: 1:250,000 @A4

Mine Grid

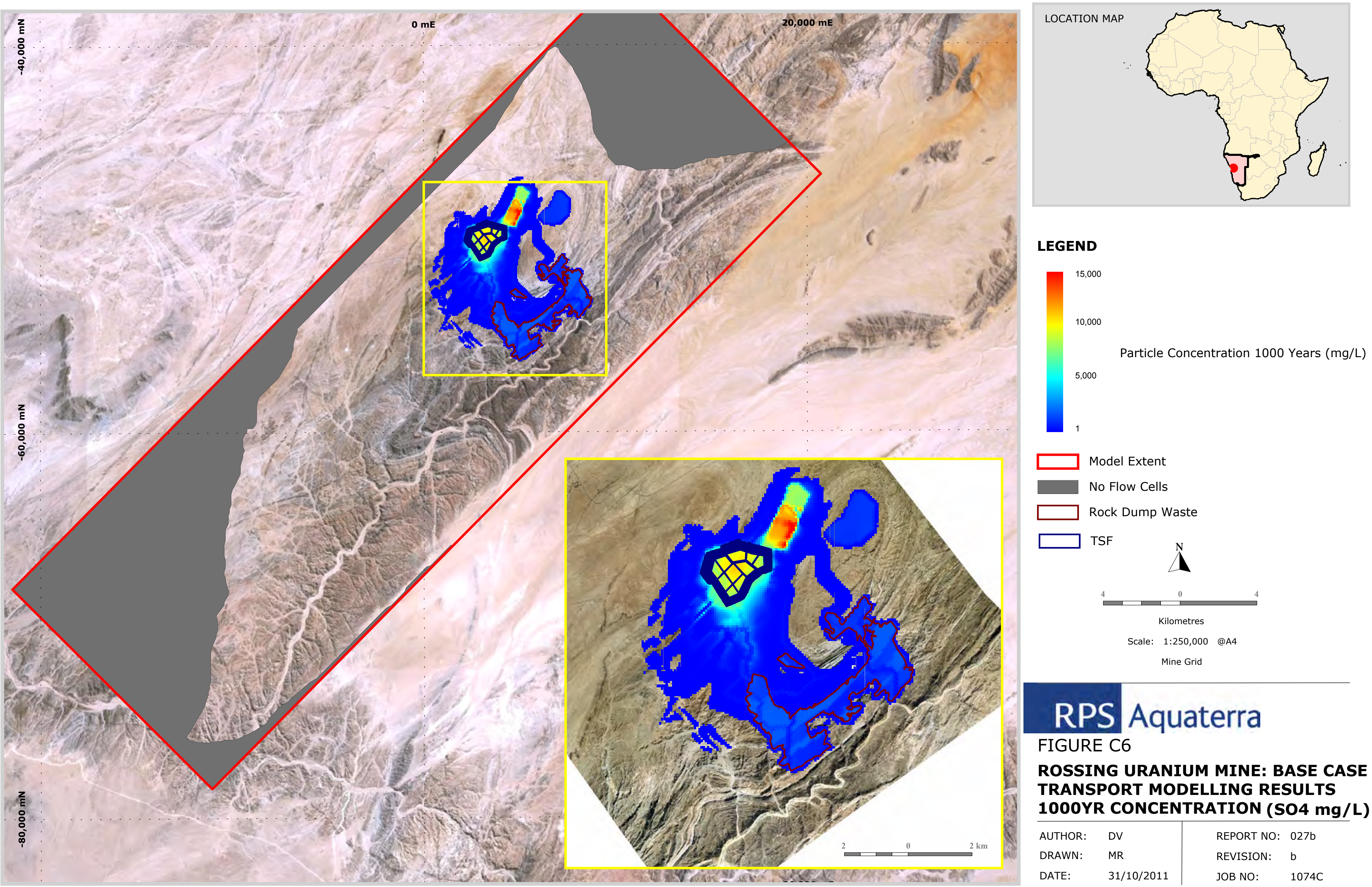
RPS Aquaterra

FIGURE C5

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 500YR CONCENTRATION(SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074C

Location: F:\Jobs\1074C\Map Info\Workspaces\025C Figure B5.wor



RPS Aquaterra

FIGURE C6

ROSSING URANIUM MINE: BASE CASE TRANSPORT MODELLING RESULTS 1000YR CONCENTRATION (SO4 mg/L)

AUTHOR:	DV	REPORT NO:	027b
DRAWN:	MR	REVISION:	b
DATE:	31/10/2011	JOB NO:	1074C

Location: F:\Jobs\1074C\Map Info\Workspaces\025C Figure B6.wor

RPS Aquaterra

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T +61 8 9211 1111 F +61 8 9211 1122 E water@rpsgroup.com.au W rpsaquaterra.com.au

MEMORANDUM

COMPANY:	Rössing Uranium Limited		
ATTENTION:	Rainer Schneeweiss		
FROM:	Jeff Jolly		
DATE:	24 August 2011	JOB NO: 1074E	DOC NO: 029a
SUBJECT:	Base Case and Expansion Case Scenarios - Uranium Movement in Groundwater		

Rainer,

We are pleased to present the results of modelling predictions to assess the potential transport of uranium resulting from the proposed Base Case and Expansion Case mining scenarios. The predictions have been completed using the latest calibrated groundwater model which was recently used to predict groundwater flows in the modelled catchment under the Base Case mine setup. Full details of the model set up are provided in the RPS Aquaterra report *"Rössing – Prediction of Post-closure Seepage",* (August 2011, our reference 1074E\006b). The details of the model predictions and results are outlined below.

1. MODEL SETUP

The details of the Base Case and Expansion Case scenarios and how features of both cases are included in model predictions are outlined below.

Base Case

The Base Case set up assumes that the existing Rössing Tailings Storage Facility (TSF) is operated for a further 16 years with continued placement of conventional tailings over the central and north-eastern extent of the current TSF. This is simulated as direct recharge to the TSF over the period 2009 to 2024. Recharge is applied at a rate of 5,200kL/d over an area of 12 hectares. The recharge is rotated, on an annual basis, through the proposed paddocks over the operational period.

Details of the recharge rates associated with the Base Case, plus pumping from the TDDS, TDX, WDW and NTSC borefields, operation of Trenches B, C, E and H, Khan River pumping and groundwater inflows to the Open Pit area summarised in Table 1 over both the 16 years operational period (nominally 2009 to 2024) and a further closure period (2025 to 3009), resulting in a total prediction time of 1000 years.

Expansion Case

The Expansion Scenario involves conventional tailings spread over the central footprint of the existing TSF, with a heap leach pad over the north-eastern end of the current TSF, Ripios disposal in the Dome area and rock dumps. Both the heap leach and the ripios facilities will operate over the period 2009 to 2024 (the operational period). The heap leach pad is simulated as a constant recharge of 4.32 x10^{-4} kL/d over an area of 50% of the proposed pad area, presuming that the other 50% of the pad area is not active. The area under heap leach is progressively increased from 0.64km^2 at commencement in 2013 to a maximum area of 1.47km^2 by 2019. The ripios facility on Dome Gorge is simulated with a recharge rate to the underlying groundwater of 0.6mm/year. The area under ripios is increased from 0.33km^2 in 2013 to a maximum area of 1.78km^2 by 2017.

Details of the Expansion Case simulation, including pumping from the TDDS, TDX, WDW and NTSC borefields, operation of Trenches B, C, E and H, Khan River pumping and groundwater inflows to the Open Pit are summarised in Table 1. These are provided for both the operational period (2009 to 2024) and the closure period (2025 to 3009).

Table 1: Assumptions and Constraints for the Base Case and Expansion Case Scenarios

Feature	Start Date	Finish Date	Quantities	Comments
Existing TSF (Base Case Only)	2009	2024	5,200kL/d over 12 hectares, plus recharge from rainfall	The seepage from TSF has been applied in the western parts of existing TSF and has been rotated through the paddock areas.
Heap Leach Pad on Existing TSF Area (Expansion Case Only)	2013	2023	4.32×10^{-4} kL/d	Seepage from the heap leach Pad is simulated at the rate of 10^{-8}m/sec with only 50% of the pad area actively recharging the groundwater system. The area under heap leach is progressively increased from an area of 0.64km^2 in 2013 to a maximum area of 1.47km^2 by 2019.
Ripios on Dome Gorge (Expansion Case Only)	2013	2023	1.6×10^{-6} kL/d	Seepage from the ripios is simulated at a rate of 0.6mm/year. The area under ripios is increased from 0.33km^2 in 2013, reaching a maximum area of 1.78km^2 in 2017
Waste Rock Dumps	2009	Ongoing after operational period and for remainder of prediction (ie closure)	0.3mm/year	Seepage from waste rock dumps is simulated at a rate of 0.3mm/year
Rainfall	2009	Ongoing after operational period and for remainder of prediction (ie closure)		10% of average annual rainfall (30mm) to gorges, 1% to other areas
TDDS Borefield	2009	Ongoing for operational period, off for remainder of prediction (ie closure)	Maximum Pumping	Pumping constraints are set consistent with minimum achievable at pumping locations
TDX Borefield	2009	Ongoing for operational period, off for remainder of prediction (ie closure)	Maximum Pumping	Pumping constraints are set consistent with minimum achievable at pumping locations
WDW	2009	Ongoing after operational period, for remainder of prediction (ie closure)	Maximum Pumping	Pumping constraints are set consistent with minimum achievable at pumping locations
NTSC Borefield	2009	Ongoing after operational period, for remainder of prediction (ie closure)	Maximum Pumping	Pumping constraints are set consistent with minimum achievable at pumping locations
Khan River Aquifer Pumping	2009	2023	Maximum Pumping	Pumping constraints are set consistent with minimum achievable at pumping locations
Pumping From Trenches B, C, E and H	2009	Ongoing after operational period, for remainder of prediction, Trench G (Upper Dome Gorge) pumping starts at beginning of closure period.	Maximum Pumping	Trench elevations are set consistent with the base of the alluvium (just above)
Seepage Dam Operation	2009	Ongoing (closure)		The seepage dam continues to operate throughout the whole simulation period, even though seepage into the dam is balance by evaporation out of the dam after 14 years.
Groundwater Inflow to the Open Pit	2009	Ongoing (closure)		Ongoing pit development simulated consistent with LOM Plan V9.3 during operational period. During closure period, Open Pit left uninfilled to form a long term groundwater sink (ie all groundwater flow towards the pit with little to no groundwater flow away from the pit)

1.1 Transport Modelling

Transport modelling was completed to assess potential movement of uranium for both the Base and Expansion Cases, using Modflow Surfact. For the Base Case, uranium movement was modelled from the TSF and waste rock dumps, while for the Expansion Case, uranium movement was modelled from the proposed heap leach pad, ripios and waste rock dumps.

The model was not calibrated to existing uranium concentrations. Rather, the predictions are designed to predict the increase in uranium concentration (above current levels) that could be expected in the future. The predictions are based on a reasonable range of model transport parameters for the TSF and Dome Gorge areas, as well as inputs of uranium from the TSF, heap leach pad and ripios seepage and seepage from the waste rock dumps, to the underlying groundwater system.

The Modflow Surfact solute transport module was used to simulate advective and dispersive solute transport and sorption processes, in conjunction with the flow processes for the Base and Expansion Cases, as summarised in Table 1.

To allow the prediction of uranium transport resulting from the Base and Expansion Cases, the following parameters have been included in the flow and transport model:

- As the model was used to predict the potential increase in uranium concentrations across the model domain as a result of seepage to groundwater from either the Base or Expansion Case, the initial uranium concentration across the model domain was set to zero, with the exception of the existing TSF area which was set an initial concentration of 1.4mg/L (based on seepage concentrations leaving the base of the current TSF and entering the Seepage Dam).
- For both the Base and Expansion cases, uranium sources and sinks were assigned as outlined below:
  - Groundwater inflow from further upstream of the catchment is assigned a uranium input concentration of zero.
  - Groundwater outflow at the Swakop River is calculated by the model, with uranium being removed consistent with the predicted concentration of uranium and predicted groundwater outflow at this location.
  - Rainfall recharge is specified with a uranium input concentration of zero.
  - Pumping from the TDS, TDDX, WDW, NTSC and trenches, assumes uranium is removed at a rate consistent with the predicted concentration and pumping rates.
  - Along the Khan River, where evapotranspiration is assigned, no uranium is removed, consistent with the processes associated with an evaporative flux.
  - For the Seepage Dam and the open pit, pumping or removal of uranium is consistent with the calculated uranium concentration and the predicted flow rate. It is noted that any concentration processes due to evaporation in the open pit will not be fully simulated by this process. However, as the open pit remains a sink over the entire prediction period and evaporation is higher than the inflow, the pit is unlikely to be a solute source.
  - Recharge from the waste rocks dumps is assigned a source concentration of 1.07mg/L, based on laboratory results from studies carried out by SRK on representative samples from the rock dumps. This seepage concentration is applied for both the operational and closure periods.
  - Recharge from the TSF is assigned consistent with the projected schedules for both the Base and Expansion cases, as summarised in Table 1. For the TSF or heap leach pad, as appropriate, recharge is assigned an input concentration of 1.4mg/L during operation only. After operation ceases, the input concentration associated with rainfall recharge to the TSF or heap leach pad is reduced to zero. Even though the no further uranium is being added with the rainfall, the model will still simulate seepage of existing water contained within the TSF (and containing uranium), into the underlying groundwater. It is noted that the recharge rates utilized for the heap leach pad are set to simulate the situation of a potential leak in the heap leach pad lining – as a result, this constitutes a “worst case” situation.
  - For the ripios (Expansion Case only), over the first two years of operation a source concentration of 62.4mg/L was included. For the remainder of the operational period (22 years) a source concentration of 15.9mg/L was included. Once operation of the ripios facility ceases, a source concentration of 0.736mg/L was included for the remaining 1000 years. These values were derived from information provided by Rössing Uranium Ltd. (Mintek report, January 2009).
- Dispersivity values (longitudinal and horizontal transverse and vertical transverse) were assigned consistent with values included in modelling completed in May 2011. These values were derived from literature values. The values assigned are summarised in Table 2.1 to 2.5.

Table 2.1: Summary of Transport Parameters - Layer 1

Hydrogeological Unit	Porosity	Longitudinal Dispersivity (m)	Horizontal Transverse Dispersivity (m)	Vertical Transverse Dispersivity (m)
Medium Tailings	0.3	300	10	1
Coarse Tailings	0.3	300	10	1
Starter Wall	0.3	300	10	1

Table 2.2: Summary of Transport Parameters - Layer 2

Hydrogeological Unit	Porosity	Longitudinal Dispersivity (m)	Horizontal Transverse Dispersivity (m)	Vertical Transverse Dispersivity (m)
Starter Wall	0.3	300	10	1
Fine Tailings	0.01	300	10	1
Coarse Tailings	0.3	300	10	1
Medium Tailings	0.3	300	10	1

Table 2.3: Summary of Transport Parameters - Layer 3

Hydrogeological Unit	Porosity	Longitudinal Dispersivity (m)	Horizontal Transverse Dispersivity (m)	Vertical Transverse Dispersivity (m)
Khan & Etusis Fm	0.01	100	10	1
Kuiseb, Karibib and Chuos	0.01	100	10	1
Quaternary Cover	0.01	100	10	1
Karibib	0.01	100	10	1
Amphibole Schist - High K Zone	0.01	100	10	1
Gorge Alluvium	0.1	300	30	3
Rössing Fm Alaskites	0.01	100	10	1
Rössing Marble	0.01	100	10	1
Khan River Alluvium	0.1	300	30	3
Faults	0.05	100	10	1

Table 2.4: Summary of Transport Parameters - Layer 4

Hydrogeological Unit	Porosity	Longitudinal Dispersivity (m)	Horizontal Transverse Dispersivity (m)	Vertical Transverse Dispersivity (m)
Khan & Etusis Fm	0.00001	100	10	1
Kuiseb, Chuos, and Karibib	0.00001	100	10	1
Quaternary Cover	0.0001	100	10	1
Karibib	0.0001	100	10	1
Rössing Marble	0.0001	100	10	1
Amphibole Schist - High K Zone	0.00001	100	10	1
Rössing Fm Alaskites	0.00001	100	10	1
Faults (outside gorges)	0.05	100	10	1
Gorge Faults	0.1	300	30	3
Khan River Alluvium	0.1	300	30	3

Table 2.5: Summary of Transport Parameters - Layer 5

Hydrogeological Unit	Porosity	Longitudinal Dispersivity (m)	Horizontal Transverse Dispersivity (m)	Vertical Transverse Dispersivity (m)
Amphibole Schist	0.01	100	10	1
Gorge Alluvium	0.1	100	10	1
Faults (outside gorges)	0.05	100	10	1
Rössing Fm Alaskite	0.01	100	10	1
Rössing Marble	0.01	100	10	1
Fault under Khan River	0.01	100	10	1
Khan & Etusis Fm	0.01	100	10	1
Gorge Faults	0.01	100	10	1
Kuiseb, Chuos, and Karibib Fm	0.01	100	10	1

The retardation, which will cause uranium to move slower than the predicted groundwater velocity is defined by two parameters, the linear distribution coefficient (Kd) and the dry bulk density (rhob). It is acknowledge that Kd values for uranium in groundwater are dependent on groundwater pH. RPS Aquaterra were provided values for Kd by Paul Brown of Rio Tinto Technical Innovation for the alluvium. Simulations were completed assuming the highest Kd values provided for the Base Case (740mL/g) and the Expansion Case (740mL/g). For the bedrock, Kd values were assigned an order of magnitude lower (ie 74mL/g). For the TSF material, a Kd value of zero was assigned. A sensitivity run was undertaken for the Base Case, using the lowest Kd value provided (ie reduced to 65mL/g for the alluvium and 6.5mL/g for the bedrock). The assigned bulk density was calculated from a particle density of 2.67g/mL (equivalent to 2,670kg/m3) and the porosity distribution assigned from RPS Aquaterra's August 2011 work.

2. RESULTS

2.1 Base Case

The predicted increase in uranium concentration for the Base Case, assuming the higher value for Kd (740mL/g) for periods of 10, 20, 50, 100, 500 and 1000 years are presented in Figures 1 to 6. An increase in uranium concentration in the groundwater is only predicted for a zone below the current TSF, with an increase in uranium concentration in this zone of under 0.1mg/L and an average of between 0.001-0.01mg/L. Even though the operating cells of the proposed TSF are smaller than the current TSF, seepage still takes place out of the footprint of the current, larger TSF. There is no increase in the predicted uranium concentration outside of the immediate TSF area, for the range of uranium concentrations shown on the figures. The predictions suggest that there is no increase in uranium concentration in the area of the waste rocks dumps until the 100 year time period. After 100 years however, there is an increase in predicted uranium concentration of up to 0.001mg/L immediately under the waste rock dumps.

The predicted increase in uranium concentration for the lower value for Kd (65mL/g) for periods of 10, 20, 50, 100, 500 and 1000 years are presented in Figures 7 to 12. The extent of the zone of increased uranium levels is similar to that for the high Kd case, but the uranium concentration increases are greater – concentrations slowly increase with time to a maximum of 1 mg/L below the TSF after 1000 years, with an average concentration of between 0.01 – 0.1mg/L. Concentrations below the rock dumps start to increase by 10 years, with a peak concentration below the rock dumps of 0.01mg/L after 1000 years. The area of increased uranium concentration does not extend outside of the rock dumps footprint.

2.2 Expansion Case

The predicted increase in uranium concentration for the Expansion Case, assuming the higher value for Kd (740mL/g) for periods of 10, 20, 50, 100, 500 and 1000 years are presented in Figures 13 to 18. Modelling results suggest that increased uranium concentrations are predicted over the entire footprint of the TSF from the beginning of the prediction periods and within the area of the heap leach pad. Similar to the Base Case, the area of increased uranium is only below the actual seepage sources. The maximum concentration increase below the heap leach is 1 mg/L, although the average values are in the range of 0.01 – 0.1 mg/L. For the TSF, average concentrations are between 0.001 and 0.01mg/L. In the ripios area, an increase in predicted uranium concentration is seen by 10 years, increasing by 1000 years to a maximum of 0.001 mg/L. Predicted increase in uranium concentration under the waste rock dump footprint only starts by 100 years, with maximum concentrations (in some limited areas only) of between 0.0001 – 0.001mg/L.

3. CONCLUSIONS

The modelling results indicate that uranium concentrations in groundwater are not expected to increase outside the footprint of the source areas (TSF, rock dumps, ripios area). Below the source areas, uranium concentrations are predicted to increase over time. The predicted increases range from a worst case during the Expansion Case of under 1mg/L below the heap leach pads (assuming a scenario that they leak) to less than 0.0001mg/L below the rock dumps for the Base Case scenario.

The concentration of uranium in the groundwater entering the Khan river from the mine site is not predicted to increase beyond current concentrations.

Yours sincerely,
RPS Aquaterra

Kathryn

Kathryn Rozlapa
Principal Modeller

Jeff

Jeff Jolly
Principal Hydrogeologist

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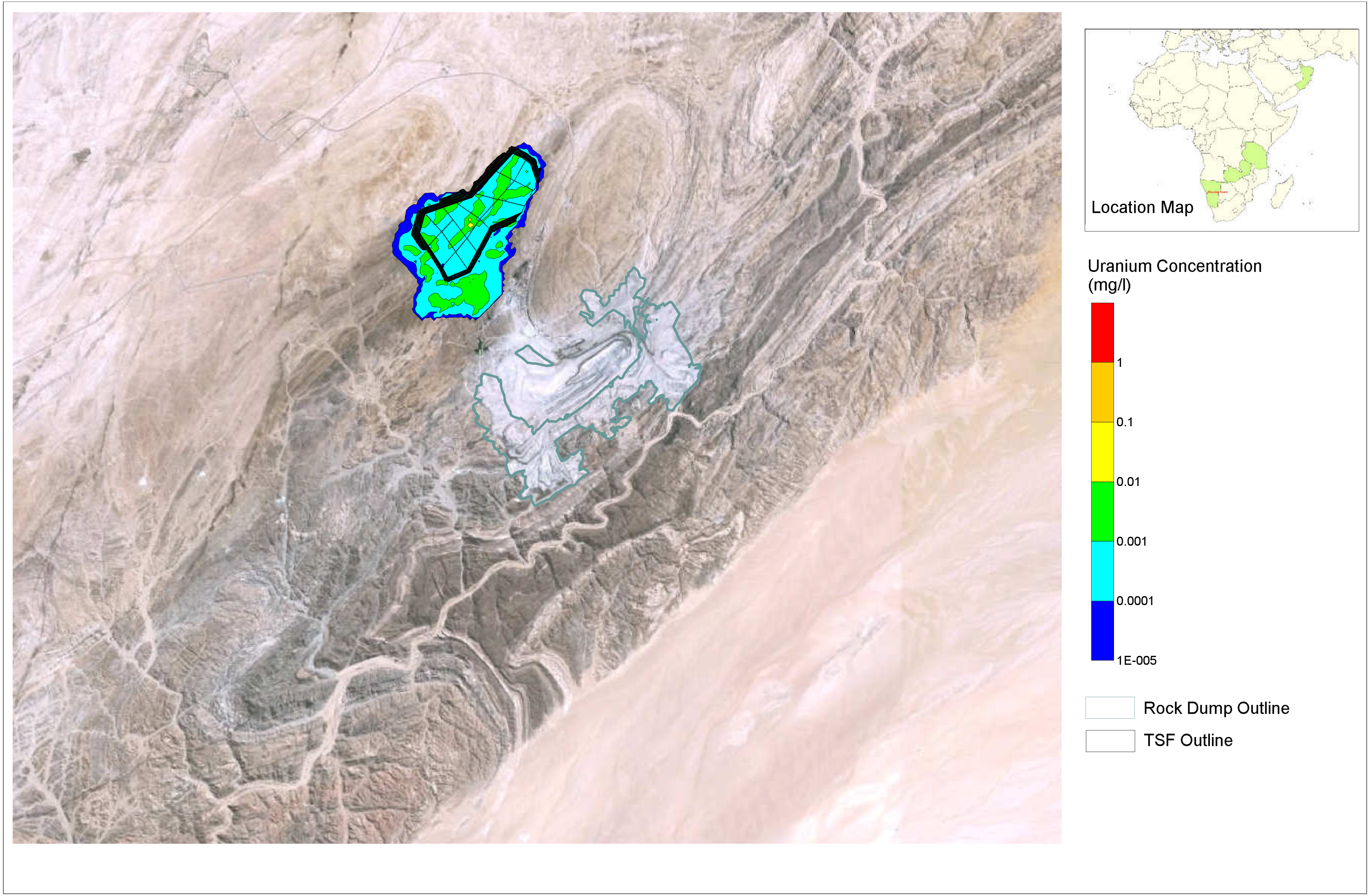
FIGURES



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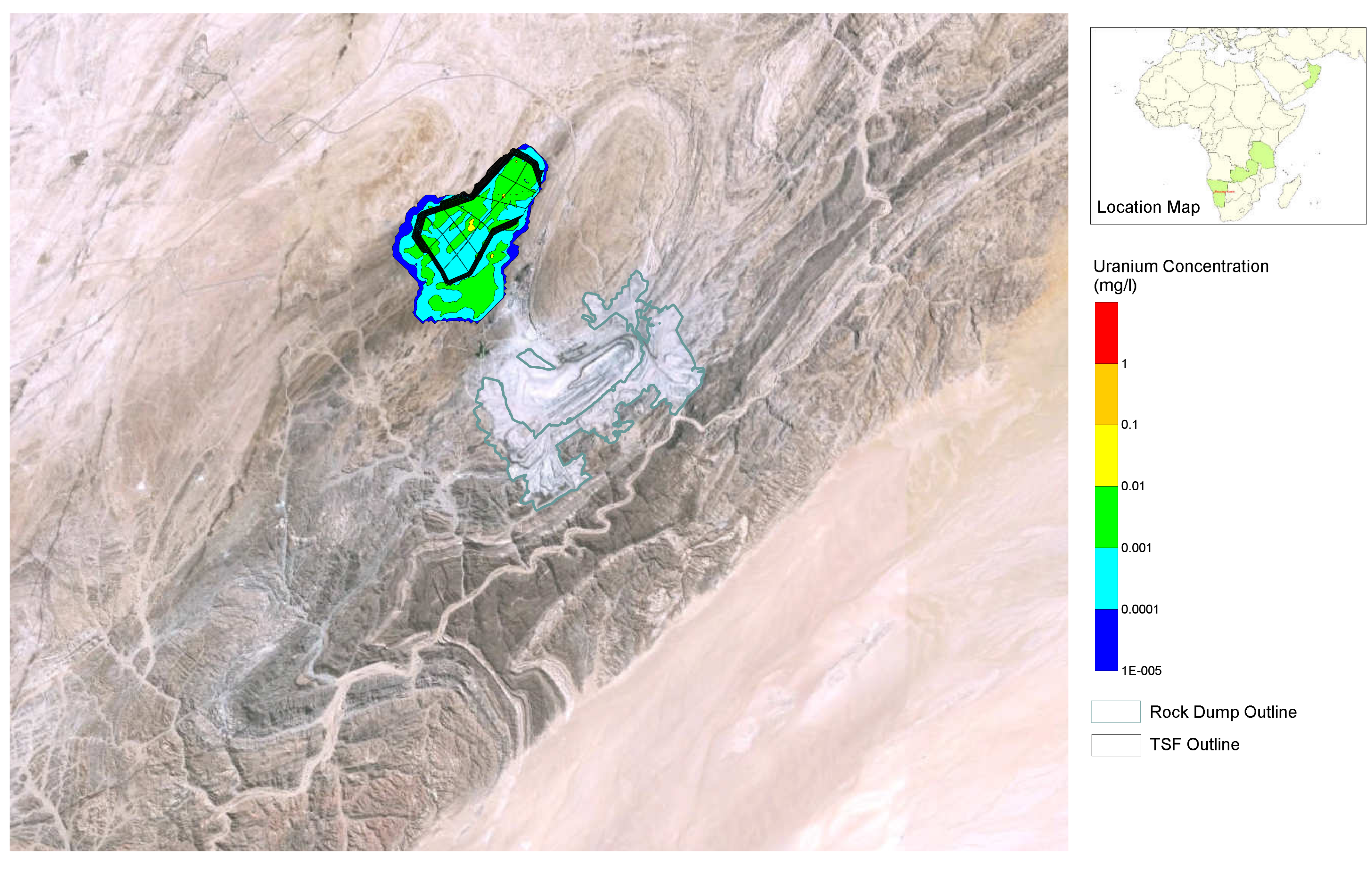
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 10 YEARS (HIGH Kd CASE) FIGURE 1

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 16/Figure 1



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BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 20 YEARS (HIGH Kd CASE) FIGURE 2

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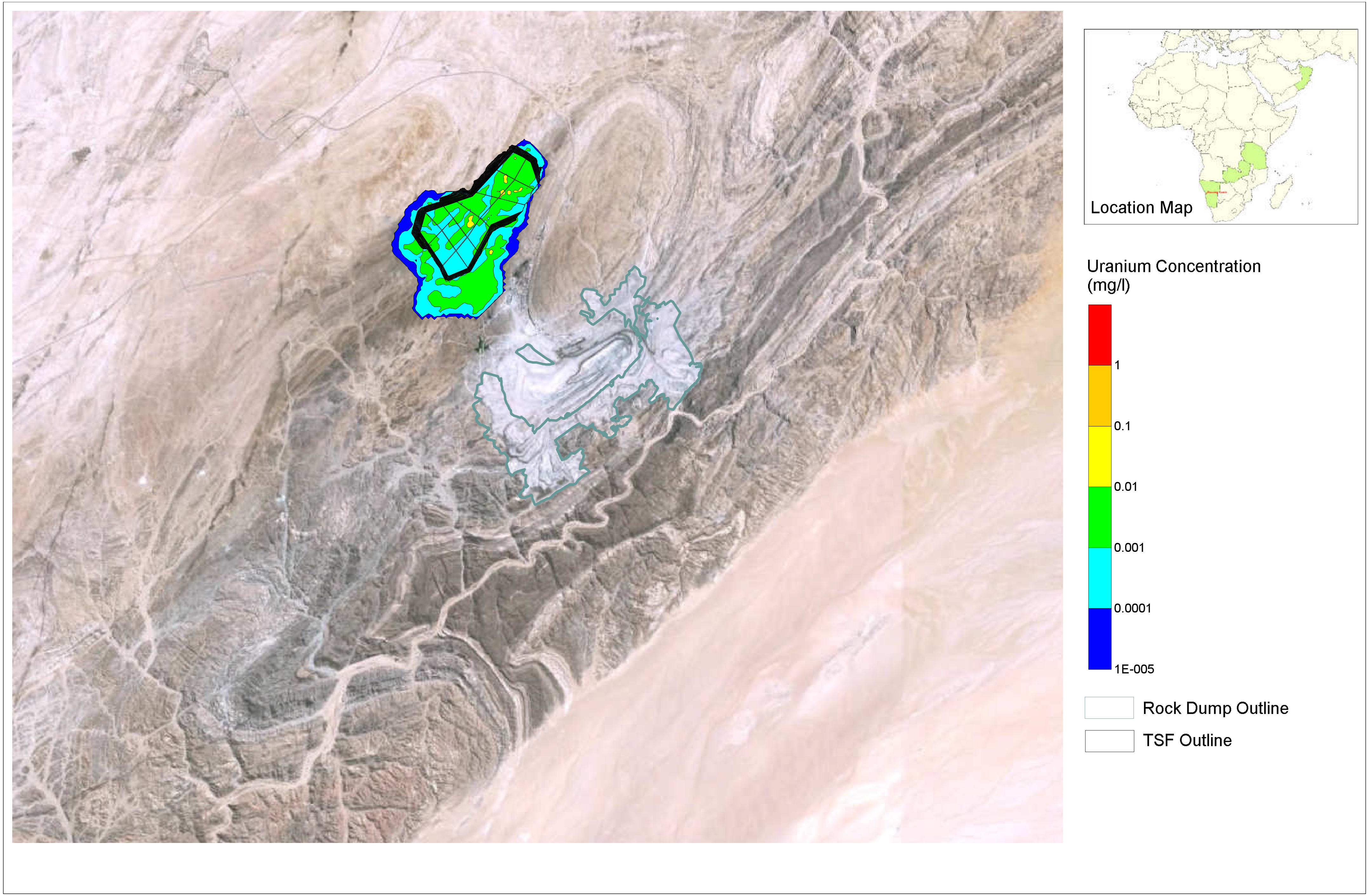

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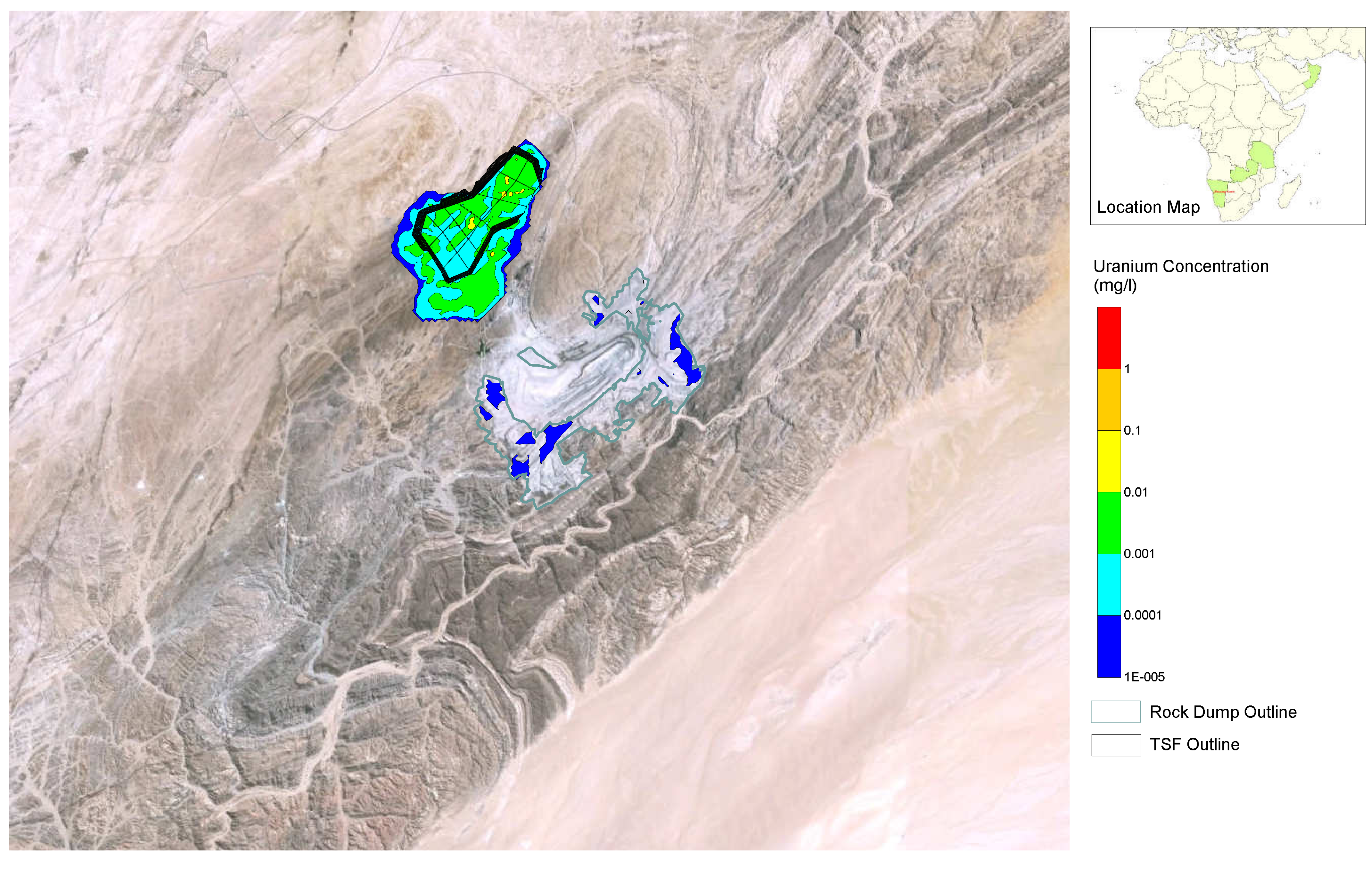
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 50 YEARS (HIGH Kd CASE) FIGURE 3

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 16/Figure 3



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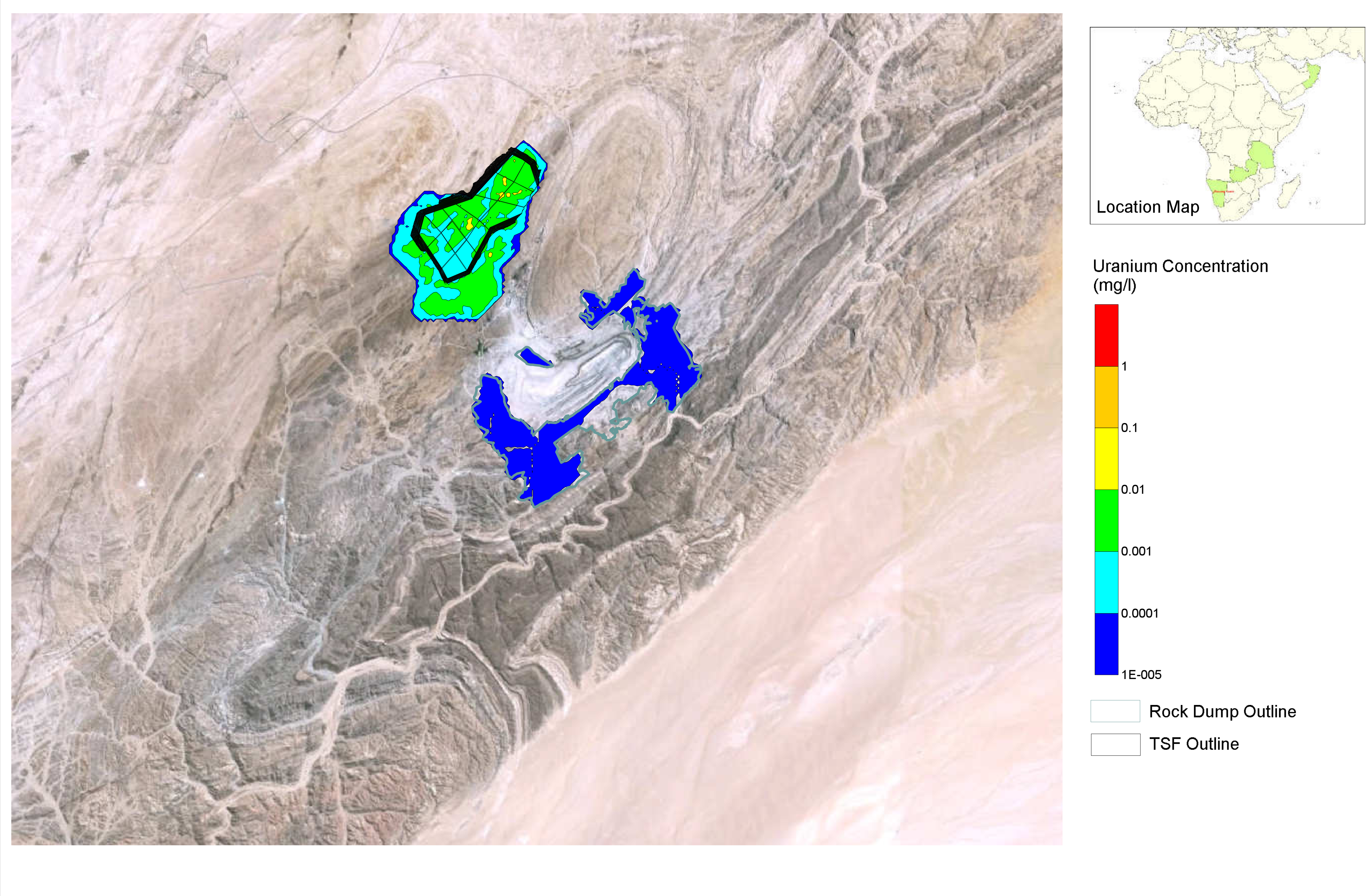
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 100 YEARS (HIGH Kd CASE) FIGURE 4

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 16/Figure 4



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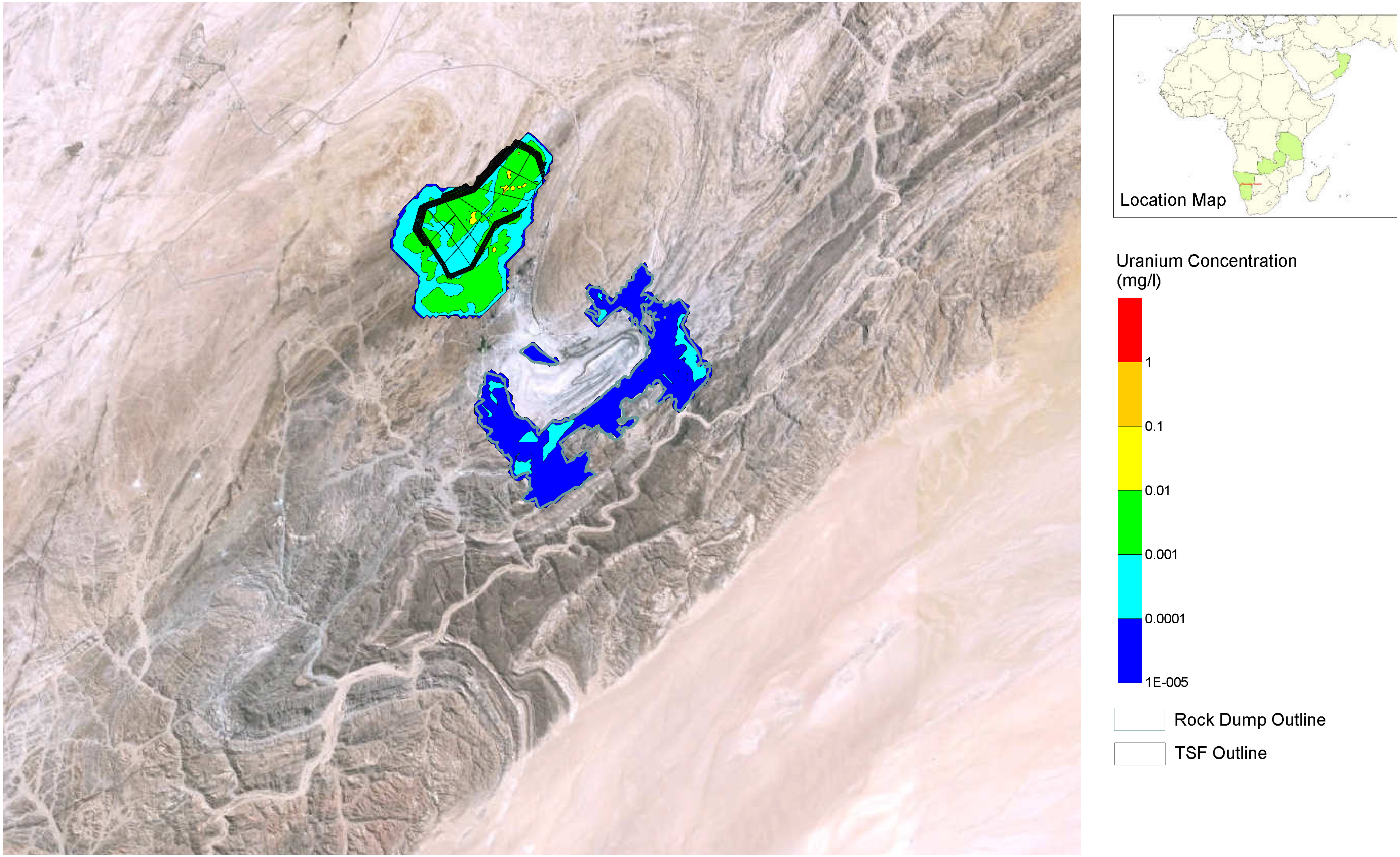
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 500 YEARS (HIGH Kd CASE) FIGURE 5

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 16/Figure 5



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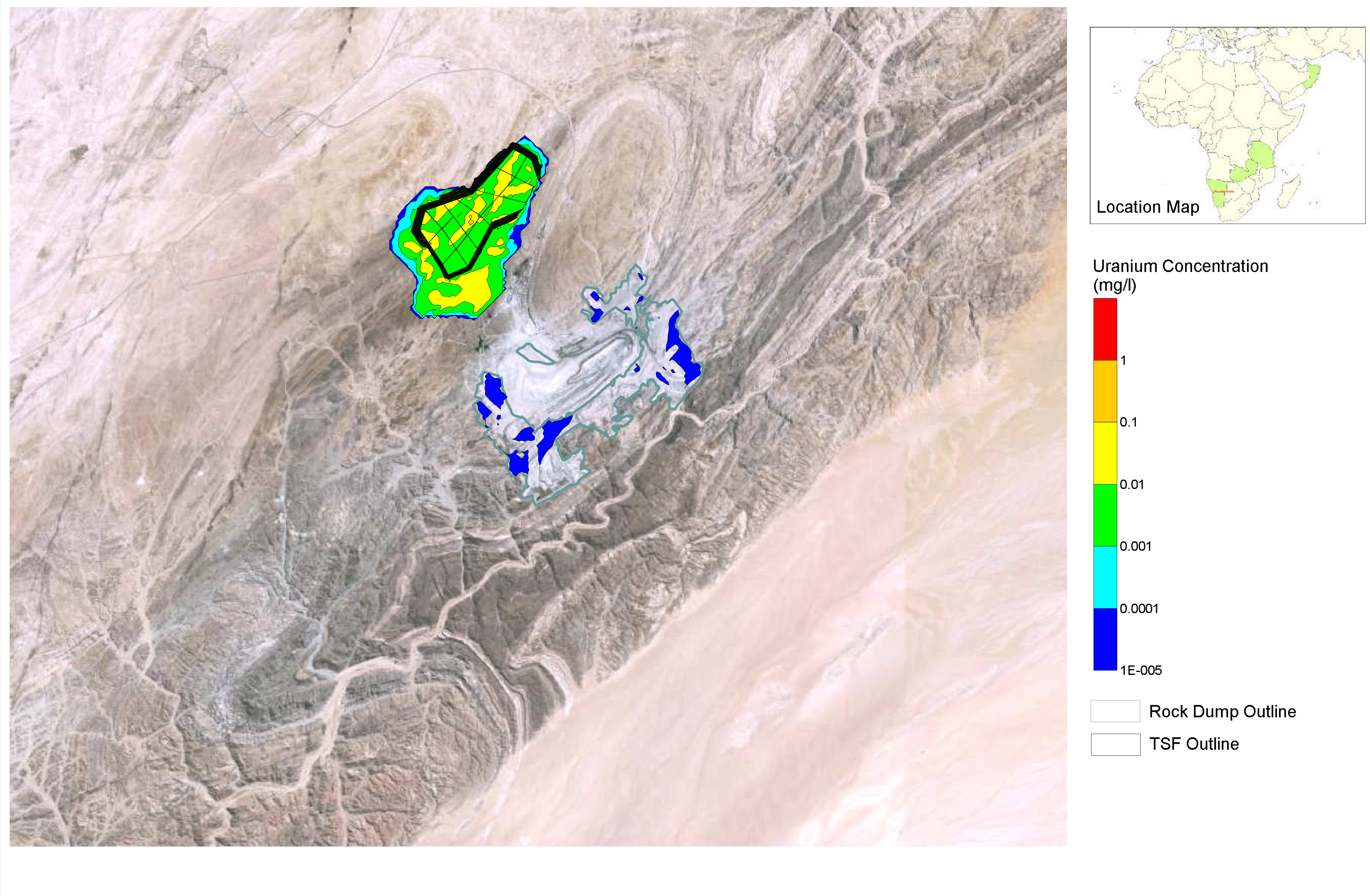
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 1000 YEARS (HIGH Kd CASE) FIGURE 6

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 16/Figure 6



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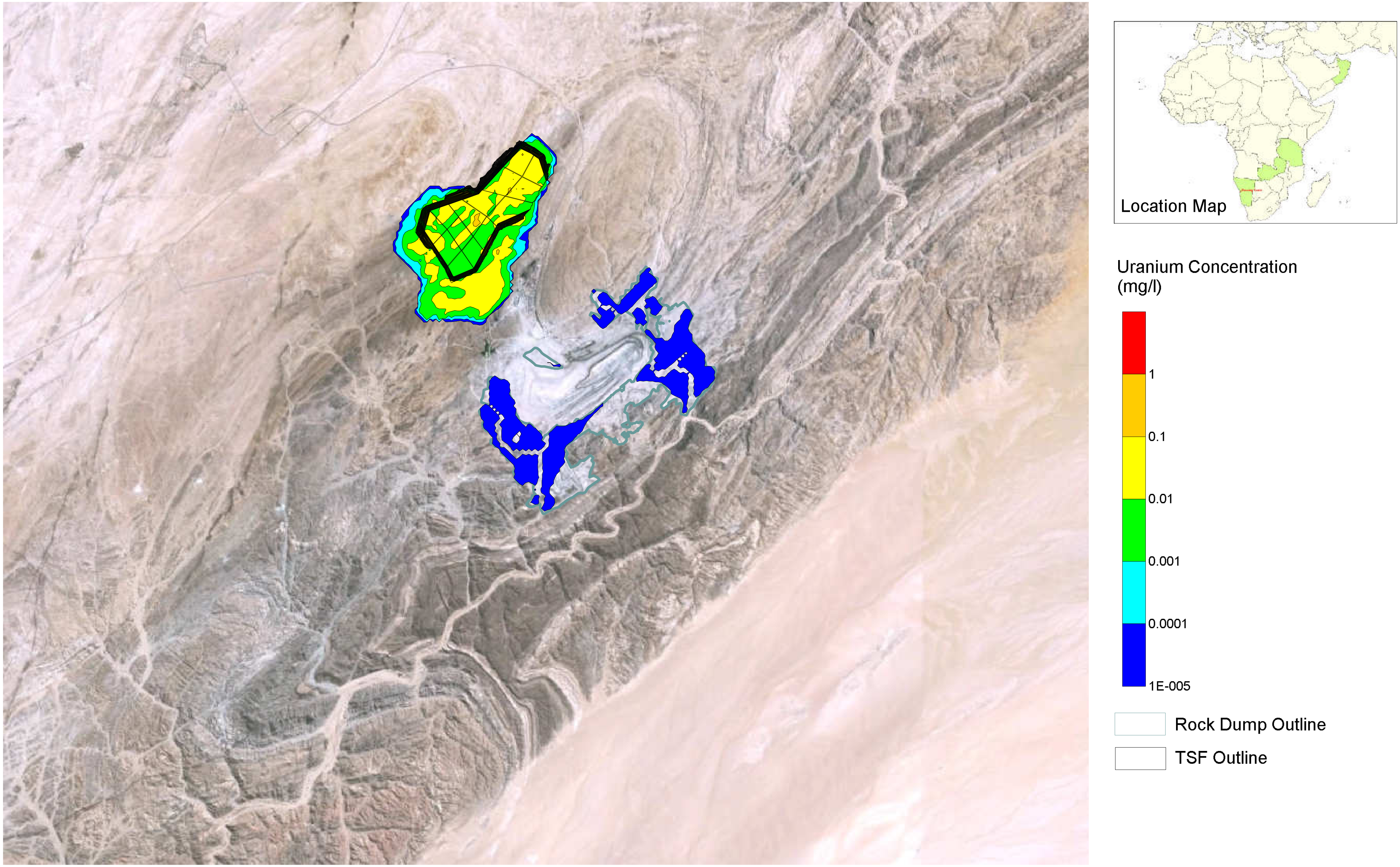
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 10 YEARS (LOW Kd CASE) FIGURE 7

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 17/Figure 7



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BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 20 YEARS (LOW Kd CASE) FIGURE 8

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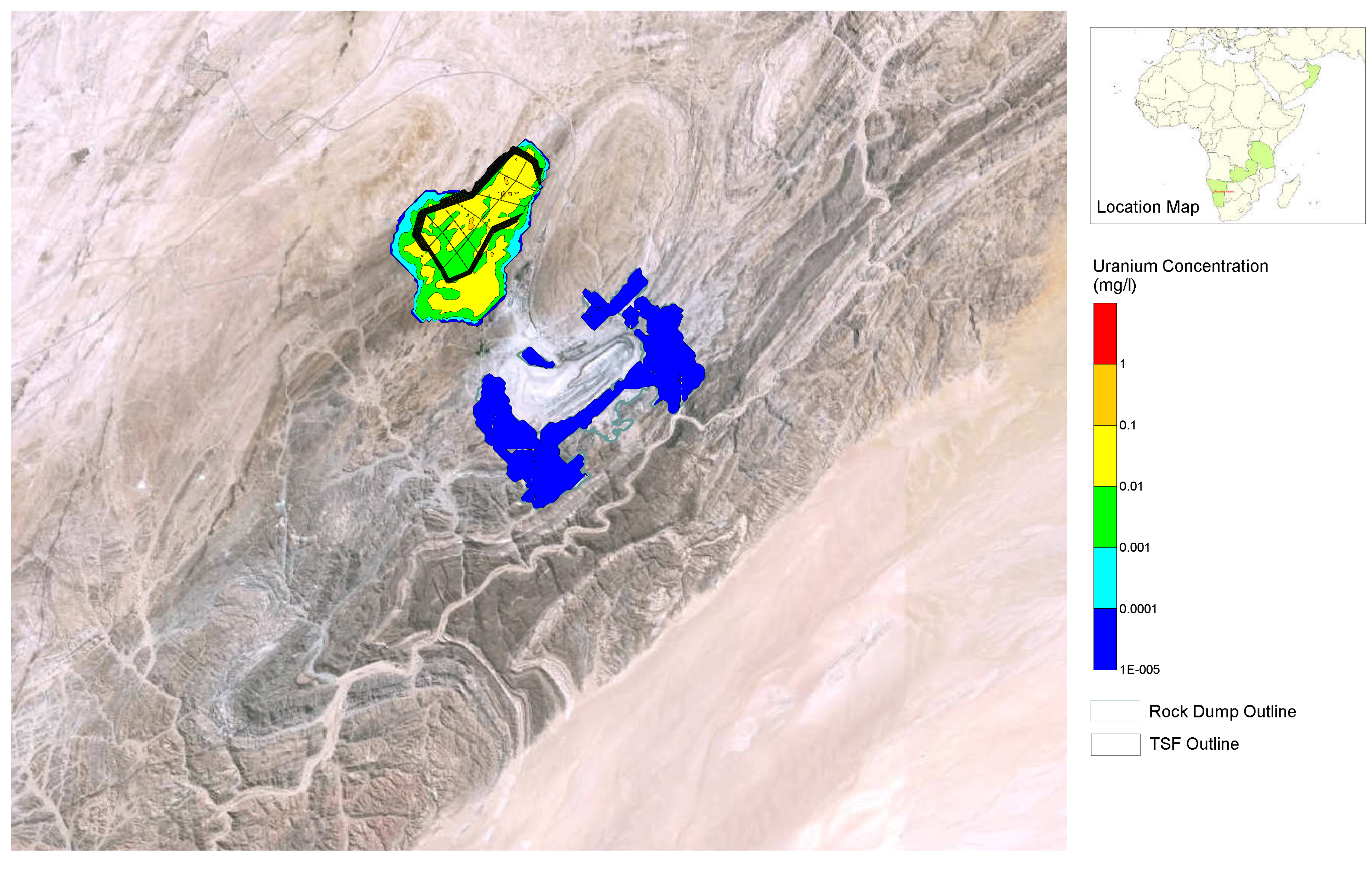

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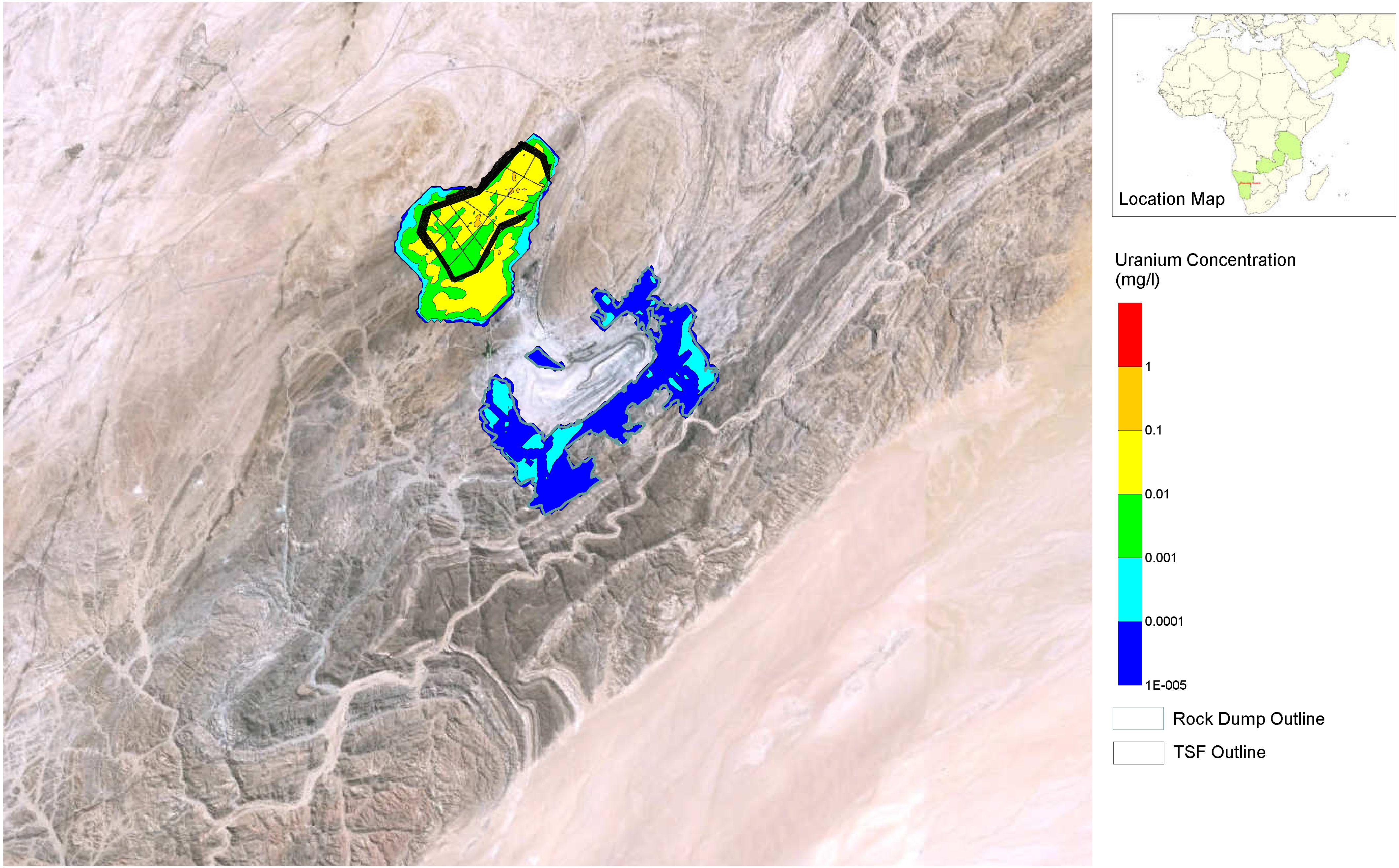
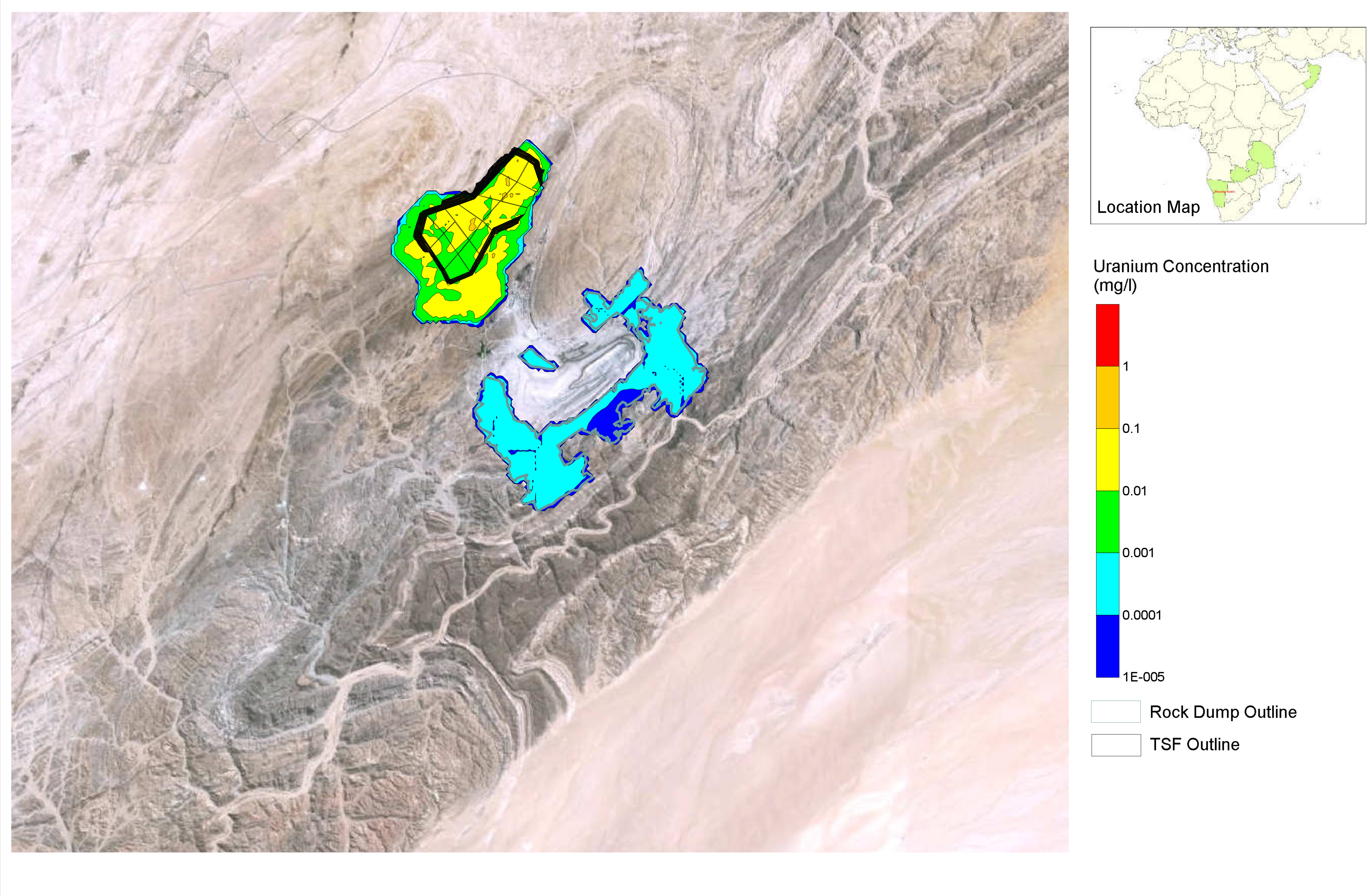
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 50 YEARS (LOW Kd CASE) FIGURE 9

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 17/Figure 9



BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 100 YEARS (LOW Kd CASE) FIGURE 10

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 17/Figure 10



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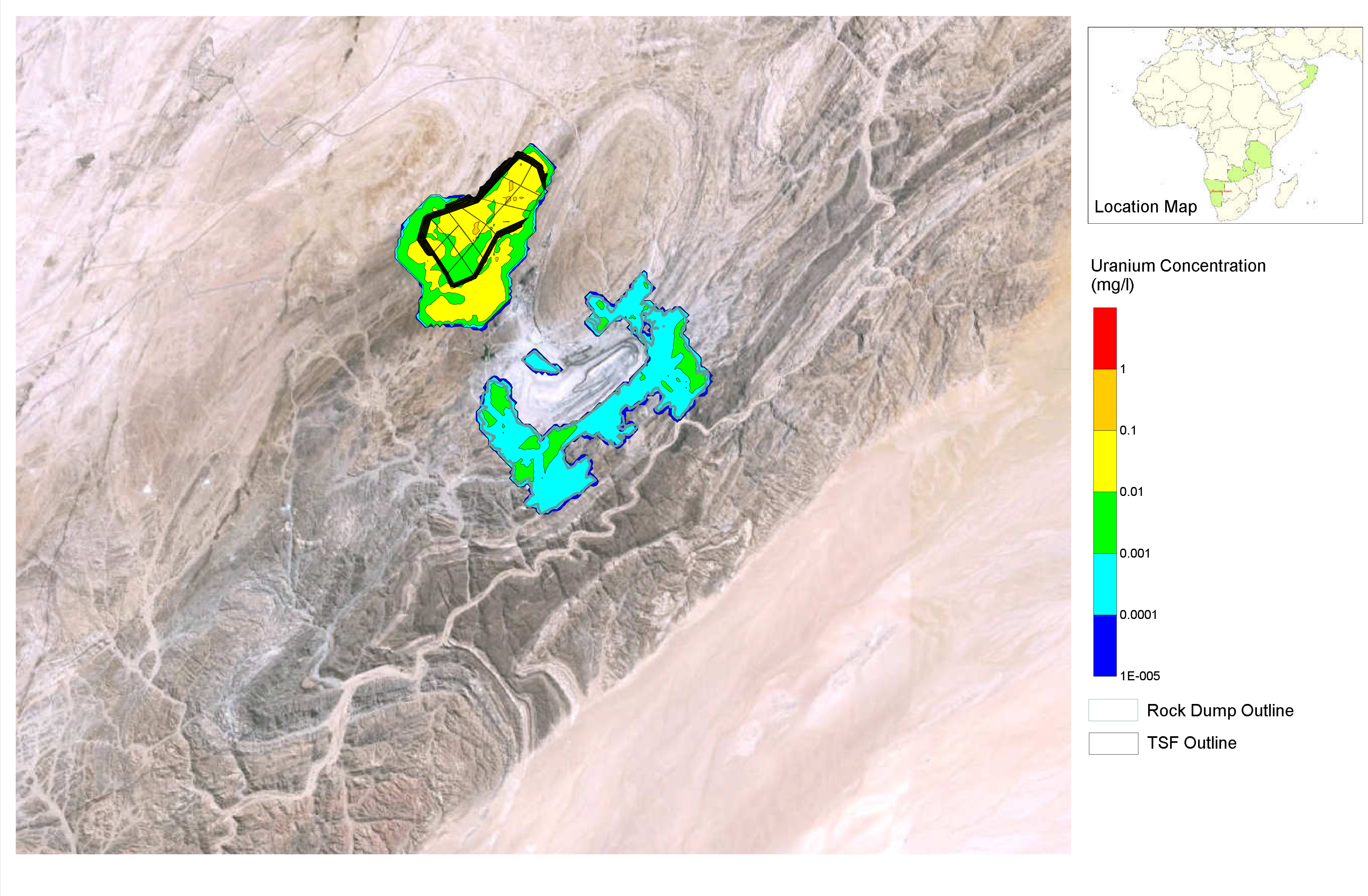
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 500 YEARS (LOW Kd CASE) FIGURE 11

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 17/Figure 11



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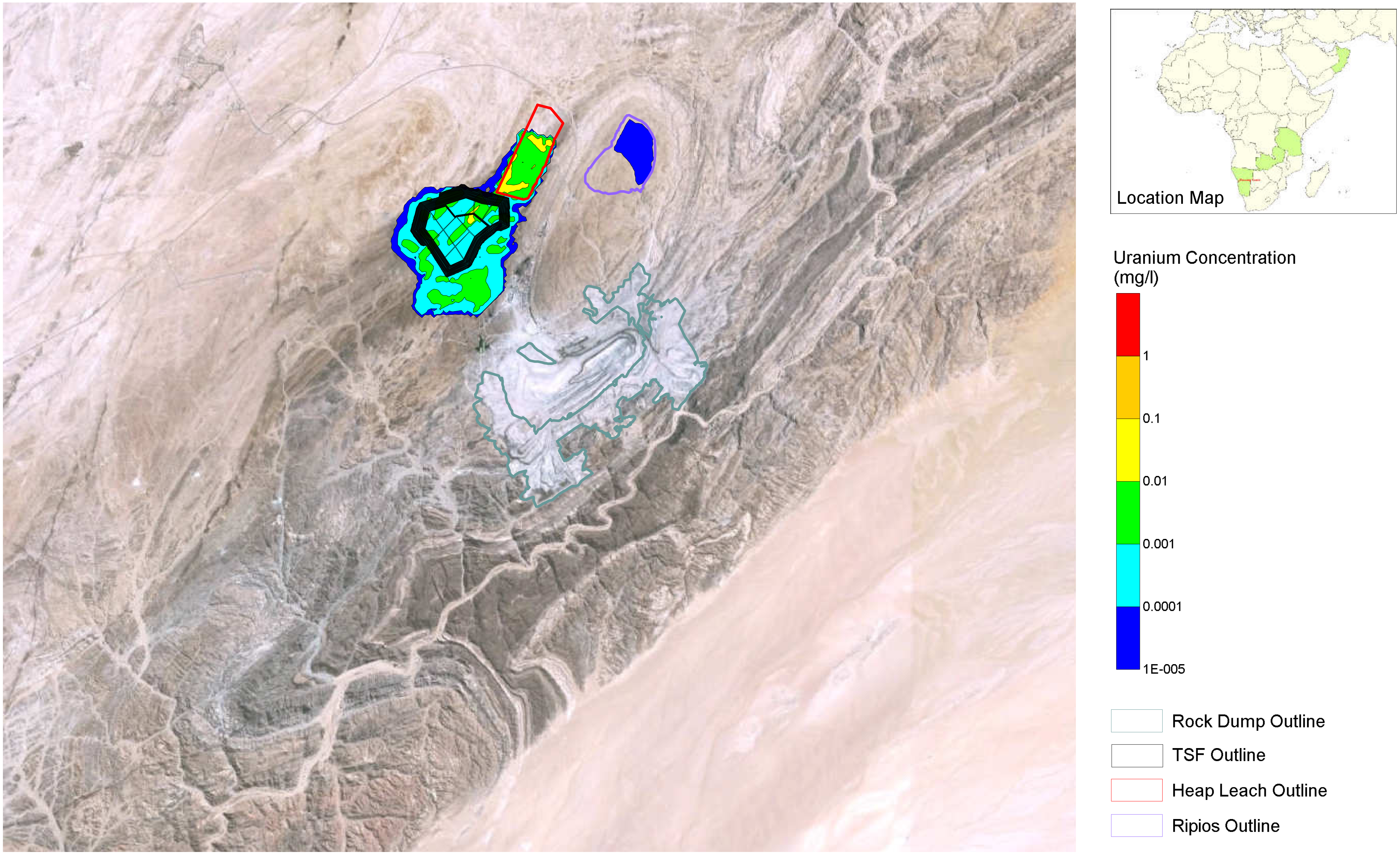
BASE CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 1000 YEARS (LOW Kd CASE) FIGURE 12

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 17/Figure 12



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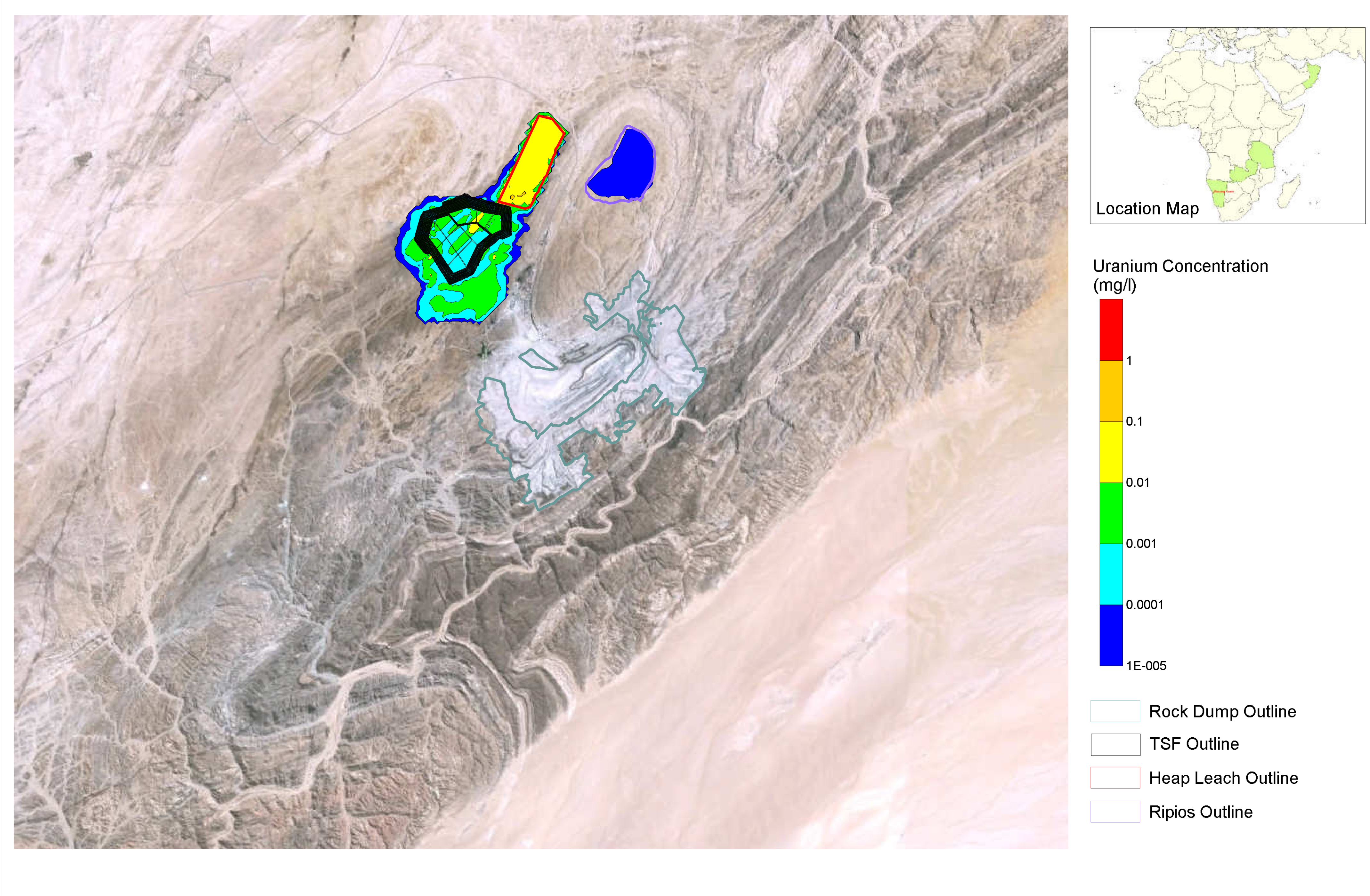
EXPANSION CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 10 YEARS (HIGH Kd CASE) FIGURE 13

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 19/Figure 13



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EXPANSION CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 20 YEARS (HIGH Kd CASE) FIGURE 14

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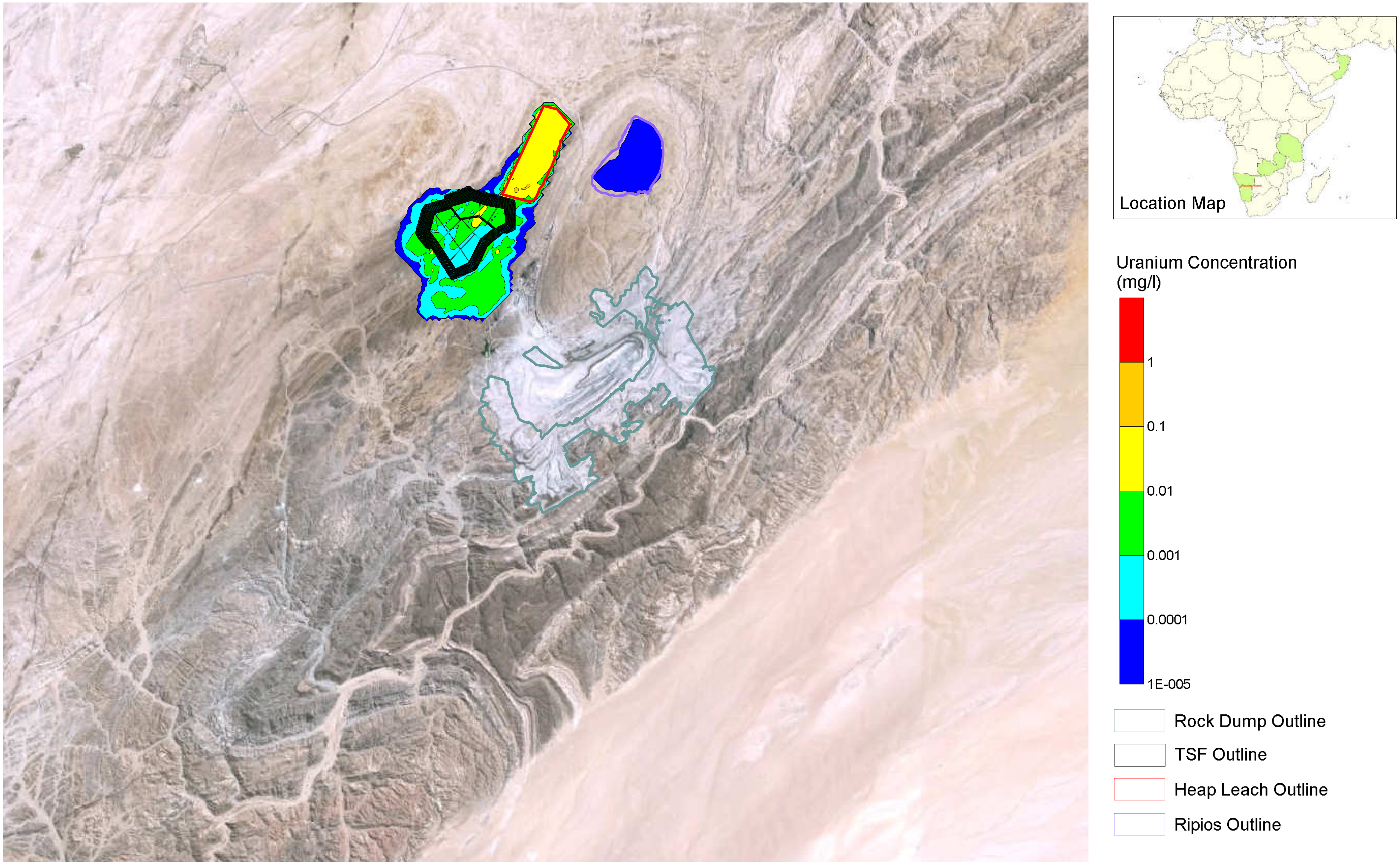

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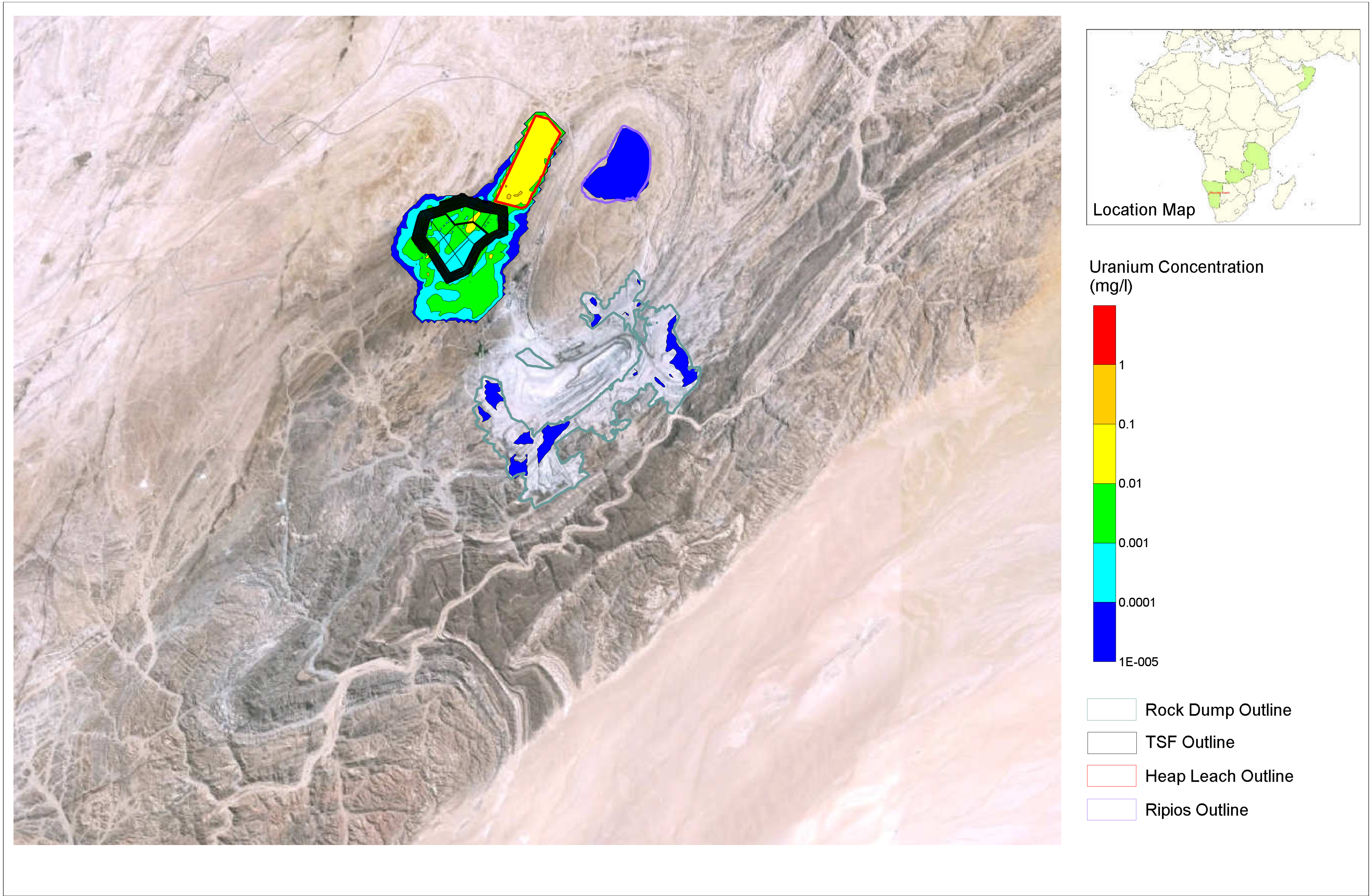
EXPANSION CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 50 YEARS (HIGH Kd CASE) FIGURE 15

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 19/Figure 15



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EXPANSION CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 100 YEARS (HIGH Kd CASE) FIGURE 16

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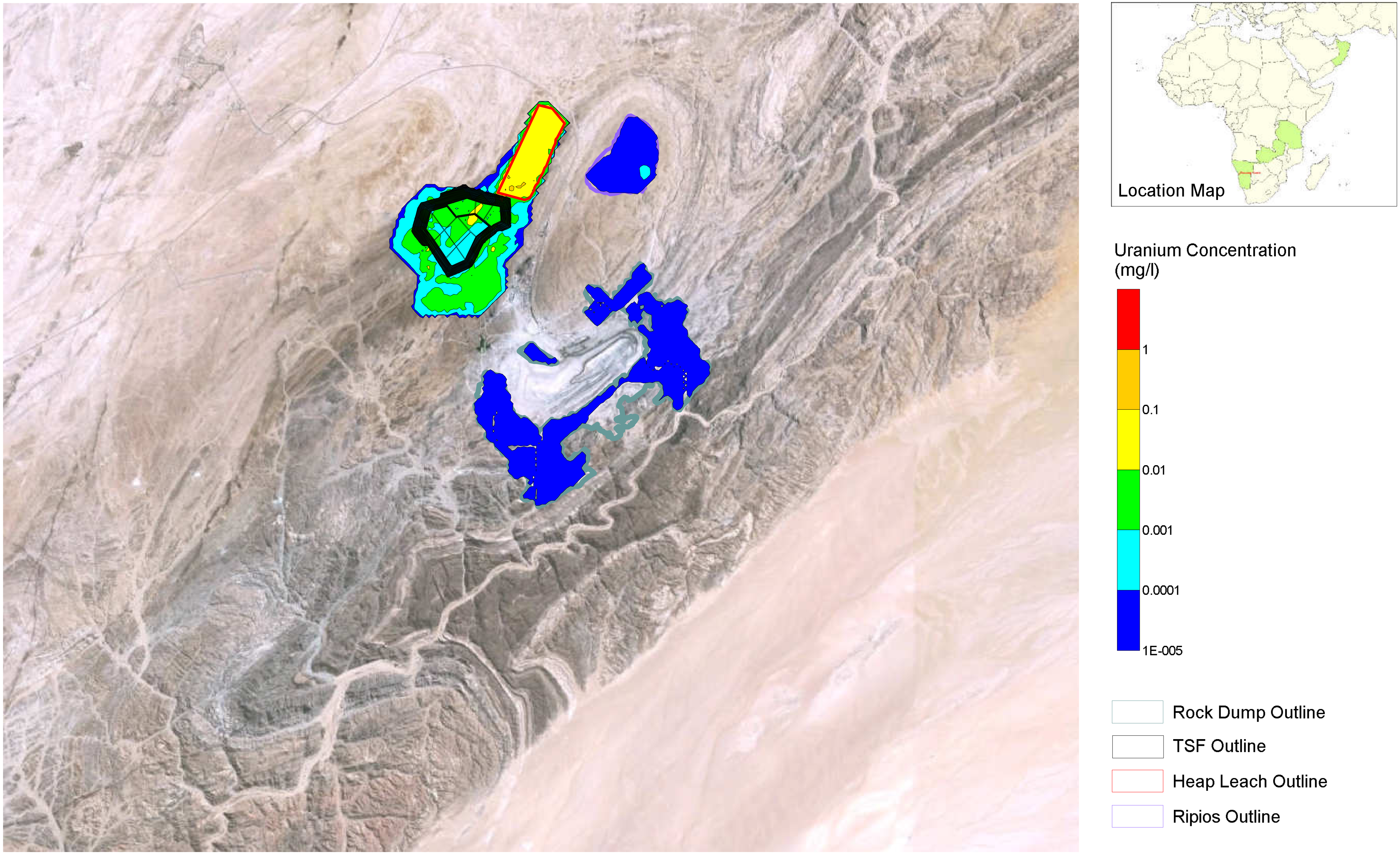

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EXPANSION CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 500 YEARS (HIGH Kd CASE) FIGURE 17

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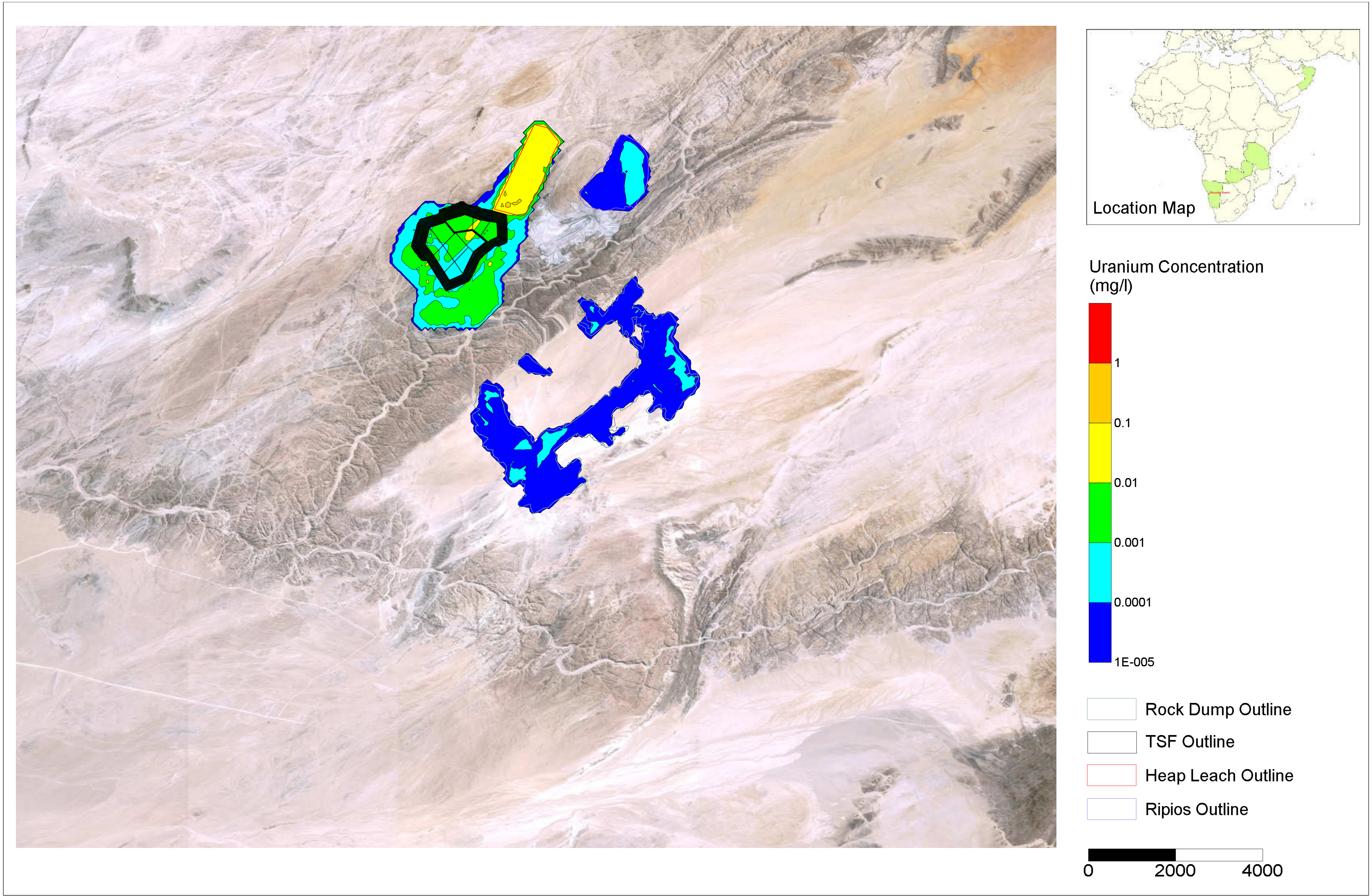

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EXPANSION CASE - PREDICTED URANIUM CONCENTRATION INCREASE AFTER 1000 YEARS (HIGH Kd CASE) FIGURE 18

F:/Jobs/1074C/Modelling/Model Results/Figures/Run 19/Figure 18