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Hydrological Assessment for the Proposed Stooping of Pillars of the Underground Works at Matla Colliery

Report

Version - 1

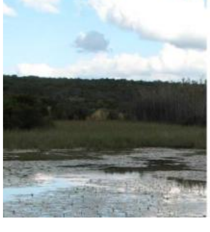
10 December 2015

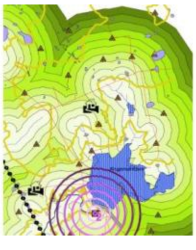
EXXARO- Matla Colliery

GCS Project Number: 13-400

Client Reference: Matla Stooping

POWERING POSSIBILITY

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GLOSSARY OF TERMINOLOGY

Berm: A wall designed and constructed to change the direction of a natural surface water flow path.

Catchment: That area from which any surface runoff will naturally drain to a specified point.

Clean water: Natural runoff water from a catchment area that has not been contaminated through contact with known pollutants.

Dirty water: Water that has been, or could potentially become, contaminated through contact with known pollutants.

Dirty water system: Any systems designed to collect, convey, contain, store or dispose of dirty water.

Drainage channel: An artificial flow path designed to convey water.

Hydrology: The study of natural water cycles that includes rainfall, evaporation and transpiration and resulting surface flows.

Health, Safety, Environmental and Community Manager (HSEC) Manager: Individual typically on mining staff responsible for the development and implementation of HSEC strategy and policy. Responsible for reporting, communicating and consulting with regulators and stakeholders. Manages compliance with legislation and approval requirements.

Pollution Control Dams (PCD): Specialised storage dams designed to prevent environmental pollution by containing and storing dirty water runoff for safe disposal through evaporation or by any other environmentally responsible process.

Raw Water Dam (RWD): Specialised storage dams designed to store water for operational and process purposes.

Runoff: Water that falls as rainfall and is not lost through evaporation, transpiration or deep percolation into the ground. This water either does not penetrate soils but flows directly across the soil surface, or re-emerges from local soils to flow on the surface along natural flow paths or watercourses.

Watercourse: Watercourse refers to a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake or dam into which, or from which water flows and any collection of water which the Minister may by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its beds and banks (National Water Act 1998 (Act 36 of 1998)).

EXECUTIVE SUMMARY

Exxaro Resources Ltd. contracted GCS Water and Environment (Pty) Ltd. (GCS) to undertake a hydrological impact assessment for the proposed stooping activities at their Matla Colliery site. Owing to time limitations on the part of the client, it was agreed that that this document would be provided, in its current, draft form, without a completed water balance, in 2015. A final version of this document will be produced, with a completed water balance section, in 2016.

Matla Colliery is situated 42km Southwest of Witbank and about 24km Southeast of the town of Ogies, located in the Highveld Coalfields in the Mpumalanga Province of South Africa. Exxaro Matla Coal is an existing underground coal mining operation that began in 1973 and consists of four complexes: Mine 1, Mine 2, Mine 3 and E'Tingweni. Matla Coal proposed to totally extract pillars (stoop) at the previously underground mined areas with the intent to reclaim the remaining coal reserves, by using the conventional board and pillar mining methods (drill and blast). The stooping will result in a maximum subsidence of 1.53m.

An Impact Assessment was carried out to determine the potential effect the proposed mining activities will have on the receiving environment. This report discusses the Hydrological Impact Assessment and will form part of an Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP), according to the National Environmental Management Act (NEMA, 1998).

The focus of this Hydrological Impact Assessment is to assess and quantify the significance of the direct and indirect impacts arising from the proposed mining activities and recommend mitigation measures to mitigate against the identified potential hydrological impacts.

Legislative and Policy Frameworks

Legislative requirements applicable to the proposed project are The South African National Water Act (36 of 1998) (South Africa, 1998), The National Water Resources Strategy, Catchment Management Strategies and Regulations on the Use of Water for Mining and Related Activities (General Notice 704 (GN704) and Regulation 77 of the National Water Act (Act 36 of 1988)).

Water Quality Analysis

Focus of the water quality analysis was placed on pH, sulphates (SO_4) and metals (manganese (Mn) and iron (Fe)) as these constituents are commonly associated with Acid Mine Drainage (AMD) and pollution at coal mines. The following baseline water quality chemistry trends were observed:

- All monitoring points exhibit neutral pH conditions. There has been no historic indications of AMD occurring at any of these monitoring points.
- On average the Mn and Fe concentrations for the selected points have remained fairly low and below the SANS 241-1 2011 maximum aesthetical limits. These could have been due to laboratory or sampling errors.
- All monitoring points have historically shown seasonal fluctuations in Electrical Conductivity (EC) (a reflection of the Total Dissolved Solids (TDS)) and SO_4 concentrations. Monitoring point 2 Mine U/S has historically shown the most elevated SO_4 concentrations. Monitoring point 2 Mine D/S, however, has shown lower concentrations which suggests that dilution is taking place between these points or from other water inflow near 2 Mine D/S.
- The EC for monitoring point 3 Mine settling pond and 2 mine U/S have historically been elevated. The latest data available (June 2014) indicated that the surface water was saline and above the SANS 241-1:2011 drinking water limits. The elevated EC readings could have been due to sampling of stagnated water.

Monitoring Plan

The surface water quality monitoring programme recommended within this study is designed to provide information and feedback to determine the success of the proposed management and mitigation programmes. The water quality monitoring is recommended to occur on a monthly basis. Regular reviews of the management plans should be undertaken to establish whether they are functioning as intended, to avoid unnecessary impacts to the environment, provide a safe work place, and work to maintain the quality of the surface water.

Flood Lines

The flood levels for the 1:50-year and 1:100-year flood peaks were determined and plotted, as were the local stream 100m buffers and the site Exclusion Zone. The results indicate that the proposed stooping does not encroach on the non-perennial streams within the study area.

Storm Water Management Plan (SWMP)

The Matla Stooping Project (Phase 1) will have no surface related activities as the mining will be underground. There will be no dirty water generating areas as a result of this. The impacts to the surface will be in the form of subsidence of approximately 1.53m, therefore the site-wide framework is to allow the subsided areas to be free-draining while at the same time limiting the amount of surface water runoff infiltrating into the underground workings. The clean water runoff being generated from the upslope clean water catchments will be diverted away from the subsided areas via perimeter berms. The water runoff generated from the subsided areas will be diverted to flow out of these areas via channels. The SWMP will be comprised of approximately 26 kilometres of diversion channels.

Water Balance and Salt Balance

Owing to time limitations on the part of the client, it was agreed that that this document would be provided, in its current, draft form, without a completed water balance, in 2015. A final version of this document will be produced, with a completed water balance section, in 2016. To date the hydrological inputs to the water balance have been calculated, the subsidence catchment areas have also been delineated. The outstanding information is the groundwater inputs to the water balance.

Risk Assessment

It appears that that no current regional water conservation or management plans will impact directly on the proposed mining development.

Potential impacts on the Matla Stooping Project (Phase 1) that are expected to arise from the mining activities include mostly catchment area reduction and erosion. Proposed mitigation measures thus include the use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction and silt ponds where appropriate

CONTENTS PAGE

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Exxaro Resources Ltd. contracted GCS Water and Environment (Pty) Ltd. (GCS) to undertake a hydrological impact assessment for the proposed stooping activities at their Matla Colliery site. Owing to time limitations on the part of the client, it was agreed that that this document would be provided, in its current, draft form, without a completed water balance, in 2015. A final version of this document will be produced, with a completed water balance section, in 2016.

Matla Colliery is situated 42km Southwest of Witbank and about 24km Southeast of the town of Ogies, located in the Highveld Coalfields in the Mpumalanga Province of South Africa, as shown in Figure 1.1. Exxaro Matla Coal is an existing underground coal mining operation that began in 1973 and consists of four complexes: Mine 1, Mine 2, Mine 3 and E'Tingweni. Matla Coal proposed to totally extract pillars (stoop) at the previously underground mined areas with the intent to reclaim the remaining coal reserves, by using the conventional board and pillar mining methods (drill and blast). The stooping will result in a maximum subsidence of 1.53m. The project will be phased with Matla Stooping Project (Phase 1) to be undertaken on the following Eskom- and Exxaro-owned properties, as shown in Figure 1.2.

- Kortlaagte 67 IS (10/67 and 1/67);
- Grootpan 86 IS (30/86, 29/86, 23/86, 10/86);
- Vierfontein 61 IS (22/61 and 27/61);
- Rietvlei 62 IS (14/62).

An Impact Assessment was carried out to determine the potential effect the proposed mining activities will have on the receiving environment. This report discusses the Hydrological Impact Assessment and will form part of an Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP), according to the National Environmental Management Act (NEMA, 1998).

The focus of this Hydrological Impact Assessment is to assess and quantify the significance of the direct and indirect impacts arising from the proposed mining activities and recommend mitigation measures to mitigate against the identified potential hydrological impacts.

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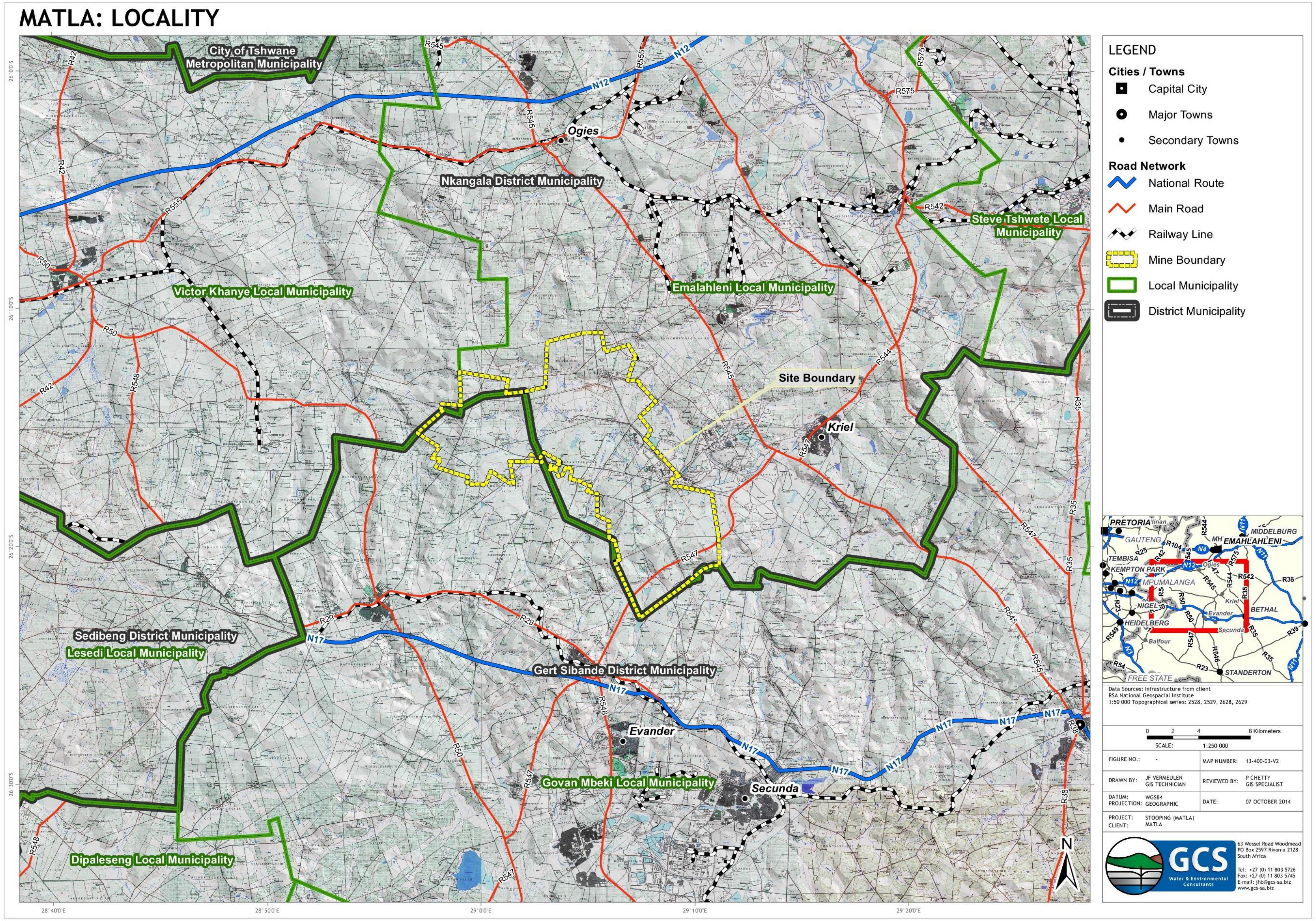


Figure 1.1 The locality of Matla Mine

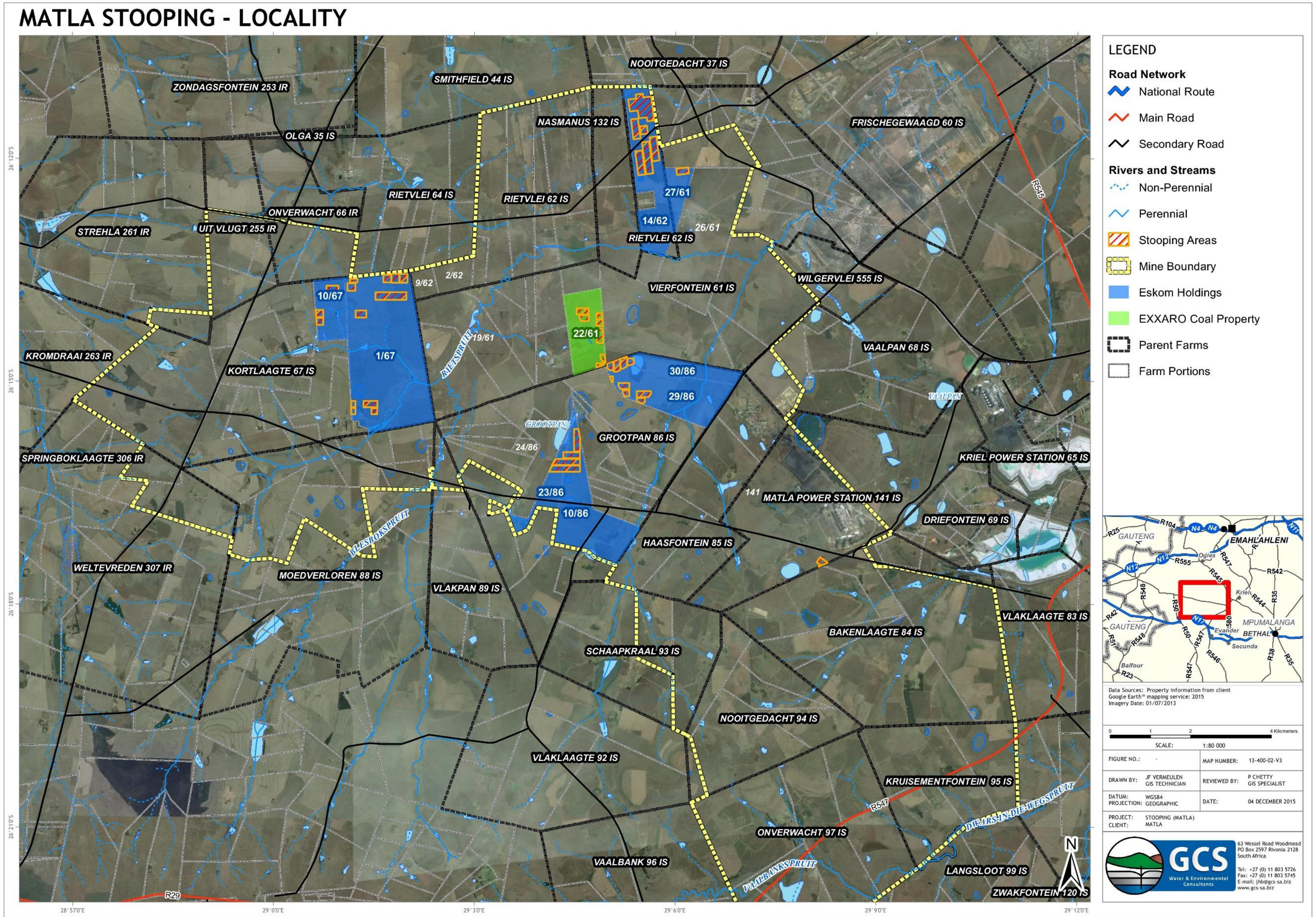


Figure 1.2 The locality of the proposed Matla Stooping Project (Phase 1)

2 SCOPE OF WORK

The scope of work undertaken is outlined as follows:

- Hydrology:
  - A climate and rainfall evaluation was undertaken;
  - Catchment delineation was carried out for the study area;
  - Mean Annual Runoff (MAR) and peak flow analyses were carried out for use in the flood line analysis, and
  - The climate and rainfall data were used as inputs into the SWMP and Water Balance.
- Legislation:
  - The relevant legislation and policy frameworks were reviewed and considered in the compilation of the Hydrological Assessment. These included the following:
    - The South African National Water Act (36 of 1998) (South Africa, 1998); and specifically
    - GN 704 and Regulation 77 of the National Water Act (Act 36 of 1998).
- Water Quality:
  - The existing Matla Mine water quality data were obtained and analysed. These results will form part of the baseline water quality description. Focus of the analysis was placed on pH, SO_4 and metals (Mn and Fe) as these constituents are commonly associated with AMD and pollution at coal mines.
- Sampling and Monitoring Programme:
  - A monitoring plan including locations of monitoring points, a recommended chemical sampling suite and sampling frequencies was developed specifically for the site. The monitoring programme will assist with the overall water management at the site, including but not limited to:
    - Preventing pollution and thereby protecting the receiving water environment;
    - Developing an understanding of the current water quality on site and monitoring how it changes over time, and

        - Assessing performance of pollution prevention measures, i.e. compliance with any license conditions that may be imposed in the future.

- Flood Lines:
    - 1:50-year and 1:100-year flood line calculations were undertaken using HEC-GeoRas and HEC-RAS software. The 100m river buffers were delineated along with the 1 in 50- and 1 in 100-year flood line extents as Regulation 4(b) of GN704 reads; 'No person in control of a mine or activity may - except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50-year flood-line or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest'. The area within this designation is termed the Exclusion Zone.
- Storm Water Management Plan:
    - Delineation of clean and dirty catchments was undertaken based on land usage and topography;
    - The storm water flows and volumes (1:50-year event) were determined;
    - The placement of berms and channels was determined so as to allow surface water runoff to flow freely into the adjacent watercourses minimizing the possibility of flooding or pooling in the subsided areas;
    - The conceptual designs were presented visually for the proposed surface water infrastructure.
- Water Balance:
    - Hydrological inputs to the water balance have been calculated,
    - The relevant subsidence catchment areas have also been calculated and will form part of the water balance;
    - A Visio-based water process flow diagram will be generated, and
    - A Goldsim-based water balance will developed to assess the impacts of the proposed mining activities. Three spreadsheet-based water balances in Department of Water and Sanitation (DWS) format will be calculated using the simulated Goldsim (modelling software) volumes; an average annual balance, an average dry month and an average wet month water balance.
- Risk Assessment:

  - Potential, relevant surface water impacts were assessed and proposed mitigation measures were recommended.
- Reporting:
  - A project close-out report detailing the assumptions made and the results of all of the activities listed above was written, and
  - Recommendations were made for additional work and data requirements.

3 METHODOLOGY

A holistic approach was followed, thus local hydrological studies were linked to regional and national concerns, regulations and management strategies. This involved working primarily at the scale of the development site, but also looking at the hydrology at a catchment scale and at a Water Management Area scale. This ensured that the outcomes of the report complied with the legislation that governs the area.

GN704 of the South African National Water Act (NWA) (Act 36 of 1998) (South Africa, 1998) stipulates the requirement in respect of use of water for mining and related activities aimed at the protection of water resources. The proposed project involves coal mining related activities resulting in GN704 being the most applicable legislation. The flood line investigation, risk assessment and SWMP were conducted in accordance with GN704. No detailed designs of storm water management infrastructure were undertaken, but the concept provided in this report will facilitate later detailed designs undertaken by civil engineers.

3.1 Hydrology

A holistic approach was followed, thus local hydrological studies were linked to regional and national concerns, regulations and management strategies. This involved working primarily at the scale of the development site, but also looking at the hydrology at a catchment scale and at a Water Management Area (WMA) scale, as highlighted in Section 4. This ensured that the outcomes of the studies complied with the legislation that governs the area.

Climate data were obtained from the South African Weather Service (SAWS). The daily rainfall record was statistically analysed to determine the Mean Annual Precipitation (MAP), average wettest month and average driest month. Surface water runoff was calculated for the delineated catchments of the proposed site, based on the WR2012 (WRC, 2015).

Three methods were used to determine the 1:50-year and 1:100-year flood peaks for the 22 delineated catchments as they along with GN704 define the extents to which infrastructure can be placed relative to streams. These methods are the Rational Method Alternative 3 (RM3), Standard Design Flood (SDF) Method and the Midgley & Pitman (MIPI) Method. The Design Rainfall Estimation Software (SANRAL, 2013) were utilised in the RM3 to calculate peak flows for the site. The rainfall depths with durations corresponding to the Time of Concentration (ToC) for each catchment were used to calculate peak flows for the particular catchments. The design rainfall depths were taken from Section 5.2.2. The underlying assumption is that the largest possible peak flow is obtained when the storm rainfall event has a duration equal to the time required for the whole catchment to contribute runoff at the outlet. A short description of the above-mentioned methods is given below:

Rational Method

The rational method was developed in the mid-19th century and is one of the most widely used methods for the calculation of peak flows for small catchments (< 15 km^2). The formula indicates that Q = CIA, where I is the rainfall intensity, A is the upstream runoff area and C is the runoff coefficient. Q is the peak flow.

Standard Design Flood Method

The standard design flood (SDF) method was developed specifically to address the uncertainty in flood prediction under South African conditions (Alexander, 2002). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions or Water Management Areas (WMAs). The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities.

Midgley & Pitman Method

Empirical methods are based on correlation between peak flows and some catchment characteristics. Regional parameters are then mapped out for South Africa. These methods are mostly suitable for medium to large catchments (SANRAL, 2013).The MIPI formula indicates that QT = 0.0377KT*P*A0.6*C0.2 where QT is peak flow for T-year return period, KT is constant for T-year return period, A is the size of catchment and P is the mean annual rainfall.

The hydrology (extracted design rainfall depths) was used as input into the calculations of the flood peaks. The underlying assumption is that the largest possible peak flow is obtained when the storm rainfall event has a duration equal to the time required for the whole catchment to contribute runoff at the outlet.

The daily rainfall record and average monthly evaporation data was used in the water balance calculations.

3.2 Water Quality

The baseline water quality was established by analysing the existing water quality monitoring results (2012 to 2014). As mentioned, focus of the analysis was placed on pH, SO_4 and metals (Mn and Fe) as these constituents are commonly associated with AMD and pollution at coal mines. The data obtained from the client was compared against the following guidelines and standards (based on the land uses present in the study area):

- Department of Water Affairs South African Water Quality Guidelines Volume 1 for Domestic Use (1996); and
- South African Bureau of Standards (SABS) SANS 241-1:2011 Drinking Water Standards (SANS 241: 2011).

3.3 Monitoring Plan

A surface water monitoring programme was recommended for the Matla Stooping Project (Phase 1) in terms of the Best Practice Guidelines G3: Water Monitoring Systems (DWAF, 2006). A desktop evaluation of the streams within the study area was carried out to determine which of the streams would be impacted on by the proposed Matla Stooping Project (Phase 1), based on the existing water quality monitoring already taking place within the extents of the study area. Thereafter, water quality sampling locations were determined. The monitoring plan was developed to include the location of monitoring points, recommended chemical sampling suite and sampling frequencies.

3.4 Flood Lines

Flood lines on river sections are analysed to evaluate risks associated with potential flooding of infrastructure and protection of natural resources. Legislation guides the minimum requirements for placement of infrastructure in relation to a natural watercourse.

GN704 stipulates that no mining infrastructure is allowed to be placed and constructed closer than 100m from a river or from the 1:50-year flood line; whichever of the 2 is farthest from the river in question. The area within this designation is termed the Exclusion Zone. Regulation 4(b) of GN704 reads; ‘No person in control of a mine or activity may - except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50-year flood-line or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest. Figure 3.1 depicts the methodology used for the flood line analysis.

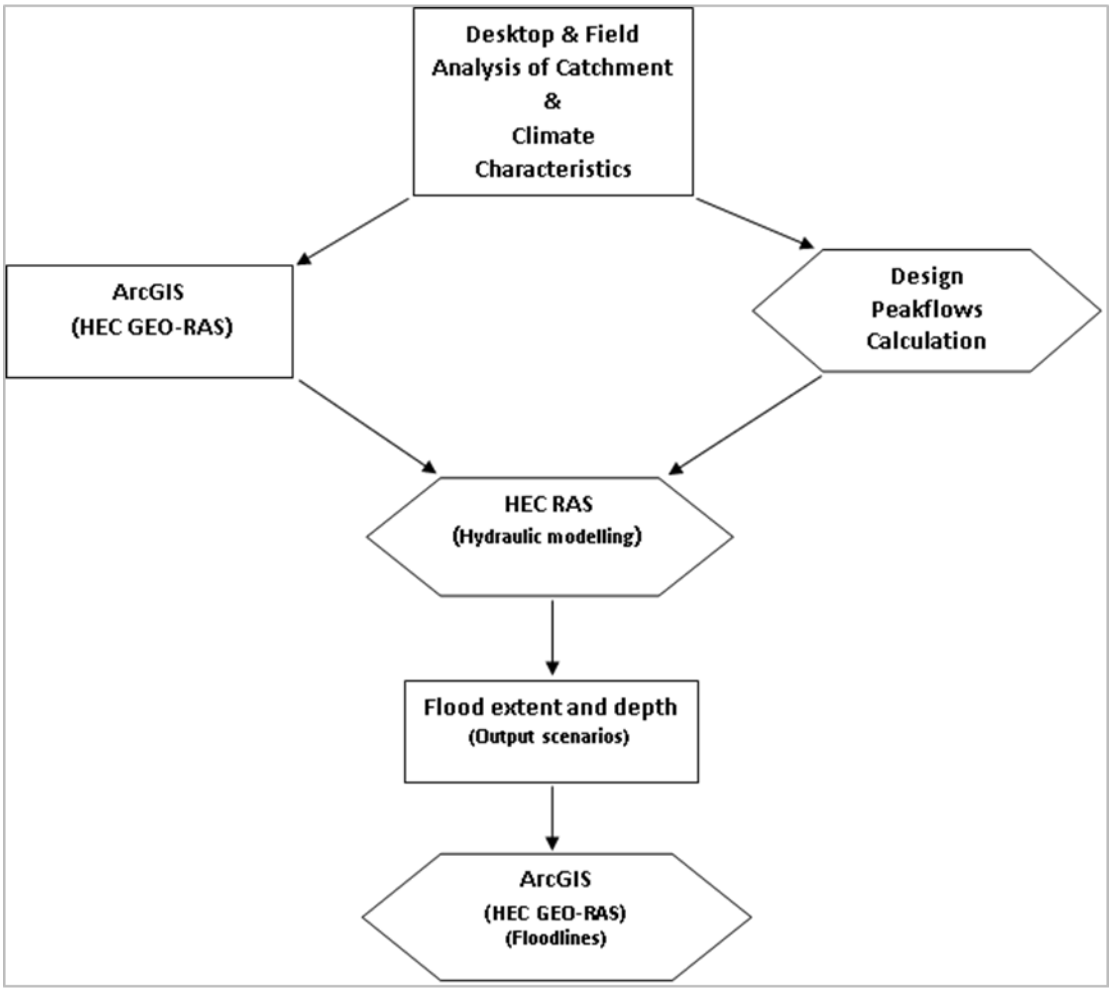


Figure 3.1 Summary of the study methodology

The approach adopted in the study can be summarised as follows:

- A desktop evaluation was carried to assess the site specific hydrological conditions of the streams, which will influence the flood line determination;
- The catchment areas were determined;

- A flood peak analysis was undertaken to determine the different recurrence interval flood peak for the four identified streams;
- The flood peaks and the survey data of the study area were used as inputs to the HEC-RAS backwater program to determine the surface water elevations for the 1: 50- and 1:100-year floods peaks;

The river sections were modelled in HEC-RAS (US Army Corps of Engineers, 1995) by creating cross sections at various intervals along the rivers. These cross sections were created in ArcView 10.1 (ESRI, 2012) and exported into HEC-RAS. The positions of the cross sections were determined by any anticipated changes in flow regime such as river bends. 1m contour data was used to generate cross sections as well as to capture the general topography of the site.

HEC-RAS (US Army Corps of Engineers, 1995) models total energy of water by applying basic principles of mass, continuity and momentum as well as applying Manning's equation for roughness between all cross sections. A height is calculated at each cross section which represents the level to which water will rise at that section, given the potential peak flows. This was calculated for the 1 in 50-year and 1 in 100-year peak flows on all river sections. Analysis was performed by modelling flows at the most downstream position in the river section first, moving upstream.

The flood lines were plotted on the available mapping software, using ARC-GIS for Geographic Information Systems work and mapping.

3.5 Storm Water Management Plan

The Matla Stooping Project (Phase 1) will have no surface-related activities as the mining will be underground. There will be no dirty water generating areas as a result of this. The impacts to the surface will be in the form of subsidence of approximately 1.53m, therefore the site-wide framework is to allow the subsided areas to be free-draining while at the same time limiting the amount of surface water runoff infiltrating into the underground workings. The clean water runoff being generated from the upslope clean water catchments will be diverted away from the subsided areas.

The water runoff generated from the subsided areas will be diverted to flow out of these areas via channels. This Conceptual SWMP methodology was developed in accordance with GN704 of the South African National Water Act (NWA) (Act 36 of 1998) (South Africa, 1998). This guideline was adopted when sizing all storm water infrastructure as these guidelines are relevant to mining activities. Further to this, dirty water channels and storm water infrastructure were sized such that they will only spill once, on average, in a 50-year period.

3.6 Water Balance

Owing to time limitations on the part of the client, it was agreed that that this document would be provided, in its current, draft form, without a completed water balance, in 2015. A final version of this document will be produced, with a completed water balance section, in 2016. To date the hydrological inputs to the water balance have been calculated, the subsidence catchment areas have also been delineated. The outstanding information is the groundwater inputs to the water balance.

As mentioned, the Water the water balance modelling process commenced by utilising the hydrological assessment results (calculated in the hydrology component) to provide hydrological inputs; these include obtaining recent information on meteorology, runoff and catchments.

A Process Flow Diagram (PFD) will be developed. This will highlight all the inputs and outflows from the subsided areas. The PFD will illustrate the connectivity of the system, all hydrological and Geohydrological processes will be included.

The Water Balance was undertaken in accordance with the Department of Water and Sanitation; DWS (previously Department of Water Affairs; DWA) Guidelines; Best Practice Guidelines (BPG) G2: Water and Salt Balances.

3.7 Sensitivity Mapping

Sensitivity mapping was undertaken in order to identify sensitive features relating to surface water within the mining right study area of the Matla Stooping Project (Phase 1). The determined sensitivities were based on findings of the desktop assessment. The sensitive area extents were then plotted using ARC-GIS for Geographic Information Systems work and mapping.

3.8 Risk Assessment

The aim of this section was to identify the potential surface water impacts that are likely to arise as a result of the proposed project. The potential impacts associated with this project have been evaluated using an impact rating system that takes into account a number of assessment criteria, namely: status of impact (positive, neutral or negative impact); magnitude (amount); duration (time scale); scale (special extent); probability (likelihood of occurrence). Assessed criteria were scored and the values totalled. The resulting values were assigned an impact ranking of low, medium and high for each impact. Following this, mitigation measures associated with the identified risks were proposed.

3.9 Software

Software used in the study included the following:

- ArcView10.1 for Geographic Information Systems (GIS) work and mapping;
- The Visio software for creating PFD;
- HEC-RAS hydraulic modelling software for flood line calculations;
- PCSWMM software for sizing SWMP infrastructure;
- Results of WRSM as published in WR2012 (Water Resources of South Africa; WRC Reports TT 380 to 382/08), used for base-line runoff data.

4 LEGISLATIVE AND POLICY FRAMEWORK

This section describes the policy and legal framework within which the hydrology assessment was undertaken.

4.1 The National Water Act

The South African National Water Act (36 of 1998) (South Africa, 1998) is the principal legal instrument relating to water resource management in South Africa. As guardian and trustee of the nation's water resources, the Government (specifically the Department of Water and Sanitation) must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons and in accordance with its constitutional mandate.

4.2 The National Water Resources Strategy

The National Water Resources Strategy sets out policies, strategies, objectives, plans, guidelines, procedures and institutional arrangements for the protection, use, development, conservation, management and control of South Africa's water resources.

4.3 Catchment Management Agencies

Catchment Management Agencies are tasked with coordinating the water demands, interests and responsibilities of all relevant government departments, institutions and water users within a specific Catchment Management Area, to ensure that, on a regional scale, water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons. The main instrument that guides and governs the activities of a Catchment Management Agency is the Catchment Management Strategy which, while conforming to relevant legislation and national strategies, provides detailed arrangements for the protection, use, development, conservation, management and control of the region's water resources. The proposed project falls within the B20E, B11E and B11D quaternary catchments and the Olifants Water Management Area.

4.4 Regulations on the Use of Water for Mining and Related Activities (aimed at the protection of water resources)

GN 704 and Regulation 77 of the National Water Act (Act 36 of 1998) stipulate the requirements in respect of use of water for mining and related activities aimed at the protection of water resources.

5 BASELINE AND RECIEVEING ENVIRONMENT

The following sections describe the baseline and receiving environment:

5.1 Locality and Topography

Matla Colliery is situated 42km Southwest of Witbank and about 24km Southeast of the town of Ogies, located in the Highveld Coalfields in the Mpumalanga Province of South Africa. Exxaro Matla Coal is an existing underground coal mining operation that began in 1973 and consists of four complexes: Mine 1, Mine 2, Mine 3 and E'Tingweni. The project will be phased with Stooping Phase 1 to be undertaken on the Eskom- and Exxaro-owned properties shown in Figure 5.1.

The mine is situated about 1600 m above mean sea level on generally flat terrain (gently undulating), close to the Rietspruit River, in the upper catchment of the Olifants River (see Figure 5.1). Vegetation is generally pure grassveld (simplified Adcocks classification). Soils are generally well drained apedal, red soils, but clay contents increases and soils become gleyed in marshy areas alongside the watercourses.

The proposed Matla Stooping Project (Phase 1) falls within the B20E, B11E and B11D quaternary catchments and the Olifants Catchment Management Area, as shown in the Figure 5.1. The site is located in the Olifants River Basin.

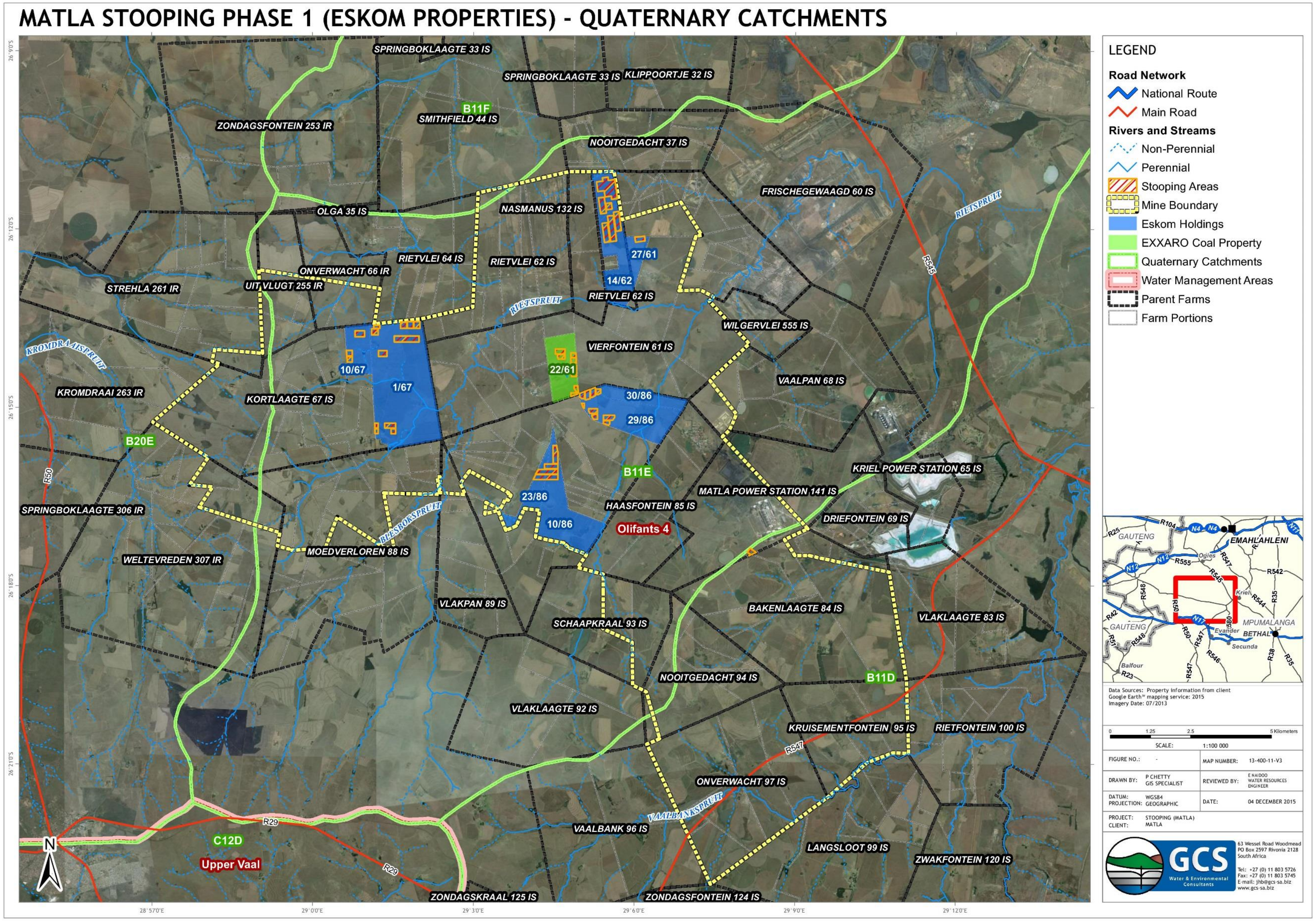


Figure 5.1 Extent of the Matla Phase 1 Stooping areas and the relevant quaternary catchments

5.2 Hydrology

The following sections describe the hydrology:

5.2.1 Climate

The local climate can be described as semi-arid high-veld conditions, with warm summers and moderate, dry winters. Average daily summer temperatures of approximately 27°C are experienced, while peak temperatures of up to 36°C do occur. Average daily winter temperatures are approximately 4°C, with minimum temperatures reaching around -4°C. The number of days when heavy frost occurs is, however, limited and freezing of wet soils, frost heave and permafrost do not occur. Relative humidity ranges from a minimum of 43% to a maximum of 92%, with dry atmospheric conditions dominating.

5.2.2 Rainfall

A long record of rainfall is required to reliably assess statistical characteristics of the local rainfall. The selection of the Strehla Station (0477762_W) is based on the fact that this is the closest station to the study area with a reliable record. The daily rainfall record covers the period from January 1921 to August 2000 (approximately 80 years). The Mean Annual Precipitation (MAP) in the vicinity of the site was calculated to be 655 mm, based on the Strehla Station dataset; the average monthly rainfall depths are shown in Figure 5.2. About 86% of the annual rainfall falls in summer (October to March), in the form of thundershowers, with the maximum amount of precipitation falling in January. Figure 5.3 shows the calculated storm duration (days of consecutive rainfall) and their statistical frequencies. This indicates that the rainfall events are short with most rainfall events occurring in one day. Figure 5.4 shows the storm distributions (days between rainfall events) and their statistical frequencies. This is relevant because it gives an indication of the typical rainfall events that have historically occurred taking into account their frequency, which helps to inform the runoff coefficient used within the water balance calculations.

The rainfall depths used within this study were extracted from the closest weather station to the study site, obtained from the Design Rainfall Estimation Programme (details given in Table 5.1) (Smithers, 2002).

Table 5.1 Details for Strehla Rainfall Station (0477762_W)

Name of rainfall station	Rainfall station number	Distance from the site (km)	Latitude (°)(‘)	Longitude (°)(‘)	Record (Years)	MAP(mm)
Strehla	0477762_W	6.912	26° 14’	28° 56’	80	655

The 24-hour storm rainfall depths for the 2-year, 10-year, 20-year, 50-year and 100-year recurrence interval events, at the SAWS Station 0478546_W (Strehla) was abstracted from the database. The depths are presented in Table 5.2.

Table 5.2 24 Hour Storm Rainfall Depths (mm)

Recurrence Interval (Years)	1 in 2	1 in 10	1 in 20	1 in 50	1 in 100
24 hour Rainfall depth (mm)	60.4	95.8	110.9	131.7	148.5

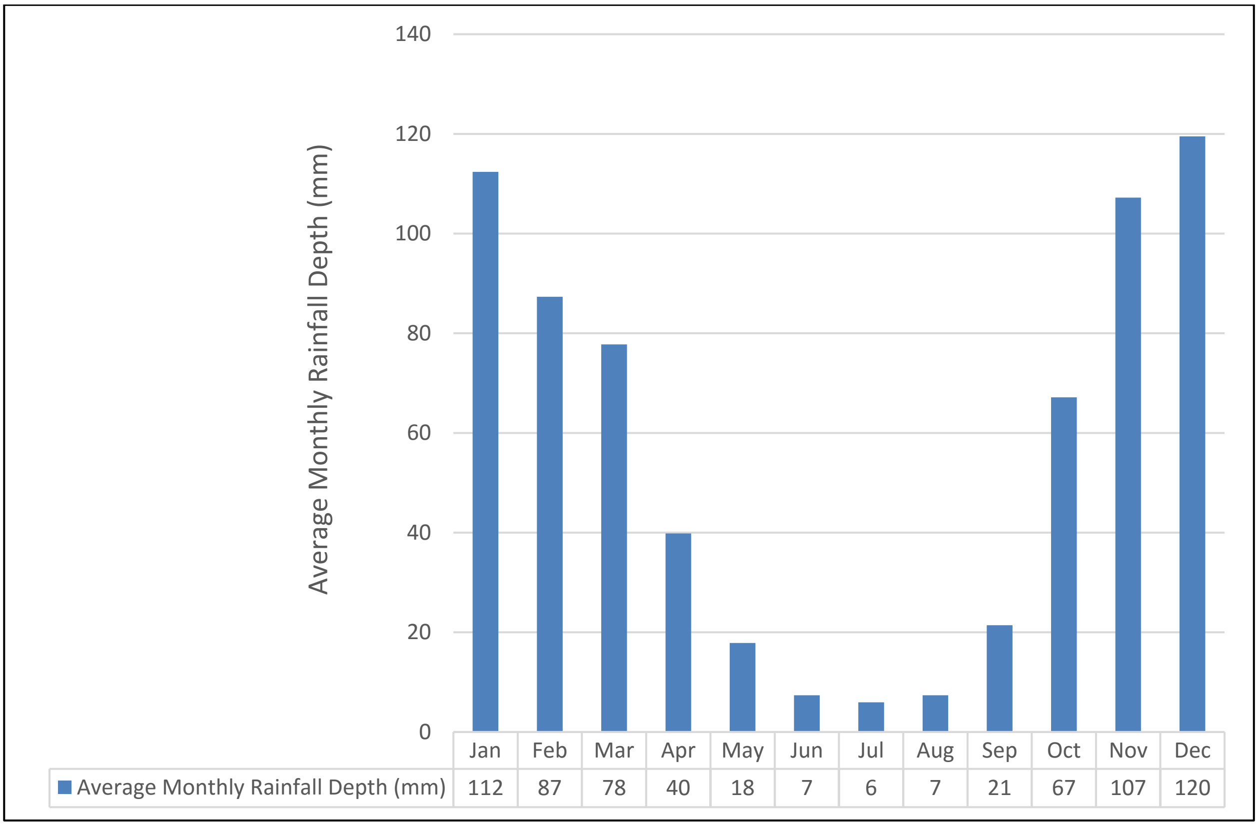


Figure 5.2 Calculated monthly average rainfall for Strehla Station (0477762_W)

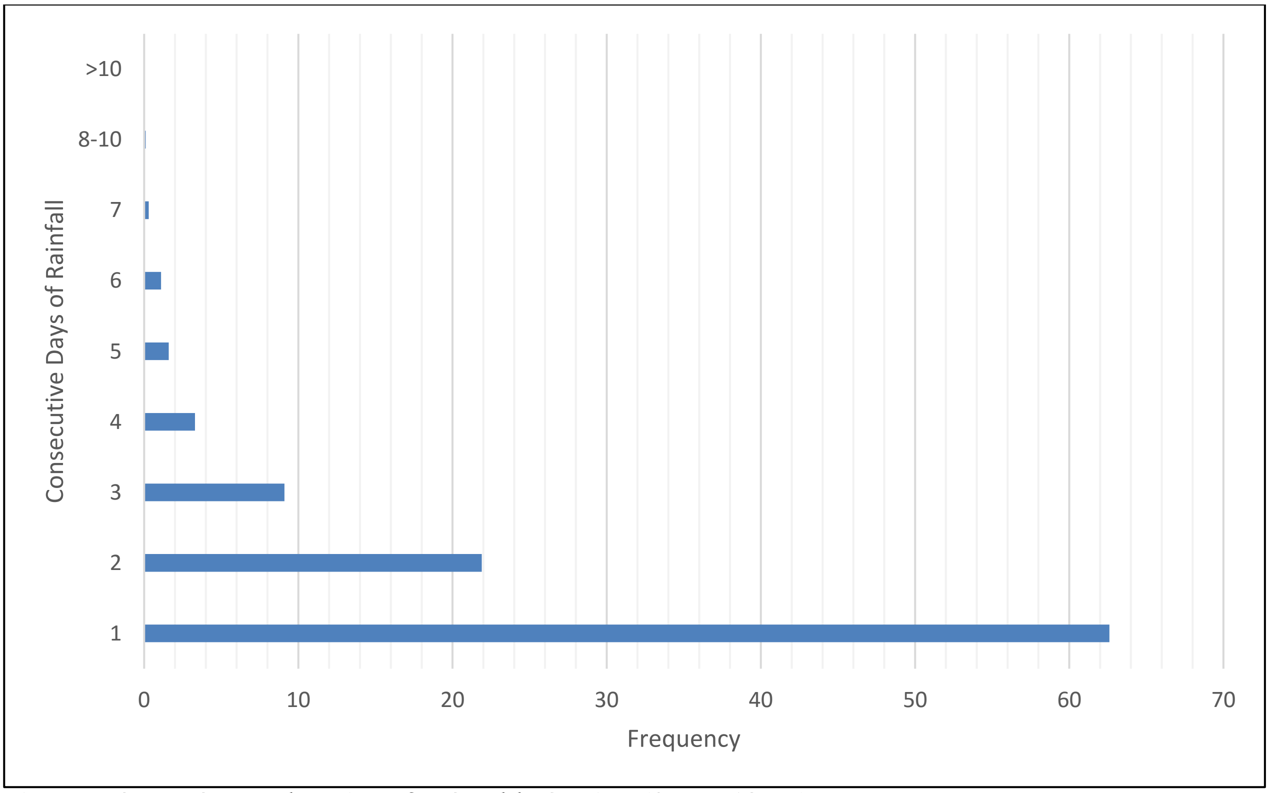


Figure 5.3 **Storm durations for Strehla Station (0477762_W)**

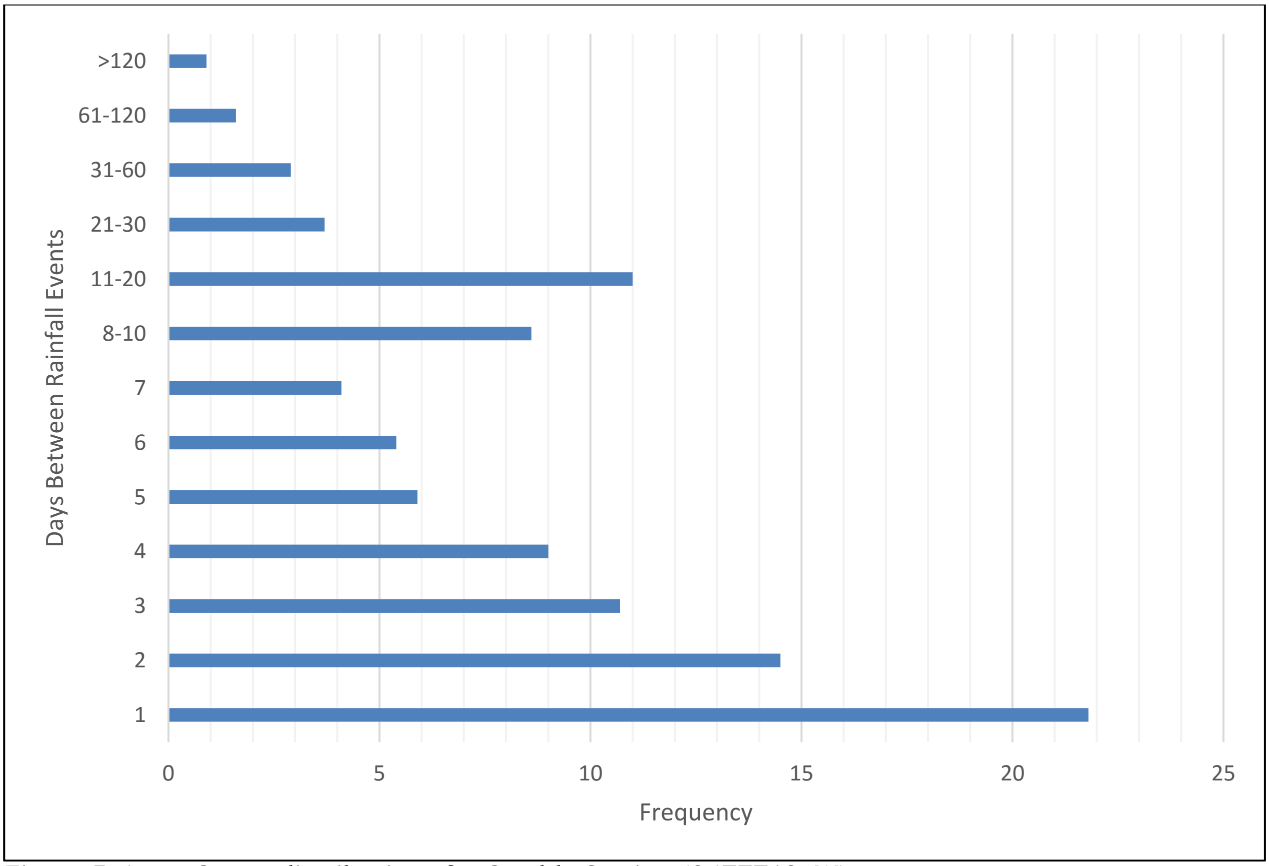
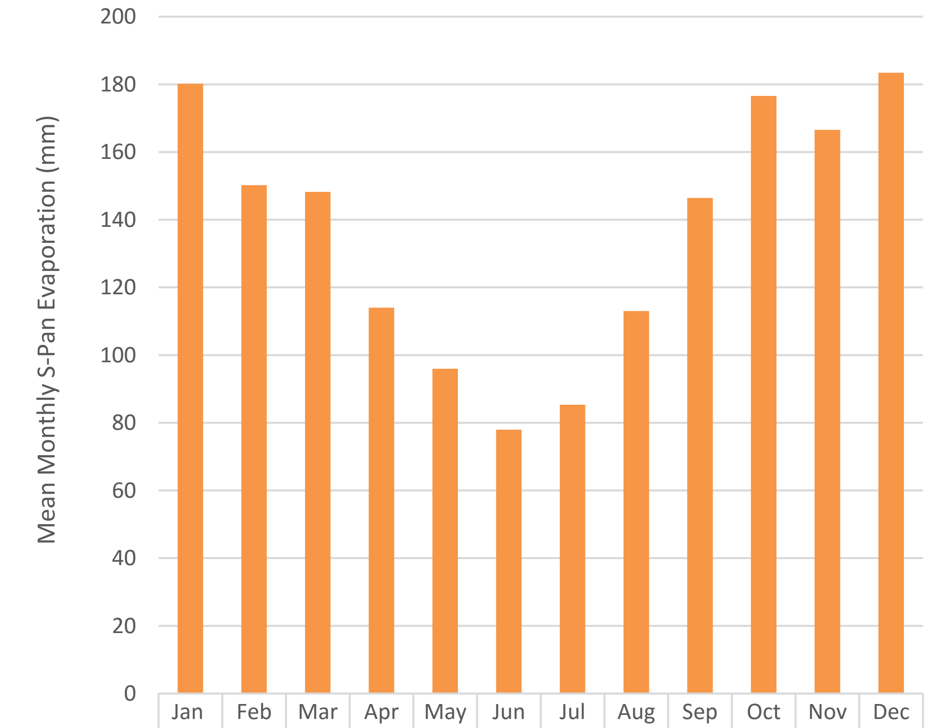


Figure 5.4 **Storm distributions for Strehla Station (0477762_W)**

5.2.3 Evaporation

The WR2012 dataset (WRC, 2012) shows annual evaporation for the site to be 1638mm (S-Pan estimate). Figure 5.5 presents the average evaporation data sourced from the WR2012 dataset for quaternary catchments B20E, B11E and B11D (evaporation zone 4A).

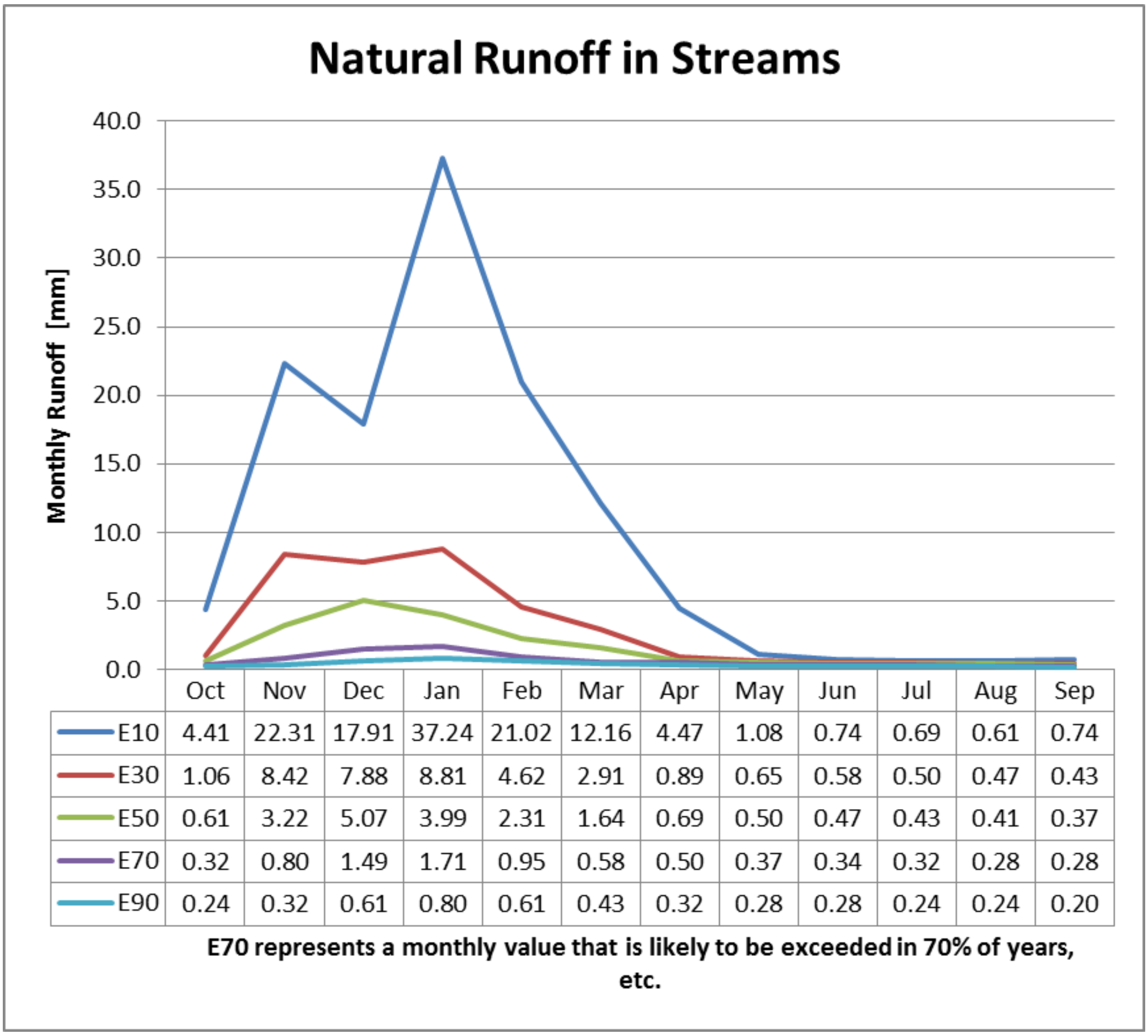


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly S-Pan Evaporation (mm)	180	150	148	114	96	78	85	113	146	177	167	183

Figure 5.5 Mean monthly S-Pan evaporation

5.2.4 Runoff

According to the WR2012 dataset, approximately 8.6% of local rainfall will contribute to local rivers and streams. Direct surface runoff is not likely to constitute more than, on average, 33% of this flow and surface runoff will be directly linked to larger rainfall events. Runoff from natural catchments near the site is estimated at a long term average of 52.2 mm per annum, and is likely to be distributed as shown in Figure 5.6.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
E10	4.41	22.31	17.91	37.24	21.02	12.16	4.47	1.08	0.74	0.69	0.61	0.74
E30	1.06	8.42	7.88	8.81	4.62	2.91	0.89	0.65	0.58	0.50	0.47	0.43
E50	0.61	3.22	5.07	3.99	2.31	1.64	0.69	0.50	0.47	0.43	0.41	0.37
E70	0.32	0.80	1.49	1.71	0.95	0.58	0.50	0.37	0.34	0.32	0.28	0.28
E90	0.24	0.32	0.61	0.80	0.61	0.43	0.32	0.28	0.28	0.24	0.24	0.20

Figure 5.6 Local runoff [mm] near the Matla Phase 1 Stooping project

5.2.5 Flood Peaks

Peak flows for 1:50-year and 1:100-year storm events were calculated for the 22 delineated catchments. Calculations were based on current conditions at the project site. The calculated peak flows can be seen in Table 5.3. The RM3 and the SDF Methods produced peaks of a similar order of magnitude for small catchments (less than 15km^2), while MIPI tended to calculate somewhat larger peaks for these small catchments. The RM3 was designed for small catchments and it uses an updated South African rainfall database (SANRAL, 2013) to calculate 24-Hour point precipitation depths. The RM3 is recommended as one of the best known and widely used methods for determining peak flows from small catchments (SANRAL, 2013). Therefore, the RM3 was chosen for use in the flood lines modelling for this study.

Table 5.3 The calculated 1 in 50- and 1 in 100-year recurrence interval flood peaks

Catchment	Method					
	Rational Alt 3		SDF		MIPI	
	1:50yr	1:100yr	1:50yr	1:100yr	1:50yr	1:100yr
	(m^3/s)					
Blesbokspruit 1	53.0	71.9	75.0	96.0	105.6	134.0
Blesbokspruit 2	39.2	53.2	57.0	72.9	79.7	101.2
Blesbokspruit 3	7.0	9.5	9.6	12.3	18.1	22.9
Blesbokspruit 4	3.8	5.1	1.4	1.8	13.4	17.0
Blesbokspruit 5	10.1	13.7	7.2	9.2	30.2	38.3
Blesbokspruit 6	9.7	13.2	19.7	25.2	27.6	35.0
Blesbokspruit 7	4.5	6.2	1.8	2.3	15.2	19.4
Blesbokspruit 8	4.9	6.6	3.5	4.5	17.0	21.6
Blesbokspruit 9	5.7	7.8	11.7	14.9	18.1	23.0
Blesbokspruit 10	4.3	5.8	1.6	2.0	13.5	17.2
Rietspruit 1	26.5	36.1	33.1	42.4	59.5	75.6
Rietspruit 2	5.1	7.0	5.1	6.5	17.0	21.6
Rietspruit 3	4.1	5.6	2.1	2.7	18.5	23.5
Rietspruit 4	3.8	5.2	2.7	3.4	11.8	15.0
Rietspruit 5	3.7	5.1	3.6	4.6	12.3	15.6
Rietspruit 6	6.5	8.9	3.5	4.5	17.6	22.3
Komdraaispruit 1	27.9	38.0	20.6	26.4	51.6	65.5
Komdraaispruit 2	8.3	11.3	12.3	15.8	20.5	26.0
Komdraaispruit 3	5.4	11.3	2.1	2.7	17.1	21.7
Komdraaispruit 4	8.1	11.0	6.1	7.8	22.9	29.1
Komdraaispruit 5	7.5	10.3	10.9	13.9	24.1	30.7
Komdraaispruit 6	13.7	18.6	6.6	8.4	30.8	39.1

6 BASELINE WATER QUALITY

Matla mine does currently have a surface water quality monitoring programme in place. Details of the relevant monitoring locations (shown in Figure 6.1) for the proposed Stooping project are provided in Table 6.1 and the chemistry data are briefly discussed in this report. As mentioned, for the purpose of this interpretation, focus has been on pH, SO_4 and metals (Mn and Fe) for these constituents are commonly associated with AMD and pollution at coal mines. The surface water quality monitoring data cover 2012 to 2014. This area was found to not cover the entire extent of the proposed Matla stooping activities.

Table 6.1 Coordinates and description of the Matla Colliery surface water sampling points relevant to the Matla Stooping Project (Phase 1)

WQ Monitoring Point	Description	Longitude	Latitude
MSW05	2 Mine U/S	E29006.188’	S26013.358’
MSW07	2 Mine D/S	E29007.212’	S26013.424’
MSW11	3 Mine Settling Pond	E29004.095’	S26014.648’
MSW14	3 Mine U/S	E29002.409’	S26016.380’

6.1 Chemistry Analysis

The sulphate (SO_4) concentration time series graph, pH vs EC time series graph, Fe concentration trend graph and Mn concentration trend graph for the selected points are depicted in Figure 6.2 to Figure 6.5. Piper plots for data captured in 2012, 2013 and 2014 are depicted in Figure 6.6 to Figure 6.8.

Table 6.2 indicates the latest available hydrochemistry data for the selected monitoring points. The results are compared to the Department of Water Affairs South African Water Quality Guidelines Volume 1 for Domestic Use (1996) and the South African Bureau of Standards (SABS) SANS 241-1:2011 Drinking Water Standards (SANS 241: 2011). These limits are used as a means of comparison but the results should be analysed in the context of the mine and its operations.

The following summarises the chemistry trends observed:

- All monitoring points exhibit neutral pH conditions. There has been no historic indications of AMD occurring at any of these monitoring points.
- On average the Mn and Fe concentrations for the selected points have remained fairly low and below the SANS 241-1 2011 maximum aesthetical limits as shown in Figure 6.4 and Figure 6.5. These could have been due to laboratory or sampling errors.

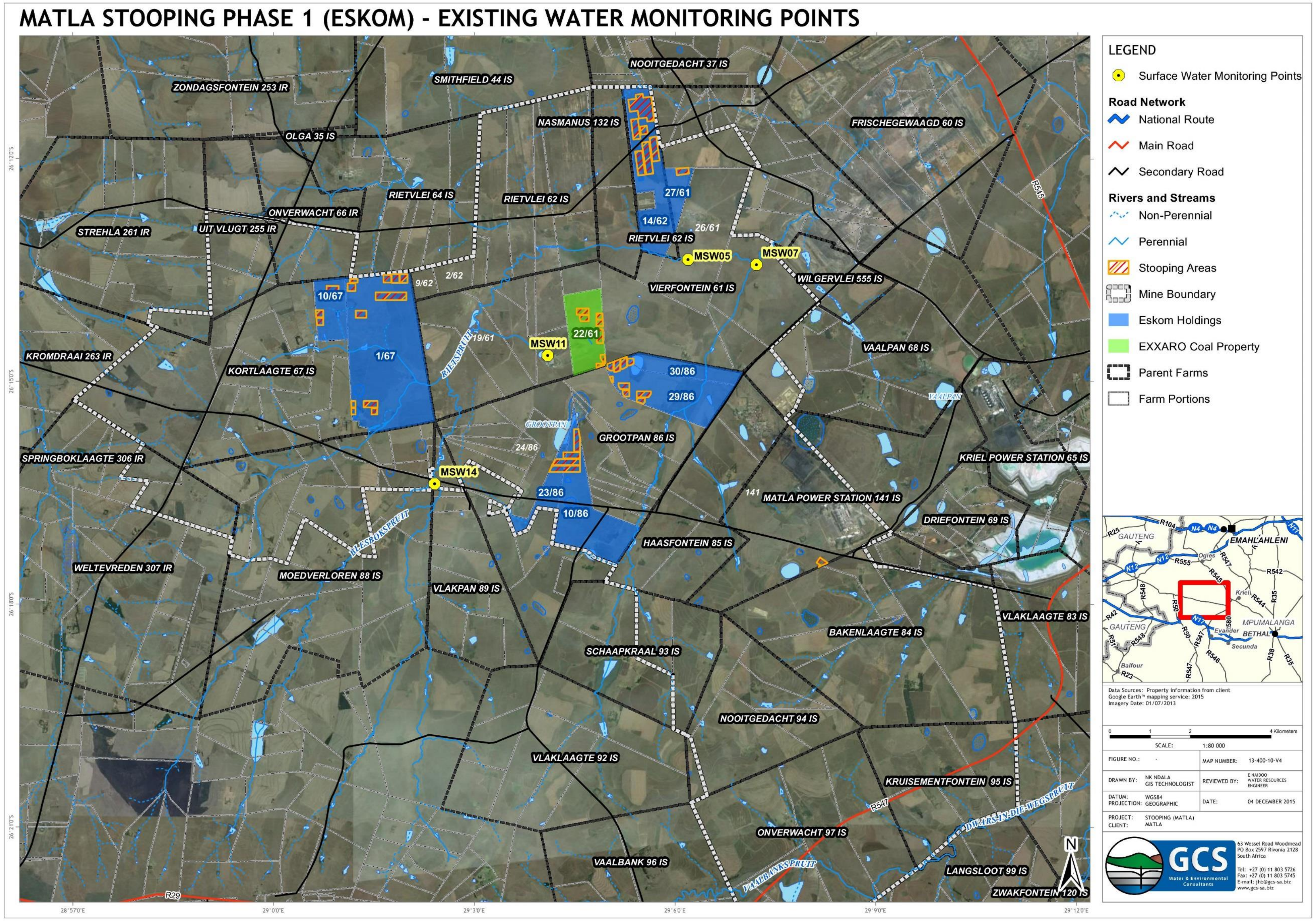


Figure 6.1 Relevant surface water monitoring points already in place at Matla Mine

- All monitoring points have historically shown seasonal fluctuations in EC (a reflection of the TDS) and SO_4 concentrations. 2 Mine U/S has historically shown the most elevated SO_4 concentrations. 2 Mine D/S, however, has shown lower concentrations which suggests that dilution is taking place between these points or from other water inflow near 2 Mine D/S.
- The EC for 3 Mine settling pond and 2 mine U/S have historically been elevated. The latest data available (June 2014) indicated that the surface water was saline and above the SANS 241-1:2011 drinking water limits. The elevated EC readings could have been due to sampling of stagnated water.
- From the piper plots produced the following can be said:
  - Monitoring points 2 Mine D/S and 3 Mine U/S have historically shown temporary hardened water conditions (Calcium (Ca), Magnesium (Mg) and Sodium (Na) rich). 2014 data, however, suggests that monitoring point 2 Mine D/S surface water chemistry has evolved to saline conditions (Na rich). Furthermore, the water chemistry at this point has evolved from HCO_3 (bicarbonate) dominant water to SO_4 dominant water. This suggests that some sulphate pollution is taking place near this point.
  - Monitoring points 3 Mine settling pond and 2 Mine U/S has historically shown saline water conditions. Monitoring point 2 Mine U/S has remained near the HCO_3 dominant apex even though SO_4 concentrations have been elevated at this point. This suggests that SO_4 is not the dominant ion at this point and that natural chemical weathering of rock is still occurring in the area.

Table 6.2 Hydrochemistry data (June 2014)

Latest Data Available: June 2014							
-		2 Mine U/S	2 Mine D/S	3 Mine settling pond	3 Mine U/S	DWA 1996 Domestic Use Limits	SANS 241-1: 2011 Drinking Water Standards
DETERMINANT	**UNIT**						
pH		8.36	7.77	8.66	7.42	6	5
						9	9.7
Conductivity (EC)	mS/m	208	81.2	204	45.7	70	170
Calcium	mg Ca/L	54.1	30.9	36.3	24.2	32	*n/s*
Magnesium	mg Mg/L	36.3	20.2	33.9	16.2	30	*n/s*
Sodium	mg Na/L	305	96.4	349	31.8	100	200
Potassium	mg K/L	7.15	7.09	18.3	6.47	50	*n/s*
Chloride	mg Cl/L	88.7	64.1	329	36.9	100	300
Sulphate	mg SO4/L	531	114	198	30.1	200	250
Nitrate	mg NO3/L	<0.01	1.17	<0.01	0.47	6	11
Iron	mg Fe/L	0.51	0.59	0.04	0.09	0.1	2
Manganese	mg Mn/L	0.08	0.04	0.04	0.15	0.05	0.5
Fluoride	mg F/L	2.32	0.78	2.89	0.43	1	1.5

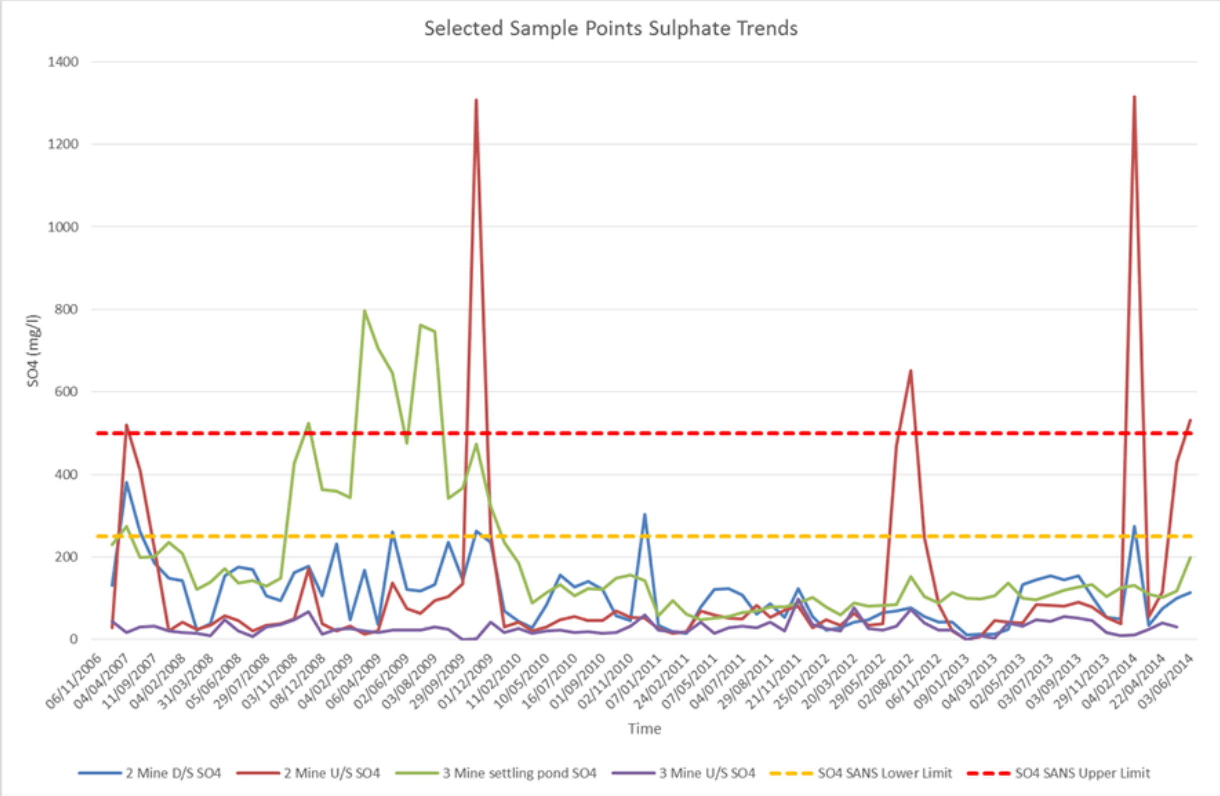


Figure 6.2 Sulphate trend graph for selected points

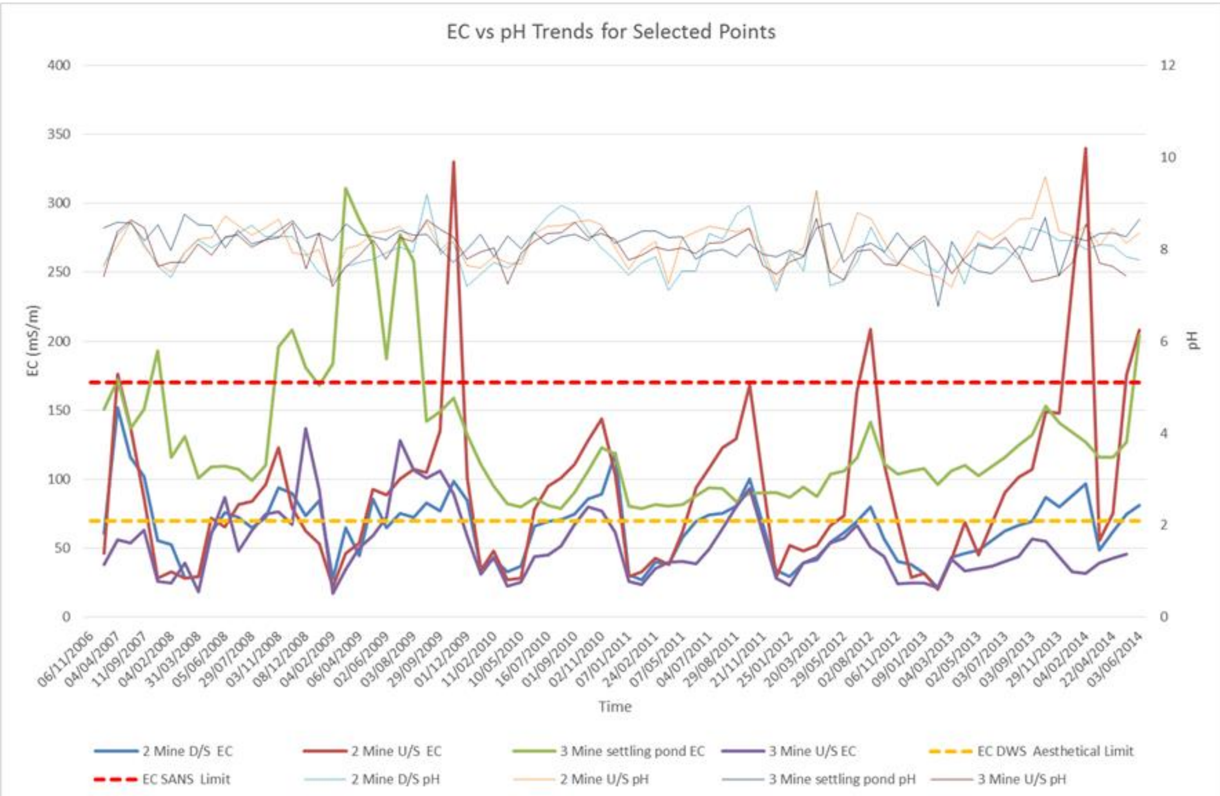


Figure 6.3 EC vs pH trend graph for selected points

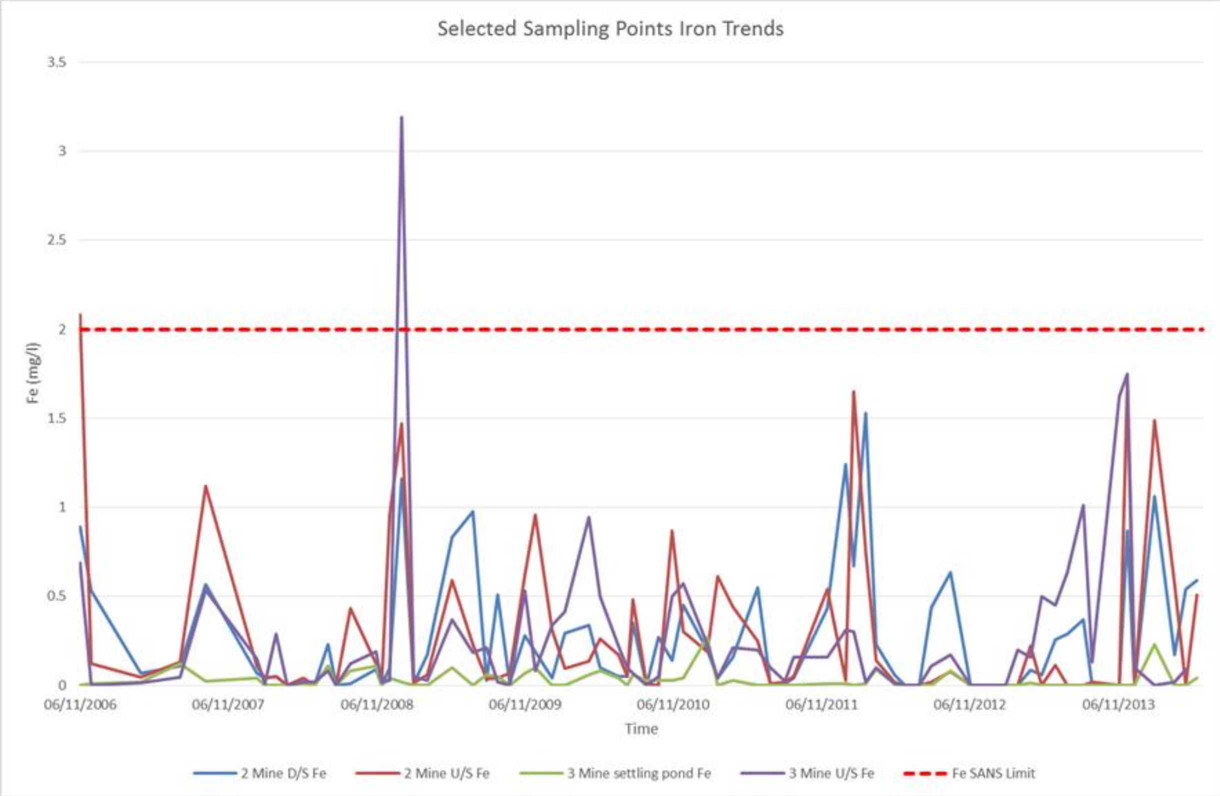


Figure 6.4 Iron trend graph for selected points

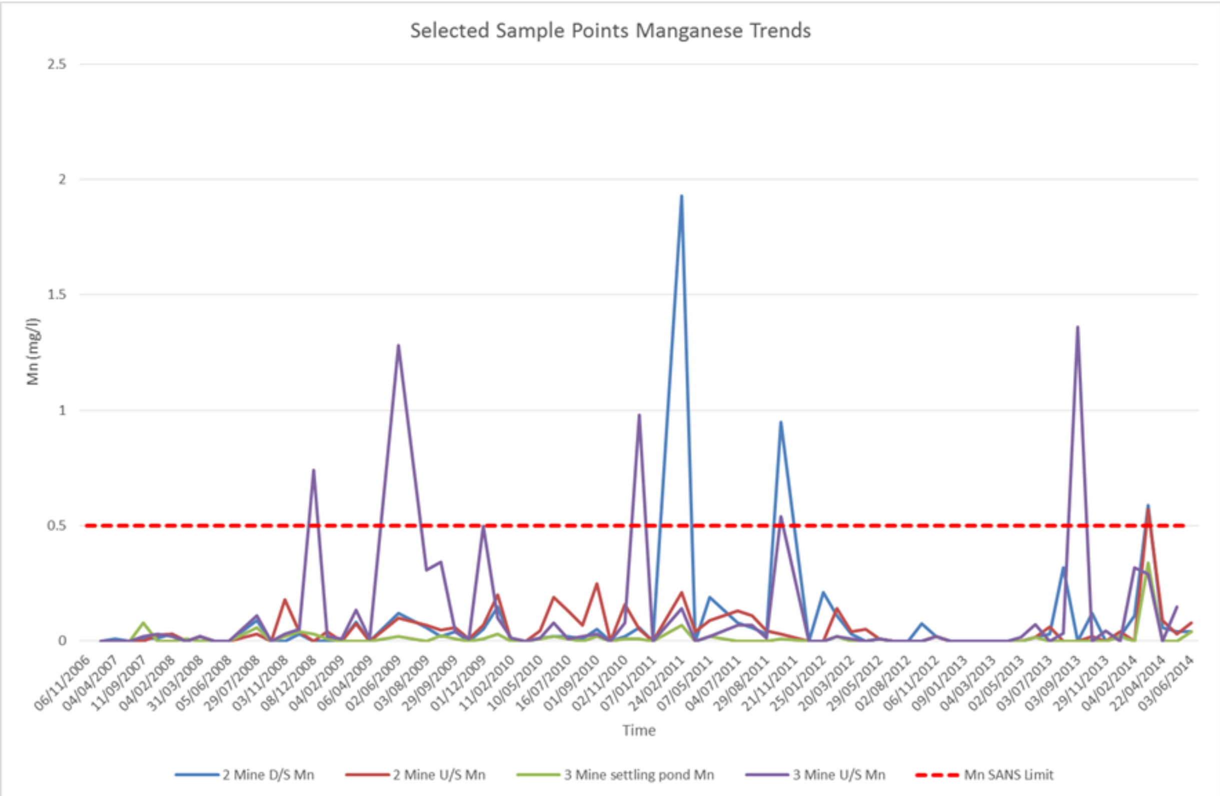


Figure 6.5 Manganese trend graph for selected points

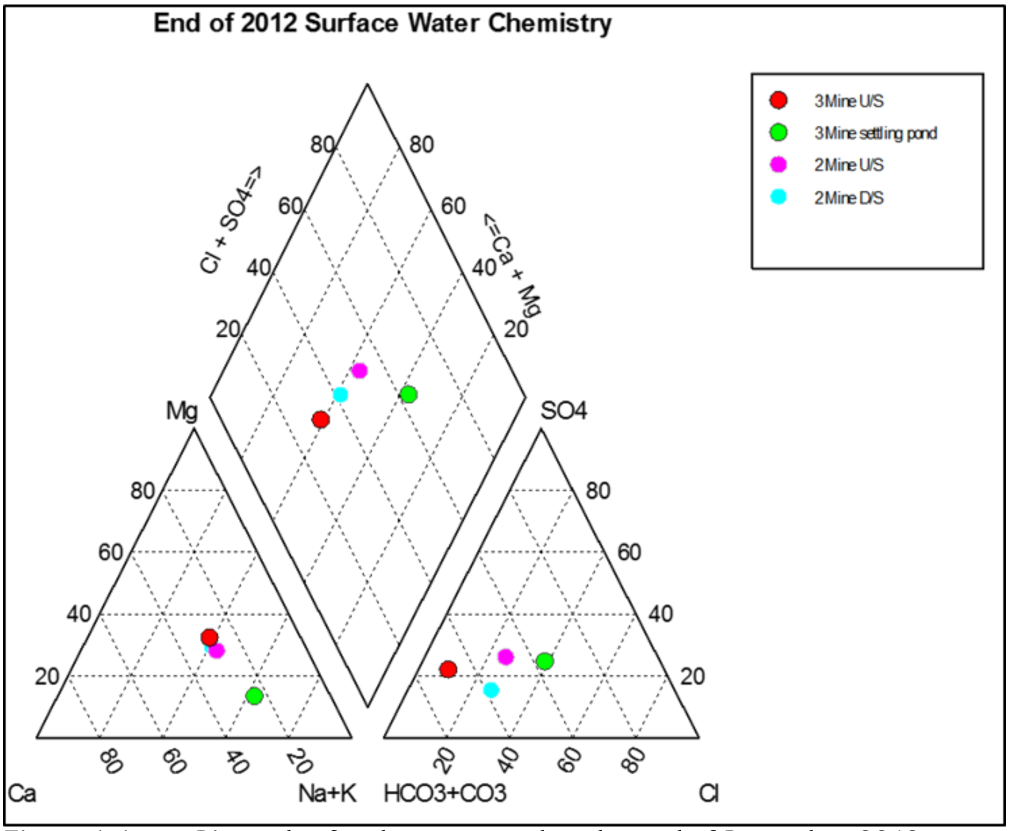


Figure 6.6 Piper plot for data captured at the end of December 2012

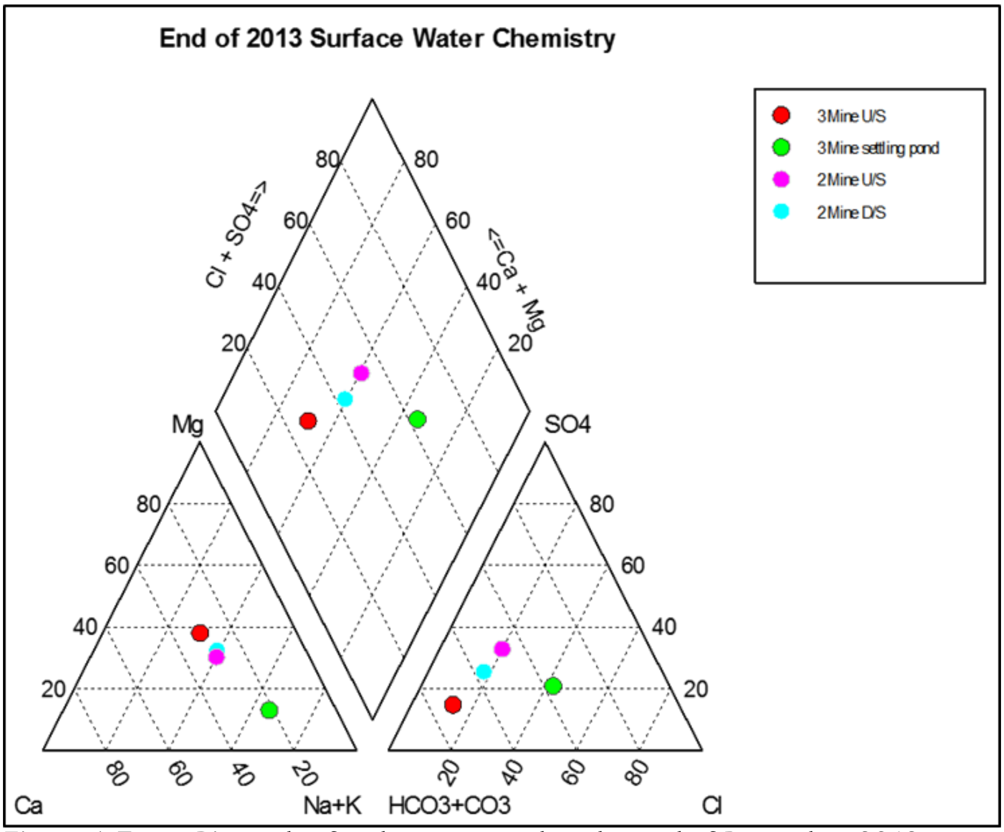


Figure 6.7 Piper plot for data captured at the end of December 2013

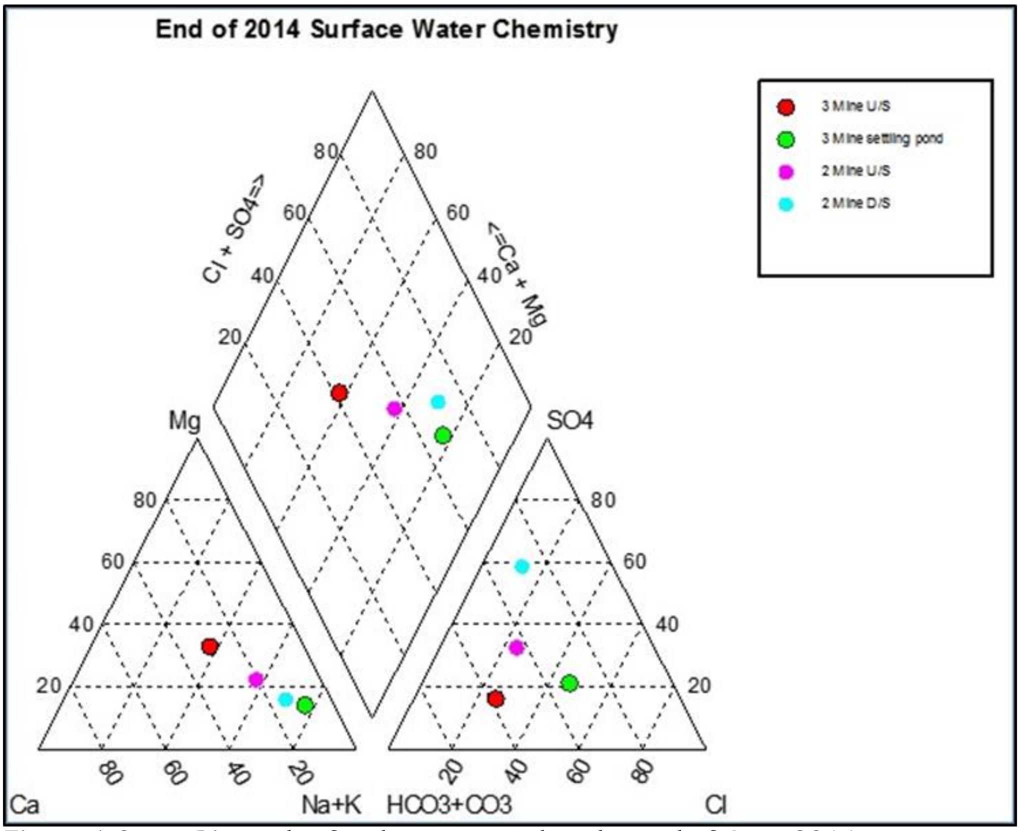


Figure 6.8 Piper plot for data captured at the end of June 2014

7 WATER QUALITY MONITORING PLAN

A surface water monitoring programme is recommended at the proposed Matla Phase 1 Stooping project in terms of the Best Practice Guidelines G3: Water Monitoring Systems (DWAF, 2006). The monitoring programme will assist with overall water management at the site, including but not limited to:

- Preventing pollution and thereby protecting the receiving water environment;
- Developing an understanding of the current water quality on site and monitoring how it changes over time, and
- Assessing performance of pollution prevention measures, i.e. compliance with license conditions.

The monitoring programme should be amended according to on-site operations and future Water Use Licences or other permit requirements.

7.1 Proposed monitoring locations

It is recommended that any water containment facilities on site be monitored for water quality and quantity on a monthly basis. The quantity should be monitored to ensure the facilities are of a sufficient size for the water volumes they are expected to contain and to verify or update the water balance. The water quality results should meet applicable standards or ensure that water released into the environment, either intentionally or unintentionally, are of appropriate quality and associated risks are well understood. Should there be any streams or natural drainage lines with flowing water within the catchment of the site (zone of impact) these should be monitored on a monthly basis upstream and downstream of the site.

Details of the proposed monitoring programme are presented in Table 7.1. Figure 7.1 shows 8 proposed locations for surface water monitoring.

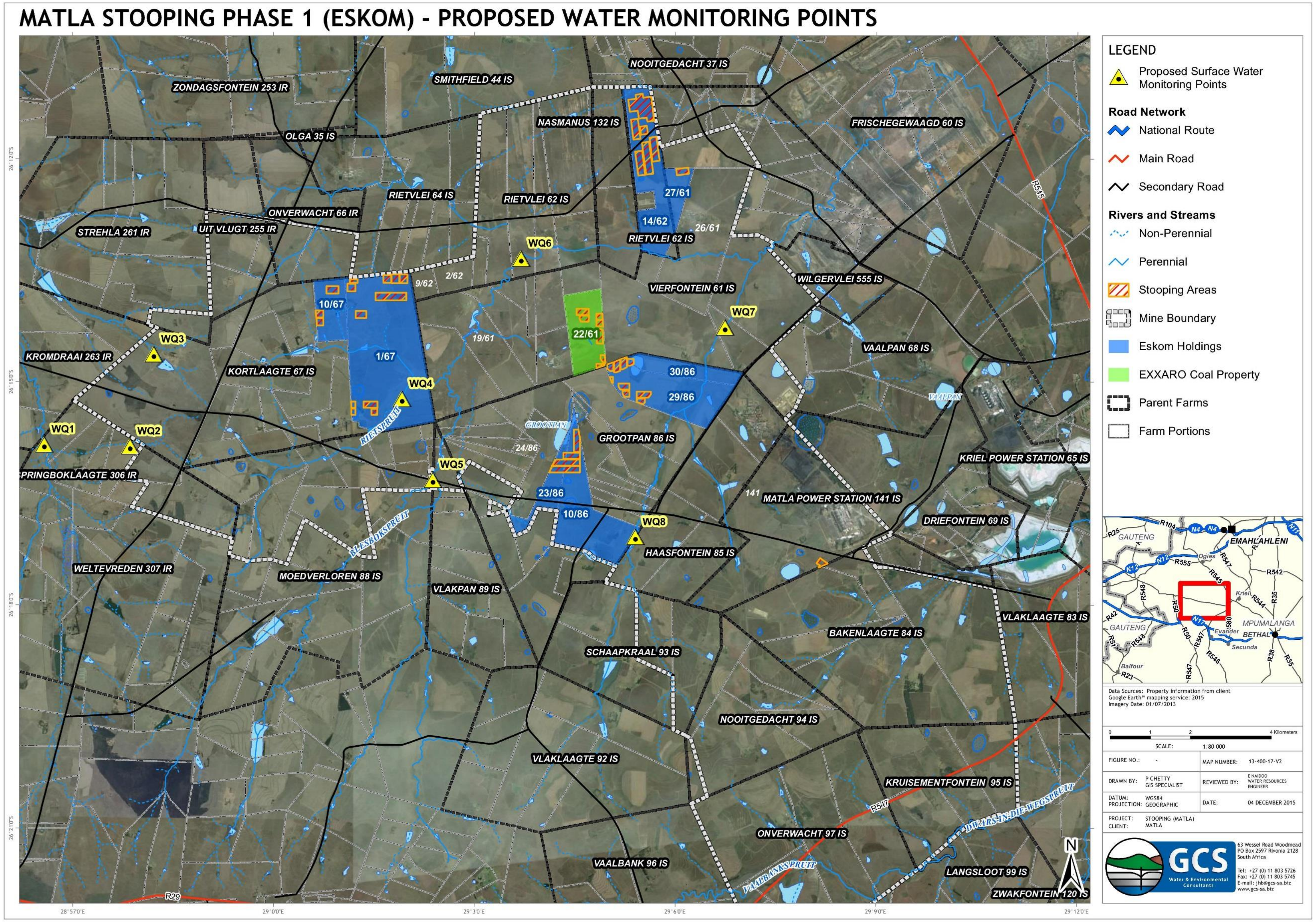


Figure 7.1 Proposed surface water monitoring points

Table 7.1 Proposed monitoring programme

Water Type	Details	Monitoring Frequency
Surface Water	• Sample point upstream and downstream of the subsidence areas • Clean water discharge point	Monthly water samples
Drinking Water (pipe lines, boreholes)	• Any supplied water used for domestic purposes should be monitored for parameters such as total and faecal coliform	Monthly water samples
Process Water	• Outlet of the oil and grease trap, washbays, storm water containment, pollution control dams and sewage treatment facilities	Monthly water samples

7.2 Applicable Parameters and Standards

The water samples should be analysed for the parameters listed below (Table 7.2) on a monthly basis, and on a bi-annual basis all samples should additionally be submitted for a full Inductively Coupled Plasma Mass Spectrometry (ICP-MS) metal scan; as specified in Table 7.3. This list of parameters should be amended annually to ensure all priority parameters are analysed monthly and lower-priority parameters are only analysed on a bi-annual basis.

Table 7.2 List of parameters for monthly analysis

pH at 22ºC	Chloride, Cl
Conductivity mS/m	Sulphate, SO_4
Total Dissolved Solids	Nitrate, NO_3
Calcium, Ca	Fluoride, F
Magnesium, Mg (mg/l)	Aluminium, Al
Sodium, Na	Manganese, Mn
Potassium, K	Iron, Fe
Total Alkalinity as CaCO3	Zinc, Zn
Bicarbonate, HCO3	

The following additional parameters should be analysed on a bi-annual basis:

Table 7.3 List of parameters for bi-annual analysis

Antimony as Sb	Nickel as Ni
Arsenic as As	Selenium as Se
Barium as Ba	Silicon as Si
Beryllium as Be	Silver as Ag
Bismuth as Bi	Strontium as Sr
Cadmium as Cd	Tin as Sn
Cobalt as Co	Titanium as Ti
Lithium as Li	Vanadium as V
Mercury as Hg	Zirconium as Zr
Molybdenum as Mo	

The water quality results should be compared to the limits specified in the latest Water Use Licence (WUL). If a WUL is not available or limits for some parameters are not specified in the Water Use Licence, the following guidelines and standards should be used:

- Department of Water Affairs South African Water Quality Guidelines Volume 1 for Domestic Use (1996a); and
- South African Bureau of Standards (SABS) SANS 241-1:2011 Drinking Water Standards.

7.3 Methodology

The sampling procedure should be in accordance with the following publications:

- SABS ISO 5667 – 1:1980 Guidance on the design of sampling programmes
- SABS ISO 5667 – 2:1991 Guidance on sampling techniques
- SABS ISO 5667 – 3:1994 Guidance on the preservation and handling of samples

Samples should be submitted to a SANAS-accredited Laboratory Service.

Field observations such as the following should be recorded on field data sheets:

- Coordinates of each surface water sampling point;
- *In-situ* EC, pH, Temperature and redox potential (Eh) are measured and recorded for each sampling point;
- Documenting general characteristics of the water samples such as colour, turbidity and smell;
- Any potential sources of contamination at the sampling points; and

- Annual photographs of each sampling point.

It is further recommended that a chain of custody be filled in at the time of sampling recording the following information:

- Date and time of sampling.
- Coordinates of each sample point (at first sampling event only).
- *In-situ* measurements for each sampling point, namely pH, EC, TDS and temperature.
- General characteristics of the water samples such as colour, turbidity (murky/clear) and smell, as well as visual observations of the sample site.

The chain of custody form is completed when the samples are transported and transferred to the laboratory for analysis.

Care should be taken to ensure that the samples taken are sufficiently large enough (1ℓ) as to allow the laboratory to run duplicate analyses if required. Samples should be kept cool when stored and transported. Samples for metal analysis should be filtered through a 0.45 µm pore size membrane in the field and preserved with nitric acid.

7.4 Data Storage and Processing

It is essential that all data relating to the monitoring programme be maintained in a reliable and secure database. This database should be updated as monthly data becomes available in order to identify any immediate problems and to identify any trends that are of concern.

7.5 Reporting

The reports that should be prepared by the relevant bodies are:

- Monthly reports;
- Bi-annual / annual reports.

The following should be included in the reports in terms of data interpretation and trend analysis:

- Summary of the analytical results, including a comparison with relevant standards;
- Map of the monitoring points showing their level of compliance;
- Brief discussion of any problem areas;
- Time series graphs showing fluctuations or trends in constituents of concern over time, and

- Recommendations and mitigations measures where applicable.

8 FLOOD LINES

Flood lines were calculated within the proposed project extents for the Rietspruit and an un-named tributary of the Rietspruit (that flows through the farm Grootpan), to the east of the proposed Matla Stooping Phase 1 project in 2012. These can be seen in Figure 8.1. The details of the existing flood line analysis can be found in Matla Hydrological Study (GCS, 2012). This document includes the streams omitted from the previous hydrological study carried out by GCS; the streams to be included are as follows:

- Blesbokspruit and the relevant tributaries;
- Rietspruit tributaries;
- Komdraaispruit and relevant tributaries.

8.1 Study Limitations

The following limitations were experienced and assumptions have been made in this specialist study:

- No flow and rainfall data against which the runoff calculations might be calibrated were available. The runoff volumes were therefore calculated theoretically;
- Since no flow data were available for estimation of the roughness coefficients, the Manning's 'n' coefficients were estimated by comparing the vegetation and nature of the channel surfaces to published data (Barnes, 1967; Chow, 1959; Hicks and Mason, 1991).

8.2 Sub-catchments

The total drainage area of the site was divided into 22 sub-catchments based on the topography of the area, as shown in Figure 8.1. The details of the sub-catchments are shown in Table 8.1.

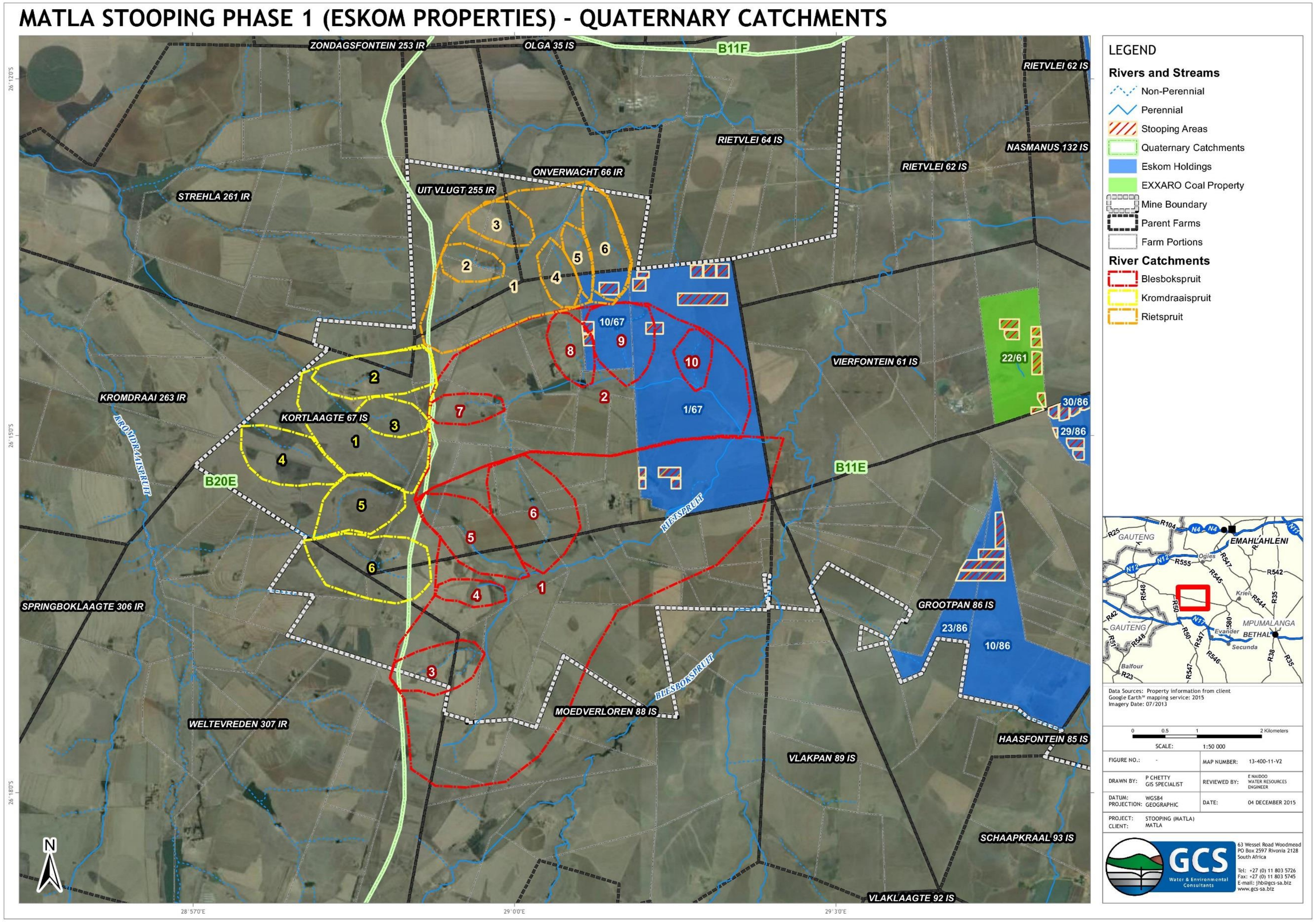


Figure 8.1 Delineated sub-catchments for the Matla Stooping Phase 1 project

Table 8.1 Sub-catchment areas used for the flood line analysis

Catchment Description	Area (km^2)
Blesbokspruit 1	18.4
Blesbokspruit 2	9.83
Blesbokspruit 3	0.85
Blesbokspruit 4	0.35
Blesbokspruit 5	1.24
Blesbokspruit 6	1.74
Blesbokspruit 7	0.45
Blesbokspruit 8	0.61
Blesbokspruit 9	1.03
Blesbokspruit 10	0.39
Rietspruit 1	5.71
Rietspruit 2	0.45
Rietspruit 3	0.52
Rietspruit 4	0.46
Rietspruit 5	0.32
Rietspruit 6	0.86
Komdraaispruit 1	3.56
Komdraaispruit 2	1.09
Komdraaispruit 3	0.51
Komdraaispruit 4	1.05
Komdraaispruit 5	0.96
Komdraaispruit 6	1.61

8.3 Hydraulic Modelling

Manning’s roughness coefficients for all the rivers were calculated to be 0.02 for the channel and 0.03 for the river banks. As mentioned, the Manning’s ‘n’ coefficients were estimated by comparing the vegetation and nature of the channel surfaces to published data (Barnes, 1967; Chow, 1959; Hicks and Mason, 1991).

8.4 Flood Line Results

In the EIA phase the 100m river buffers were delineated (Figure 11.2) along with the 1 in 50- and 1 in 100-year flood line extents (Figure 8.2) as Regulation 4(b) of GN704 reads; 'No person in control of a mine or activity may - except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50-year flood-line or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest'. The area within this designation is termed the Exclusion Zone.

The results indicate that the proposed stooping does not encroach on the non-perennial streams within the study area, as shown in Figure 8.2.

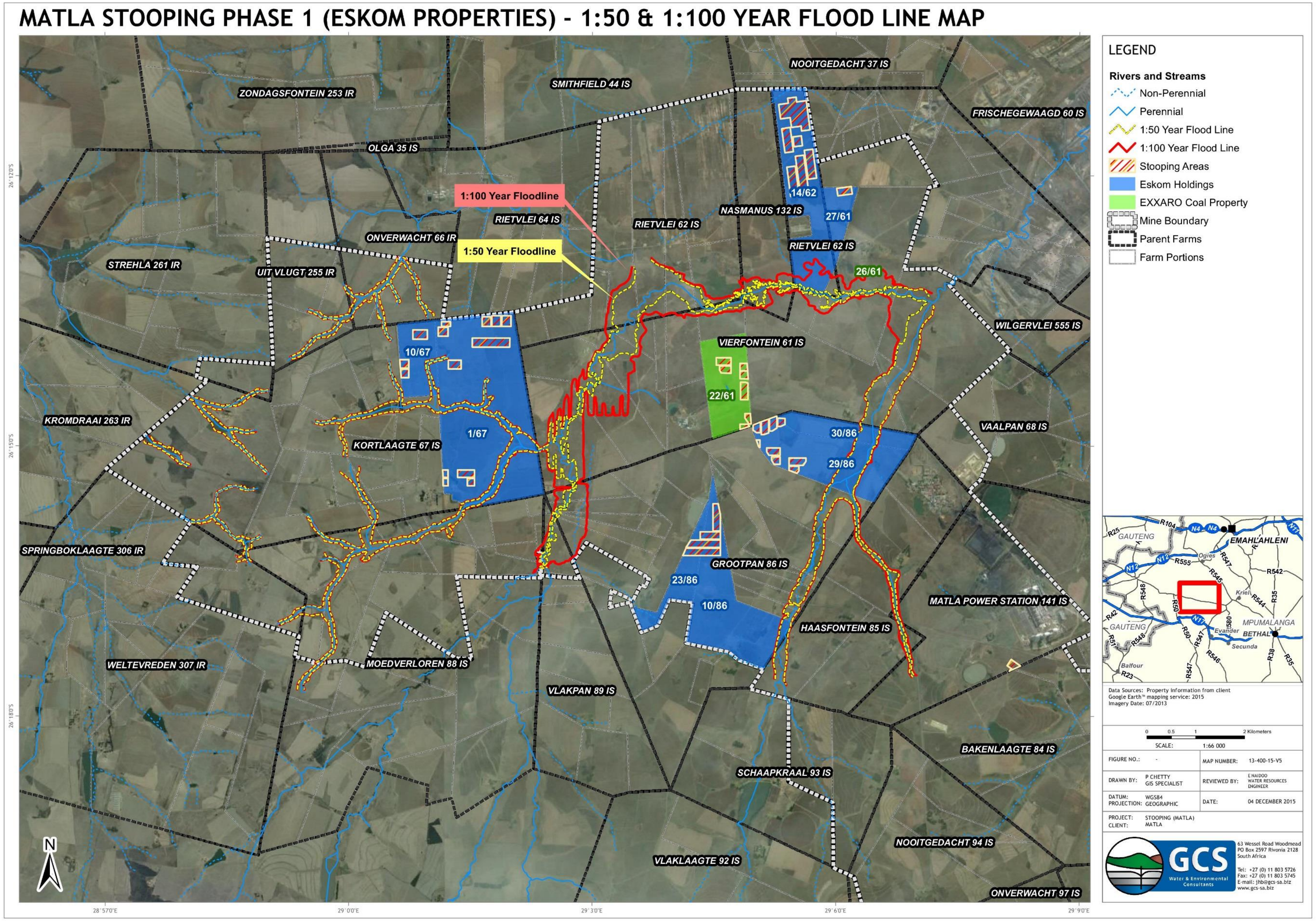


Figure 8.2 Extent of the 1:50-year and 1:100-year flood lines for the Matla Stooping Phase 1 project

9 STORM WATER MANAGEMENT PLAN

A SWMP is a statutory requirement for mining and related activities in South Africa and is defined by General Notice 704 and Regulation 77 of the National Water Act (Act 36 of 1988). No water use licences in terms of this act will be granted without an approved SWMP. The purpose of a SWMP is to prevent the pollution of water resources in and around mining areas, or areas where mining related activity occurs. Regulations define a methodological approach to preventing and/or containing pollution on mining sites, set design standards and specify measures that must be taken to monitor and evaluate the efficacy of pollution control measures that are implemented.

9.1 Proposed Storm Water Management Strategy

The Matla Stooping Project (Phase 1) will have no surface related activities as the mining will be underground. There will be no dirty water generating areas as a result of this. The impacts to the surface will be in the form of subsidence of approximately 1.53m, therefore the site-wide framework is to allow the subsided areas to be free-draining while at the same time limiting the amount of surface water runoff infiltrating into the underground workings. The clean water runoff being generated from the upslope clean water catchments will be diverted away from the subsided areas. The water runoff generated from the subsided areas will be diverted to flow out of this area via channels. The proposed storm water management strategy is detailed below:

- Berms will be placed along the perimeter of the subsided areas. Care should be taken as no pooling should occur on the upstream side of the berm as the berms' stability could be affected. Upstream clean water catchments should be diverted away from the subsided areas via a clean water cut-off trenches which will safely discharge the water to the receiving environment as shown in Figure 9.1 to Figure 9.4.
- The surface water runoff generated within the subsided areas will be free-drained to the lowest point within this bunded area and discharged into the receiving environment via strategically-placed openings in the perimeter berm, as shown in Figure 9.1 to Figure 9.4. Care should be taken to mitigate any erosion that may take place; this may be in the form of energy dissipaters or silt traps. If erosion does become a problem or the final, detailed design specifies, additional lining may be required for the channels, such as riprap. This channel lining, when implemented, will greatly reduce the risk of erosion. Another option would be to implement energy dissipation devices. Energy dissipaters are devices designed to protect downstream areas from erosion by reducing the velocity of flow to acceptable limits.

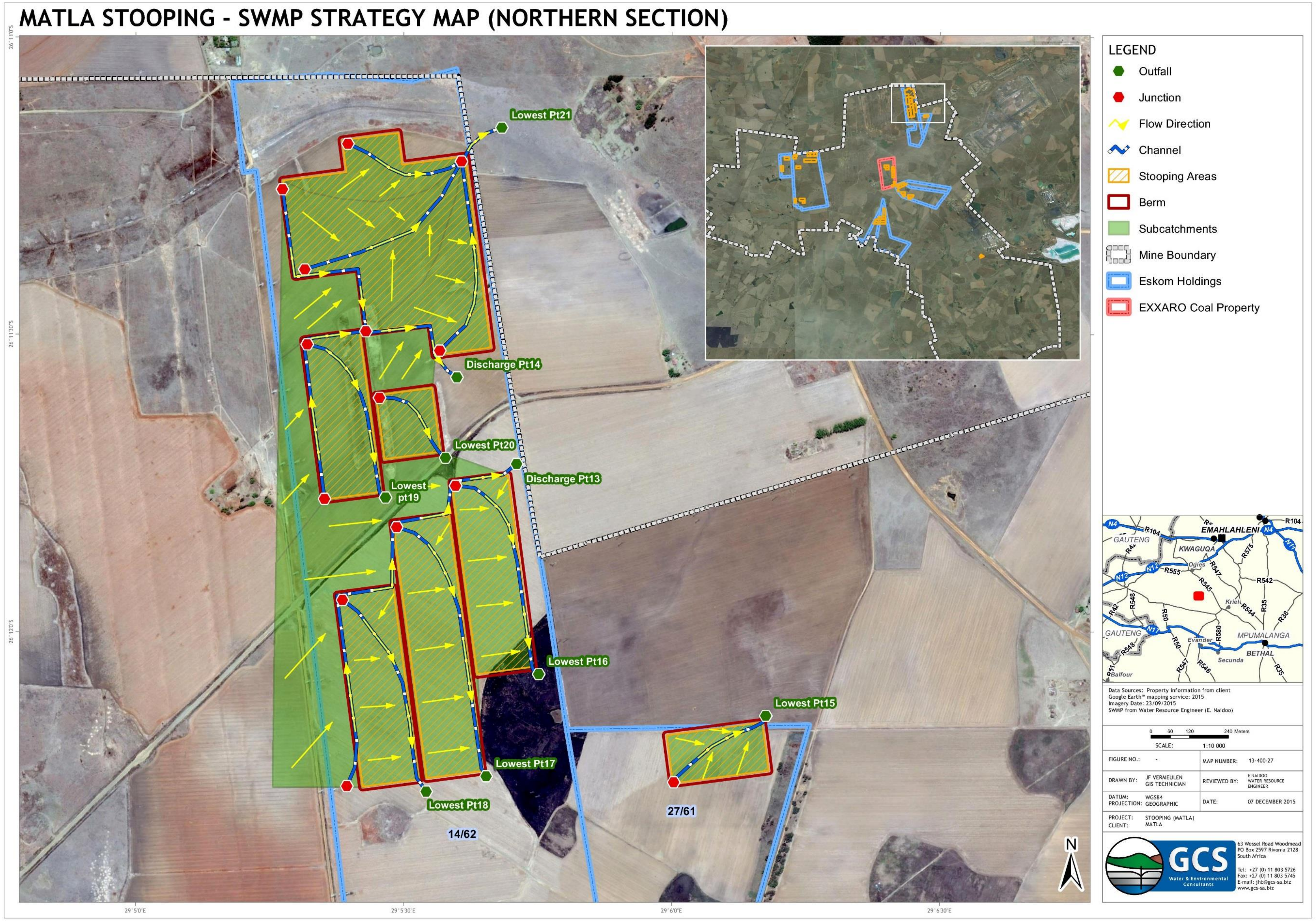


Figure 9.1 Proposed SWMP strategy – Northern section

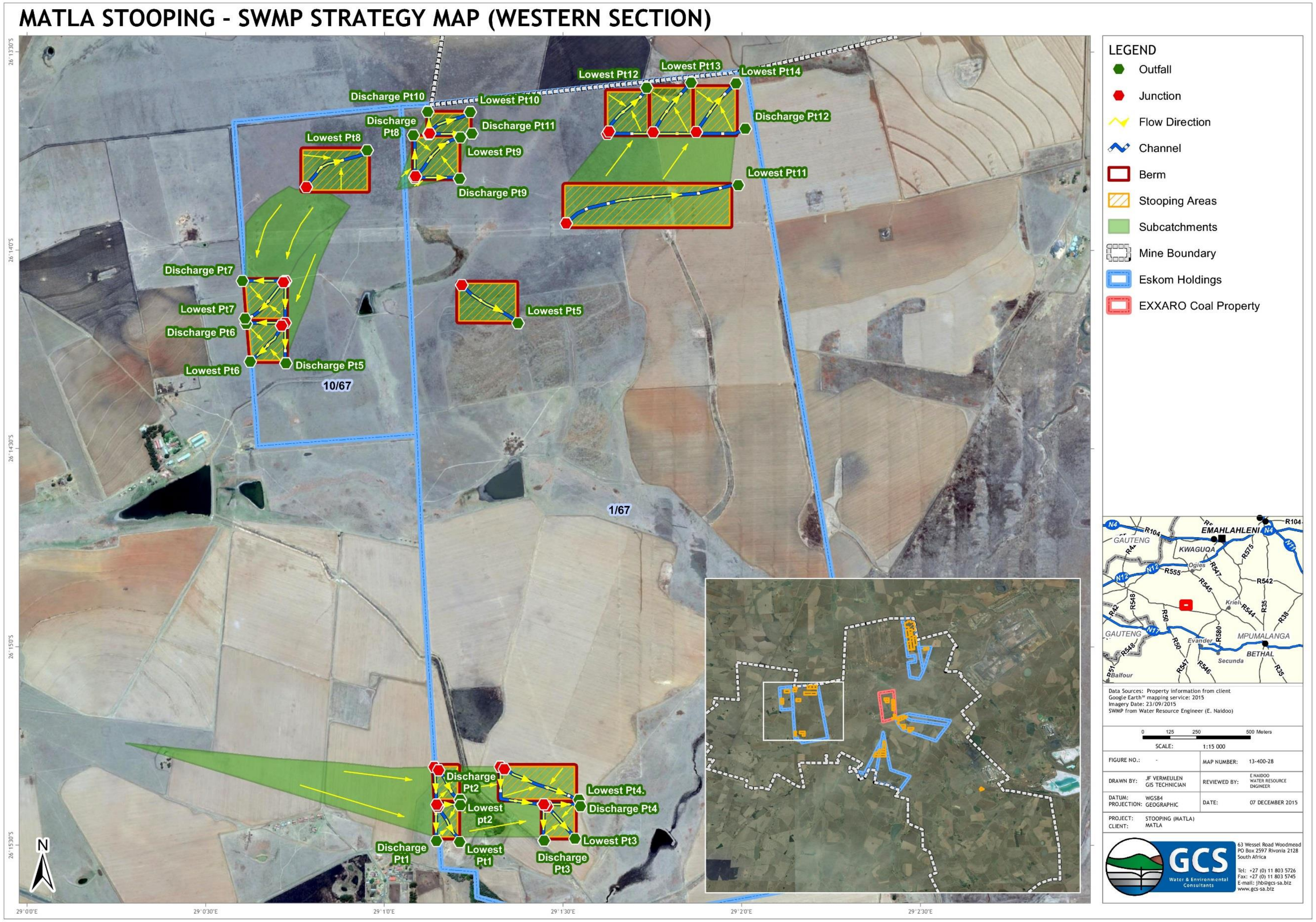


Figure 9.2 **Proposed SWMP strategy- Western section**

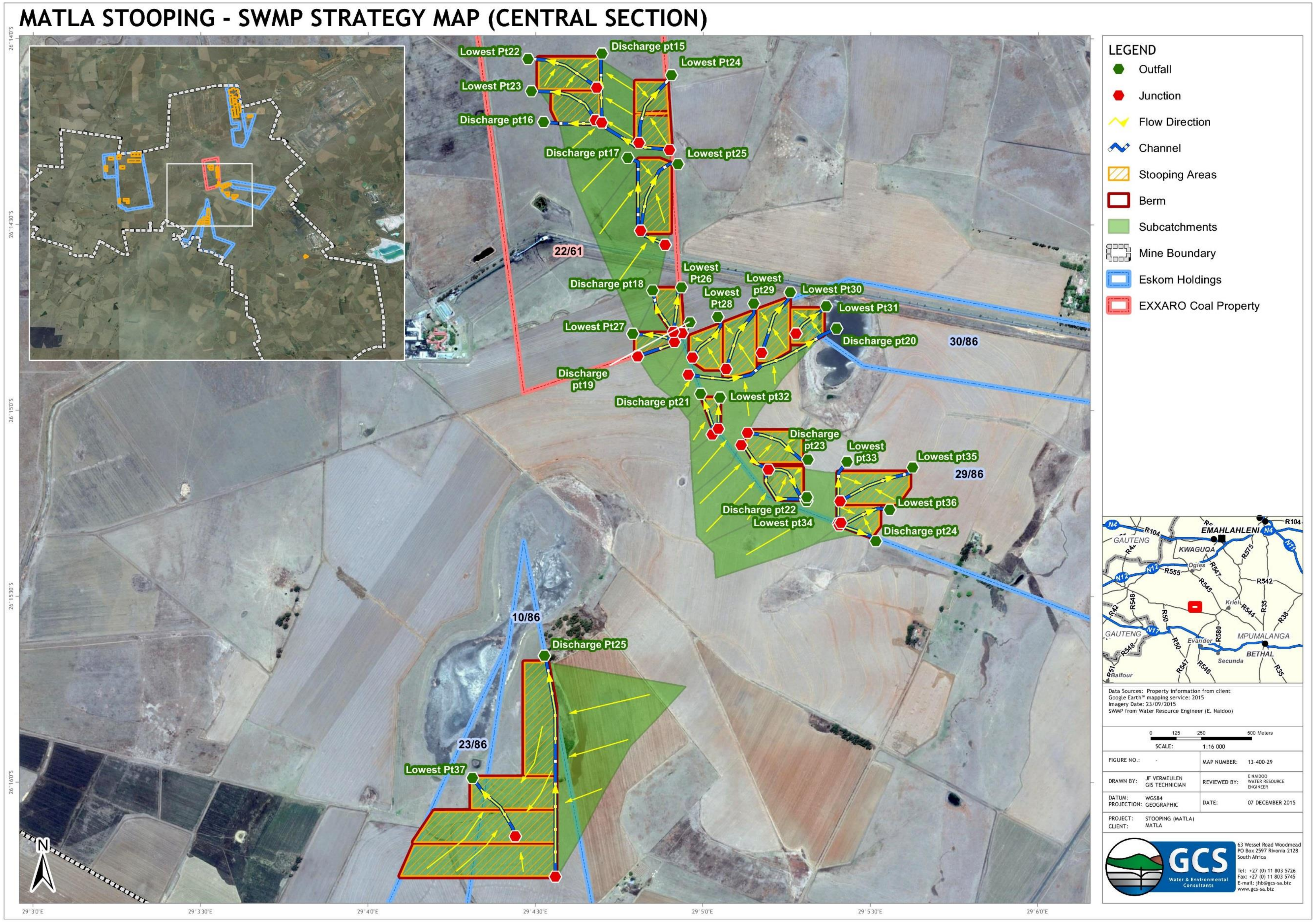


Figure 9.3 Proposed SWMP strategy – Central section

Figure 9.4 **Proposed SWMP strategy - South-Eastern section**

9.2 Delineation of Catchments

Discretisation into sub-catchments is based on the topography of the study area, as shown in Figure 9.5 to Figure 9.8. This was undertaken in order to determine the clean water and dirty water catchment areas. No designation of the clean and dirty water catchments was carried out as there are no dirty water generating activities taking place on the surface. The parameters used to model the overland flow are listed in Table 9.1. Manning's 'n' coefficient used in the model for the impervious areas and pervious areas were 0.013 (float finish, concrete) and 0.15 (veld type vegetation), respectively (McCuen, 1996).

The soils were identified as being in the sandy loam group (WR2012). The model uses these criteria to incorporate infiltration into the analysis using the Green-Ampt infiltration method. The sandy loam group resulted in a Suction Head of 110.1 mm, a Hydraulic Conductivity of 21.8 mm/hr and an Initial Deficit of 0.36 being used in the modelling. Simulated runoff volumes are summarised in Table 9.1 for the 50-year recurrence interval storm event.

Table 9.1 Catchment parameters used in the modelling of the overall SWMP

Name	Area (ha)	Flow Length (m)	Slope (%)	Runoff Volume (m^3)	Peak Runoff (m^3/s)
S1.	21.7	1093	1.7	3350	0.92
S2.	1.6	55	1.7	660	0.52
S3.	0.3	30	1.7	120	0.12
S4.	1.5	50	1.7	650	0.54
S5.	9.8	230	1.5	3040	1.37
S6.	5.2	100	3.3	2140	1.52
S7.	0.6	35	3.3	290	0.31
S8.	2.2	55	3.2	960	0.87
S9.	4.6	105	1.8	1790	1.15
S10.	2.9	105	0.3	880	0.39
S11.	0.4	25	0.3	160	0.12
S12.	3.1	70	0.5	1150	0.68
S13.	4.9	250	1.5	1480	0.64
S14.	13.2	380	3	3890	1.64
S15.	5.6	110	2.8	2230	1.51
S16.	0.8	95	0.5	260	0.14
S17.	0.6	60	0.4	210	0.12
S18.	3.7	90	1.4	1450	0.94
S19.	0.3	35	1.5	130	0.12
S20.	0.8	55	1.4	350	0.26
S21.	1.8	60	1.4	730	0.53
S22.	4.0	120	1.1	1420	0.79

S23.	4.4	140	0.8	1430	0.70
S24.	4.0	110	1.3	1480	0.88
S25.	16.4	220	1.5	5160	2.37
S26.	14.3	180	1.7	4860	2.50
S27.	4.5	125	2.2	1730	1.08
S28.	4.1	90	1.5	1610	1.05
S29.	5.8	140	1.3	2020	1.09
S30.	5.0	155	0.9	1620	0.78
S31.	13.0	300	2.2	3920	1.71
S32.	5.3	210	3.8	1930	1.10
S33.	15.3	200	3.7	5560	3.22
S34.	2.0	90	5.1	870	0.70
S35.	1.8	105	3	730	0.51
S36.	1.4	80	1.8	560	0.39
S37.	2.8	135	3.2	1090	0.71
S38.	2.6	80	6.7	1160	1.05
S39.	4.4	120	2.9	1730	1.15
S40.	4.6	150	2.6	1710	1.03
S41.	2.7	105	3.9	1100	0.79
S42.	19.3	200	2.3	6620	3.48
S43.	0.7	65	1.2	300	0.21
S44.	2.1	95	1.2	790	0.49
S45.	12.4	300	2.5	3830	1.71
S46.	4.5	115	2.5	1770	1.17
S47.	2.4	105	2	930	0.60
S48.	16.0	625	2	3520	1.17
S49.	5.5	90	3.3	2290	1.67
S50.	2.3	97	2.9	930	0.65
S51.	0.8	64	2	340	0.26
S52.	31.7	616	2.3	7270	2.48
S53.	37.8	620	4.6	10030	3.84
S54.	2.8	115	5.2	1160	0.84
S55.	4.5	110	1.6	1710	1.06
S56.	12.1	200	1.5	3910	1.87
S57.	15.8	175	0.8	4840	2.14
S58.	10.5	115	0.8	3640	1.93
S59.	28.2	255	1.9	8790	3.98
S60.	6.8	150	0.3	1830	0.72
S61.	9.6	190	1.3	3090	1.47
S62.	3.5	155	2.1	1260	0.72
S63.	4.1	170	2	1440	0.79
S64.	6.1	200	0.5	1630	0.63
S65.	8.3	115	1.2	3030	1.74
S66.	14.0	200	2.2	4790	2.49

S67.	5.7	135	2.1	2140	1.29

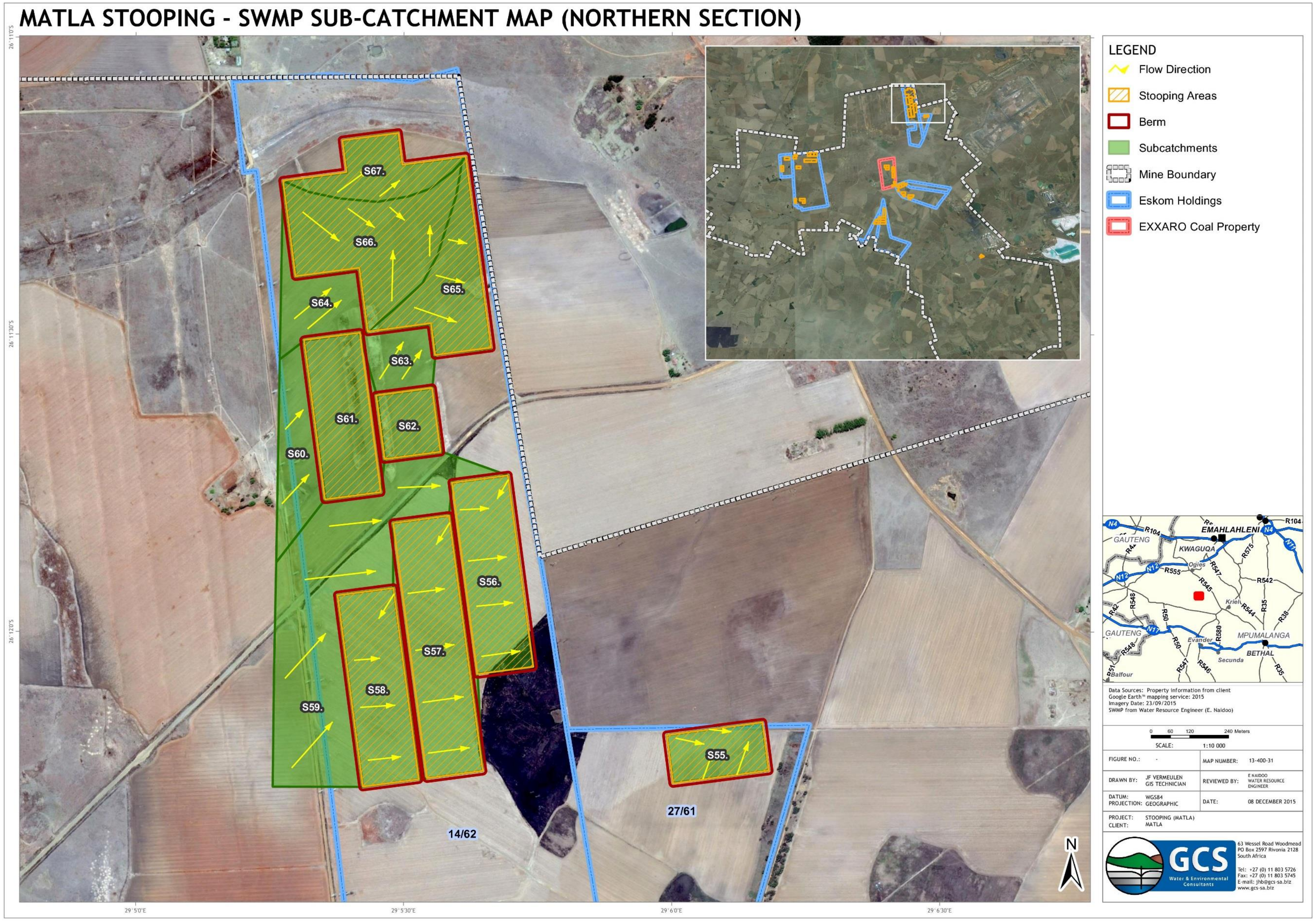


Figure 9.5 Layout and extent of the discretised surface water sub-catchments- Northern section

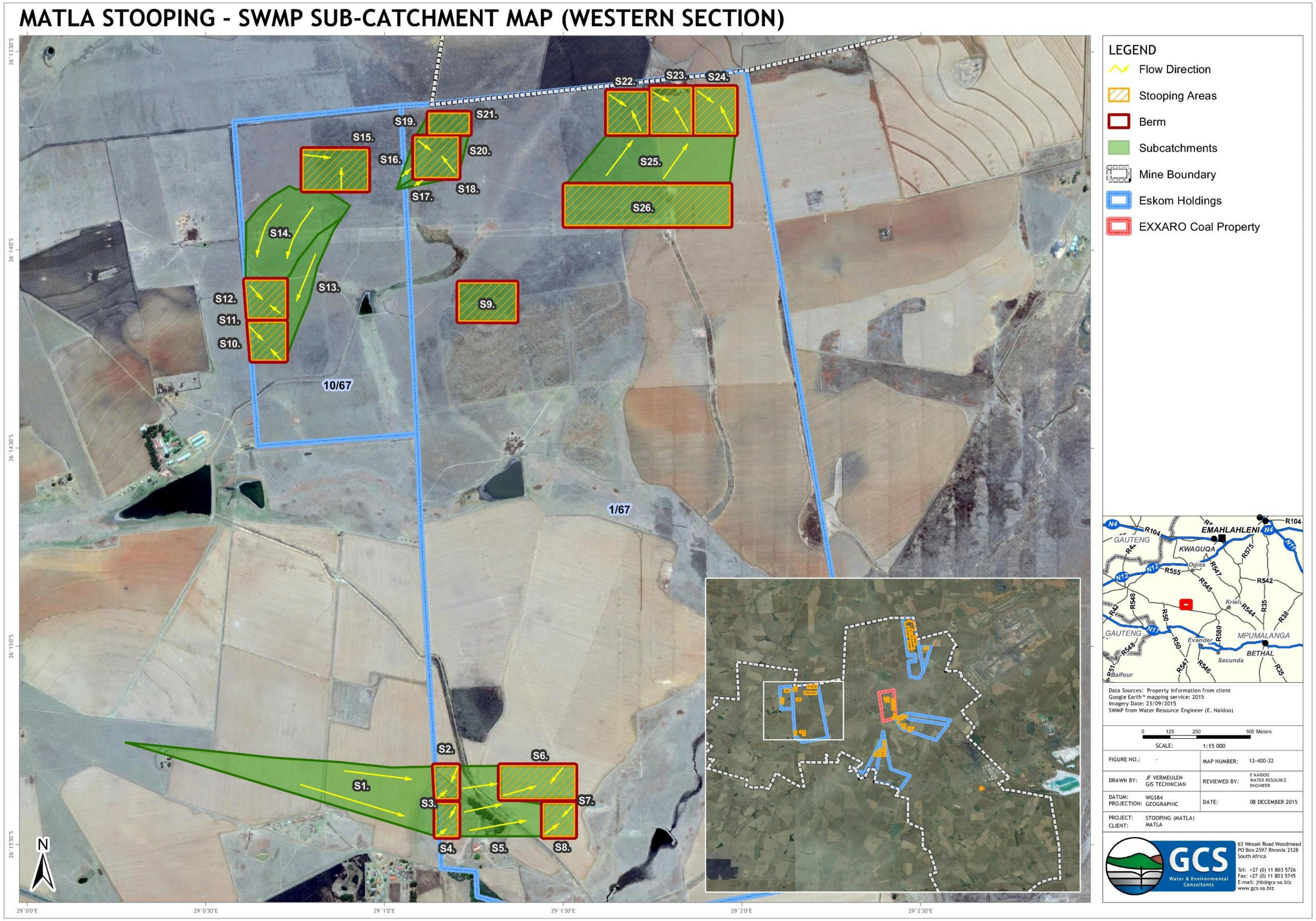


Figure 9.6 Layout and extent of the discretised surface water sub-catchments- Western section

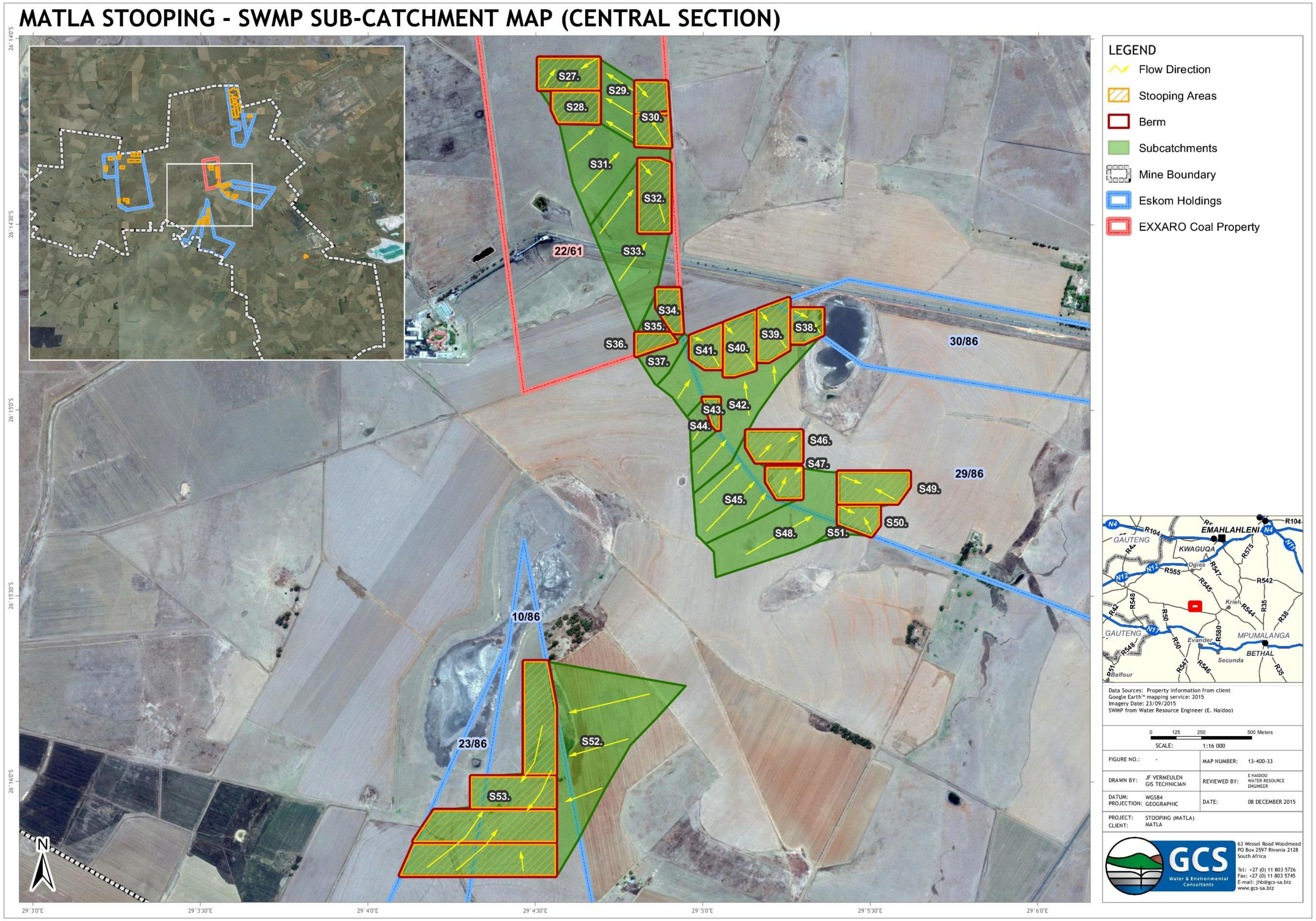


Figure 9.7 **Layout and extent of the discretised surface water sub-catchments- Central section**

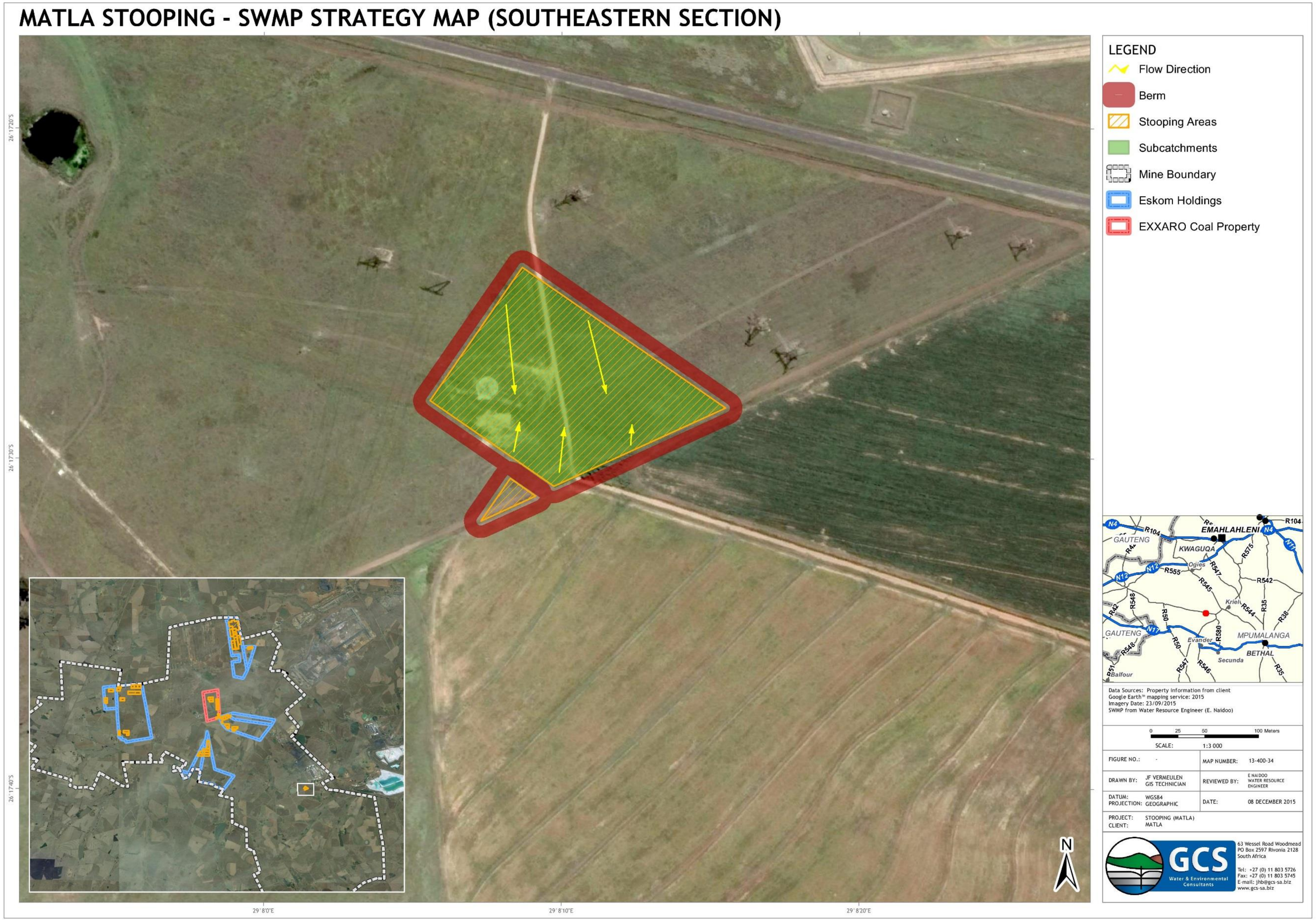


Figure 9.8 Layout and extent of the discretised surface water sub-catchments- South-Eastern section

9.3 Channels

The diversion channel has been sized to divert the runoff for the 50-year return period flood peak, as per GN704 (shown in Table 9.2). The proposed conceptual diversion channel layout can be seen in Figure 9.9 to Figure 9.12. The Manning's roughness assumed for the channels was 0.035 (vegetation-lined channels) (Hicks *et al.*, 1998).

The results show that one of the channels (C42 and C53, as shown in Figure 9.9 to Figure 9.12) is at risk of eroding, due to the maximum velocity being 3m/s. The high velocities are due to the steep catchment gradients present on the site. Therefore, additional lining may be required for the channels, such as riprap. This channel lining, when implemented, will greatly reduce the risk of erosion. Another option would be to implement energy dissipation devices. Energy dissipaters are devices designed to protect downstream areas from erosion by reducing the velocity of flow to acceptable limits.

Table 9.2 Channel characteristics and results

Name	Length (m)	Roughness	Cross-Section	Height (m)	Bottom Width (m)	Left Slope (1:H)	Right Slope (1:H)	Slope (m/m)	Max. Flow (m^3/s)	Max. Velocity (m/s)
C1.	345	0.035	Trapezoidal	1	1	2	2	0.032	0.92	1.81
C2.	194	0.035	Trapezoidal	0.8	0.5	2	2	0.017	0.52	1.33
C3.	111	0.035	Trapezoidal	1	1	2	2	0.017	0.12	0.83
C4.	174	0.035	Trapezoidal	0.8	0.5	2	2	0.017	0.51	1.32
C5.	518	0.035	Trapezoidal	1	1	2	2	0.026	1.34	1.87
C6.	199	0.035	Trapezoidal	0.8	0.5	2	2	0.032	0.85	1.83
C7.	171	0.035	Trapezoidal	1	1	2	2	0.033	0.30	1.32
C8.	378	0.035	Trapezoidal	0.8	0.5	2	2	0.033	1.51	2.14
C9.	318	0.035	Trapezoidal	0.5	0.5	2	2	0.018	1.12	1.62
C10.	383	0.035	Trapezoidal	1	1	2	2	0.024	0.64	1.48
C11.	225	0.035	Trapezoidal	0.5	0.5	2	2	0.020	0.39	1.28
C12.	182	0.035	Trapezoidal	1	1	2	2	0.020	0.12	0.86
C13.	253	0.035	Trapezoidal	0.5	0.5	2	2	0.018	0.66	1.43
C14.	200	0.035	Trapezoidal	1	1	2	2	0.022	1.64	1.85
C15.	348	0.035	Trapezoidal	1	0.5	2	2	0.028	1.49	2.01
C16.	209	0.035	Trapezoidal	1	1	2	2	0.015	0.12	0.81
C17.	199	0.035	Trapezoidal	1	1	2	2	0.039	0.13	1.09
C18.	283	0.035	Trapezoidal	0.5	0.5	2	2	0.015	0.92	1.47
C19.	201	0.035	Trapezoidal	1	1	2	2	0.020	0.26	1.09
C20.	103	0.035	Trapezoidal	1	1	2	2	0.020	0.12	0.87
C21.	220	0.035	Trapezoidal	0.5	0.5	2	2	0.014	0.53	1.26
C22.	273	0.035	Trapezoidal	0.5	0.5	2	2	0.025	0.78	1.63
C23.	291	0.035	Trapezoidal	0.5	0.5	2	2	0.025	0.68	1.58
C24.	293	0.035	Trapezoidal	0.5	0.5	2	2	0.025	0.86	1.68

C25.	649	0.035	Trapezoidal	1	1	2	2	0.028	2.32	2.22
C26.	834	0.035	Trapezoidal	1	1	2	2	0.028	2.39	2.24
C27.	381	0.035	Trapezoidal	0.5	0.5	2	2	0.022	1.05	1.68
C28.	374	0.035	Trapezoidal	0.5	0.5	2	2	0.015	1.02	1.51
C29.	343	0.035	Trapezoidal	1	1	2	2	0.036	1.07	1.97
C30.	389	0.035	Trapezoidal	0.5	0.5	2	2	0.015	0.76	1.40
C31.	659	0.035	Trapezoidal	1	1	2	2	0.031	1.69	2.12
C32.	417	0.035	Trapezoidal	0.5	0.5	2	2	0.038	1.07	2.07
C33.	552	0.035	Trapezoidal	1	1	2	2	0.048	3.14	2.93
C34.	230	0.035	Trapezoidal	0.5	0.5	2	2	0.051	0.69	2.06
C35.	285	0.035	Trapezoidal	1	1	2	2	0.041	0.50	1.67
C36.	214	0.035	Trapezoidal	1	1	2	2	0.018	0.38	1.19
C37.	328	0.035	Trapezoidal	1	1	2	2	0.019	0.69	1.41
C38.	205	0.035	Trapezoidal	0.5	0.5	2	2	0.067	1.03	2.53
C39.	340	0.035	Trapezoidal	0.5	0.5	2	2	0.029	1.13	1.90
C40.	363	0.035	Trapezoidal	0.5	0.5	2	2	0.026	1.01	1.77
C41.	261	0.035	Trapezoidal	0.5	0.5	2	2	0.039	0.79	1.93
C42.	803	0.035	Trapezoidal	1	1	2	2	0.051	3.37	3.05
C43.	158	0.035	Trapezoidal	1	1	2	2	0.012	0.21	0.89
C44.	213	0.035	Trapezoidal	1	1	2	2	0.013	0.48	1.16
C45.	492	0.035	Trapezoidal	1	1	2	2	0.018	1.69	1.75
C46.	343	0.035	Trapezoidal	0.5	0.5	2	2	0.025	1.14	1.80
C47.	271	0.035	Trapezoidal	0.5	0.5	2	2	0.020	0.59	1.42
C48.	323	0.035	Trapezoidal	1	1	2	2	0.036	1.16	2.02
C49.	407	0.035	Trapezoidal	1	1	2	2	0.033	1.66	2.16
C50.	260	0.035	Trapezoidal	0.5	0.5	2	2	0.029	0.65	1.65
C51.	201	0.035	Trapezoidal	1	1	2	2	0.020	0.25	1.09

C52.	1104	0.035	Trapezoidal	1	1	2	2	0.016	2.38	1.86
C53.	365	0.035	Trapezoidal	1	1	2	2	0.047	3.83	3.06
C54.	286	0.035	Trapezoidal	1	1	2	2	0.052	0.84	2.11
C55.	361	0.035	Trapezoidal	0.5	0.5	2	2	0.016	1.03	1.54
C56.	697	0.035	Trapezoidal	1	1	2	2	0.022	1.80	1.90
C57.	865	0.035	Trapezoidal	1	1	2	2	0.022	2.07	1.97
C58.	673	0.035	Trapezoidal	1	1	2	2	0.022	1.84	1.91
C59.	1464	0.035	Trapezoidal	1	1	2	2	0.033	3.77	2.68
C60.	693	0.035	Trapezoidal	1	1	2	2	0.032	0.70	1.31
C61.	575	0.035	Trapezoidal	0.5	0.5	2	2	0.013	0.95	1.42
C62.	300	0.035	Trapezoidal	0.5	0.5	2	2	0.021	0.70	1.50
C63.	394	0.035	Trapezoidal	1	1	2	2	0.032	1.85	2.19
C64.	670	0.035	Trapezoidal	1	1	2	2	0.033	0.61	1.20
C65.	630	0.035	Trapezoidal	1	1	2	2	0.012	1.64	1.40
C66.	622	0.035	Trapezoidal	1	1	2	2	0.019	2.41	2.01
C67.	387	0.035	Trapezoidal	1	1	2	2	0.016	1.25	1.54
C68.	170	0.035	Trapezoidal	1	1	2	2	0.012	4.48	2.02

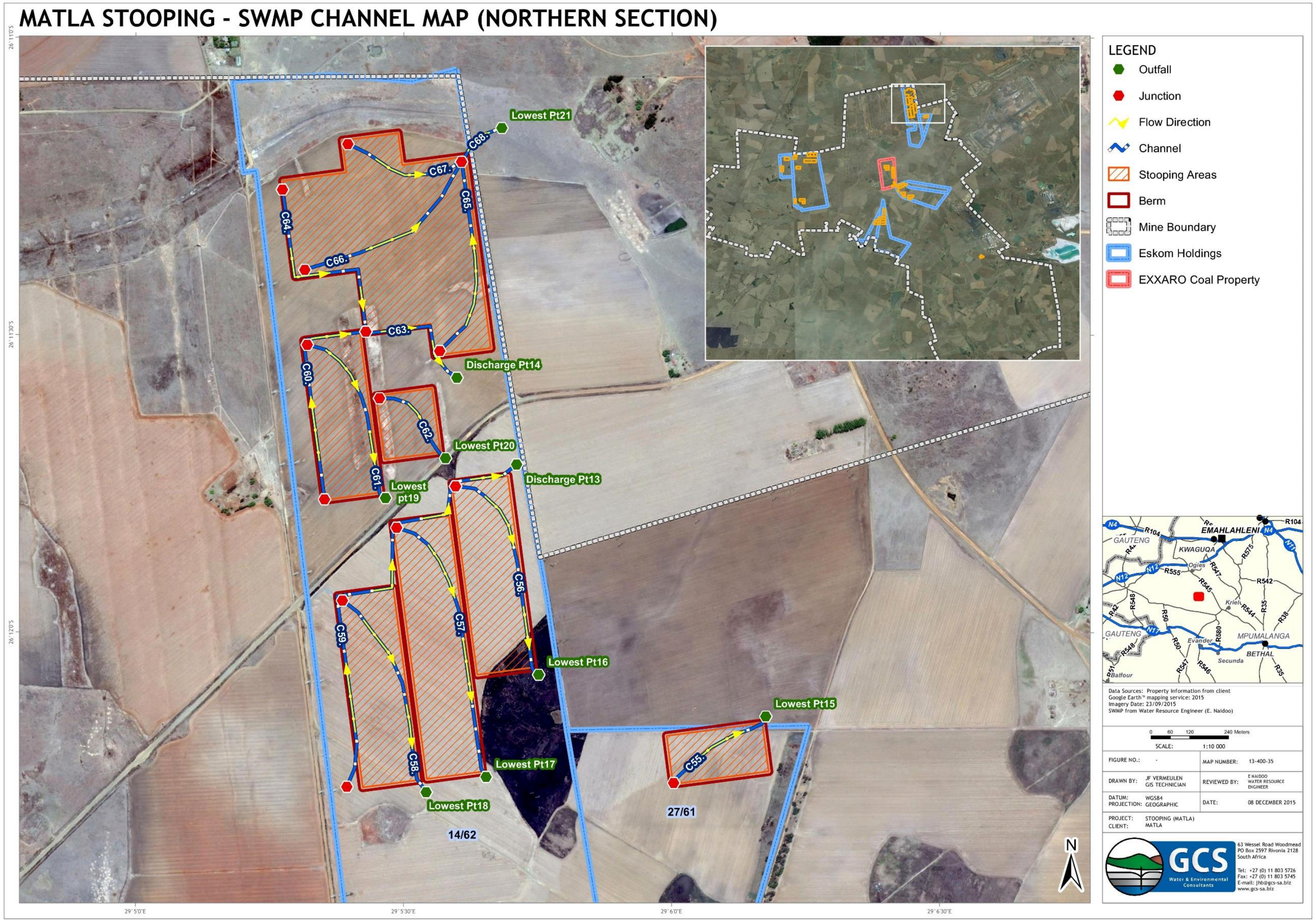


Figure 9.9 **The proposed channel layout- Northern section**

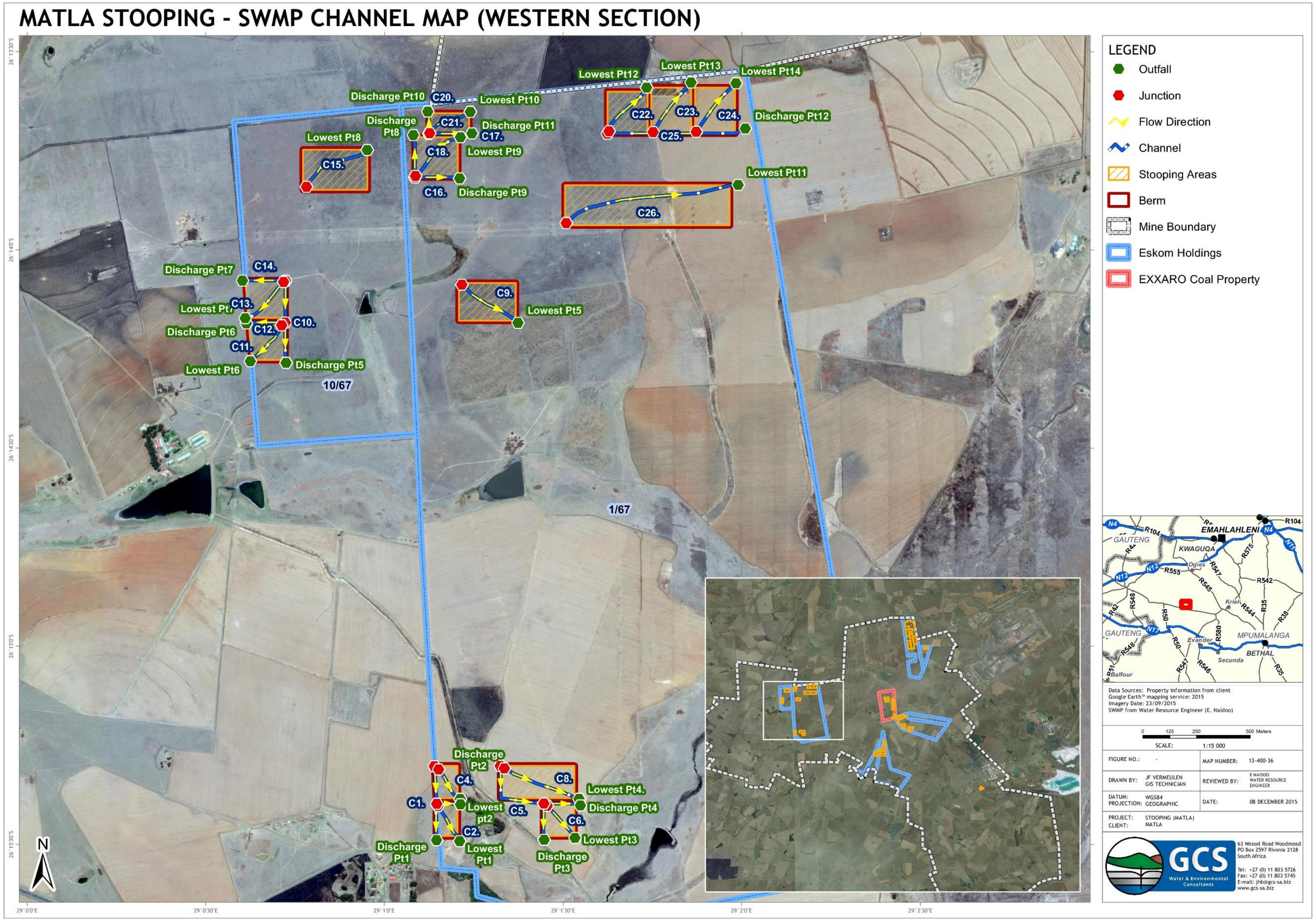


Figure 9.10 The proposed channel layout- Western Section

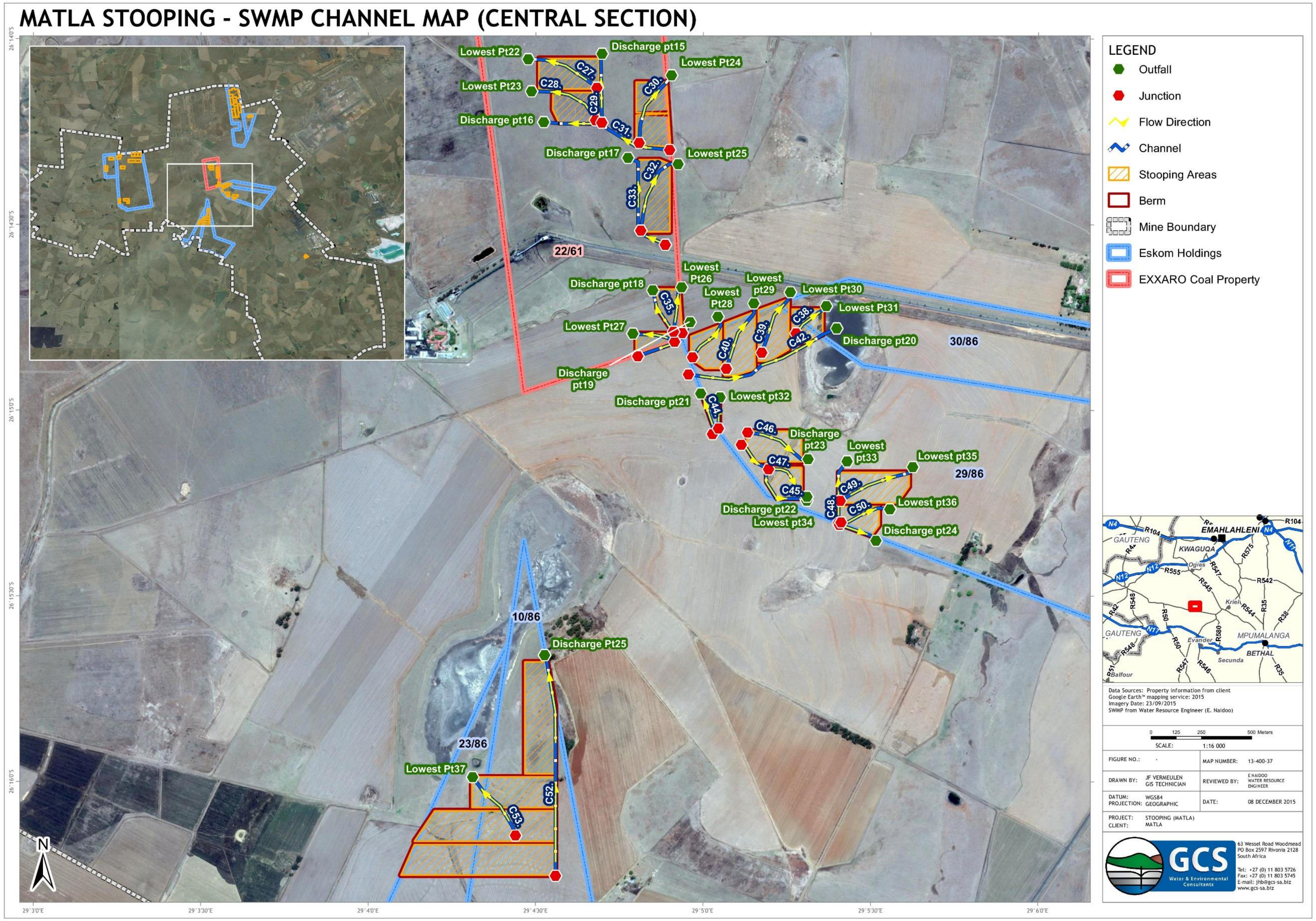


Figure 9.11 The proposed channel layout- Central section

Figure 9.12 The proposed channel layout- South-Eastern Section

10 WATER BALANCE

Owing to time limitations on the part of the client, it was agreed that that this document would be provided, in its current, draft form, without a completed water balance, in 2015. A final version of this document will be produced, with a completed water balance section, in 2016. To date the hydrological inputs to the water balance have been calculated, the subsidence catchment areas have also been delineated. The outstanding information is the groundwater inputs to the water balance.

An accurate water balance is considered to be one of the most important and fundamental water management tools available to the mines. The purpose of a water balance includes (DWA, 2006):

- Providing the necessary information that will assist in defining and driving water management strategies;
- Auditing and assessment of the water reticulation system, with the main focus on water usage and pollution sources. This includes identifying and quantifying points of high water consumption or wastage, as well as pollution sources. Seepage and leakage points can also be identified and quantified when the balances are used as an auditing and assessment tool;
- Assisting with the design of storage requirements and minimising the risk of spillage; and
- Assisting with the water management decision-making process by simulating and evaluating various water management strategies before implementation.

The water balance was determined using the standard DWS methodology (DWA, 2006) and includes:

- A water process flow diagram;
- Volumetric water balances in the required DWS format.

11 SENSITIVITY MAPPING

Sensitivity mapping was undertaken in order to identify sensitive features relating to surface water within the mining right study area of the proposed Matla Stooping Project (Phase 1). The determined sensitivities were based on findings of the desktop assessment.

Site sensitivities were classified and mapped based on the methodology below, as shown in Figure 11.1.

Sensitivity Rating	Description	Weighting	Preferences
Least Concern	The inherent feature status and sensitivity is already degraded. The proposed development will not affect the current status and/or may result in a positive impact. These features would be the preferred alternative for mining or infrastructure placement.	-1	
Low/Poor	The proposed development will not have a significant effect on the inherent feature status and sensitivity.	0	Negotiable
High	The proposed development will negatively influence the current status of the feature.	+1	
Very High	The proposed development will negatively significantly influence the current status of the feature.	+2	

Figure 11.1 Sensitivity ratings and weighting

The only so-called 'very high' areas that can be identified according to specific available legislation are those that lie outside of the exclusion zone in accordance with GN704 of the NWA (South Africa, 1998). In the EIA phase the 100m river buffers were delineated (**Error! eference source not found.**) along with the 1 in 50- and 1 in 100-year flood line extents as Regulation 4(b) of GN704 reads; 'No person in control of a mine or activity may - except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50-year flood-line or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest'. The area within this designation is termed the Exclusion Zone.

The proposed underground mining activity for phase 1 is located within the sensitive areas (also referred to as ‘no – go’ areas according to GN704 and which represent the exclusion zone) as shown in Figure 11.2. The resulting exclusion zone indicates that the proposed stooping (surface activity) does not encroach on the non-perennial streams within the study area, as shown in Figure 11.2.

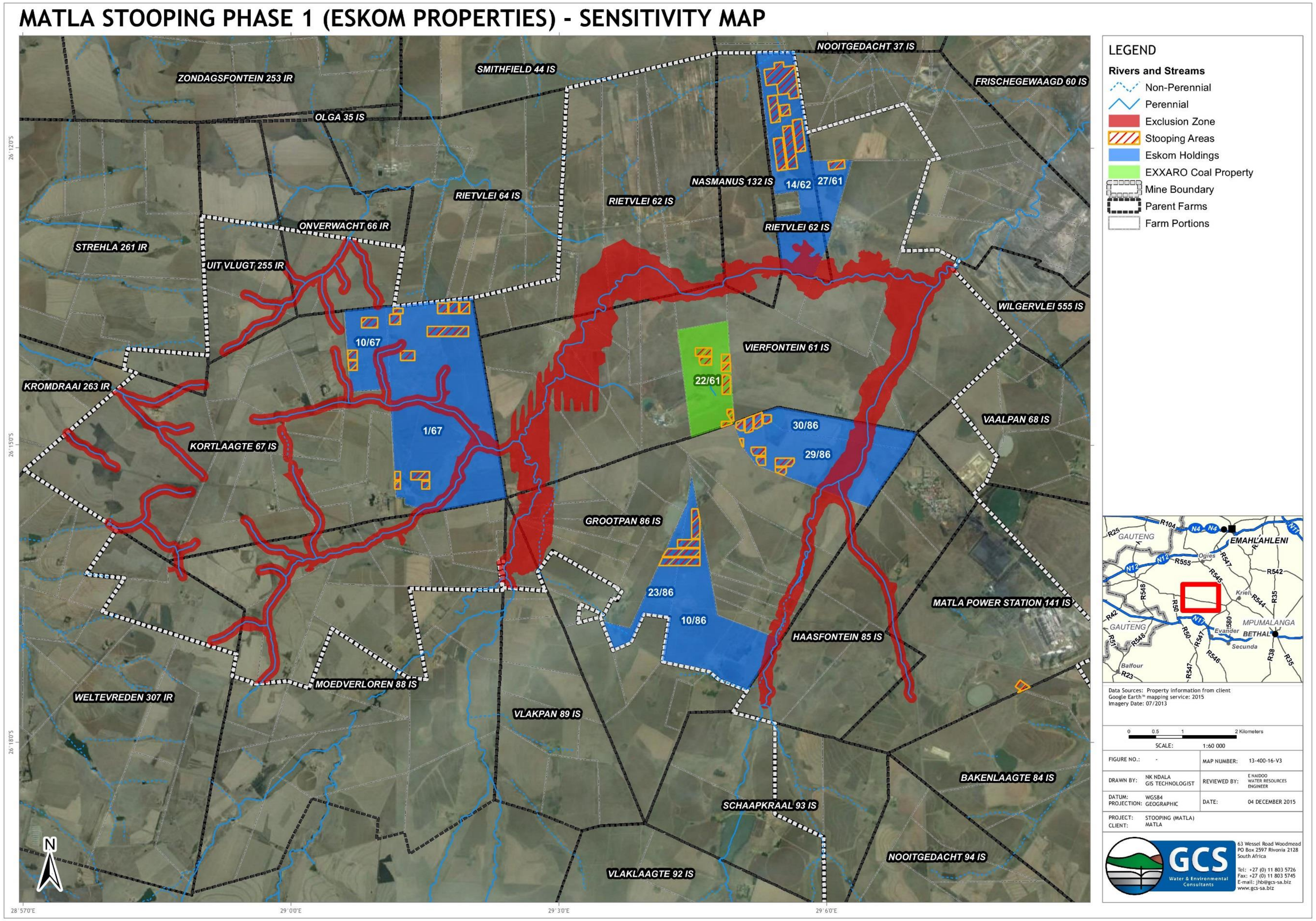


Figure 11.2 Sensitivity map for the proposed Matla Stooping Project Phase 1

12 ASSESSMENT AND RATINGS OF SURFACE WATER IMPACTS

The aim of this section is to identify the potential surface water impacts that are likely to arise as a result of the proposed project.

12.1 Impact Assessment Methodology

The methodology for identification of potential impacts of the proposed project was based on:

- Study of the project description;
- Review of historic baseline studies and impact assessments for proposed project area; and
- Research work from similar established projects.

As mentioned in the Methodology Section (and elaborated-upon here), the potential impacts associated with this project have been evaluated using an impact rating system that takes into account a number of assessment criteria, namely: status of impact (positive, neutral or negative impact); magnitude (amount); duration (time scale); scale (special extent); probability (likelihood of occurrence). Assessed criteria are scored (as shown in **Table 12.1**) and the values are totalled. The resulting value is assigned an impact ranking of low, medium and high for each impact as shown in **Table 12.2**.

Table 12.1 Impact assessment ratings

Status of Impact

+: Positive (A benefit to the receiving environment)

N: Neutral (No cost or benefit to the receiving environment)

-: Negative (A cost to the receiving environment)

Magnitude:=M	***Duration:=D***
10: Very high/don't know	5: Permanent
8: High	4: Long-term (ceases with the operational life)
6: Moderate	3: Medium-term (5-15 years)
4: Low	2: Short-term (0-5 years)
2: Minor	1: Immediate
0: Not applicable/none/negligible	0: Not applicable/none/negligible
Scale:=S	***Probability:=P***
5: International	5: Definite/don't know
4: National	4: Highly probable
3: Regional	3: Medium probability
2: Local	2: Low probability
1: Site only	1: Improbable
0: Not applicable/none/negligible	0: Not applicable/none/negligible

Table 12.2 Impact Rankings

Significance	*Environmental Significance Points*	*Colour Code*
High (positive)	>60	H
Medium (positive)	30 to 60	M
Low (positive)	<30	L
Neutral	0	N
Low (negative)	>-30	L
Medium (negative)	-30 to -60	M
High (negative)	<-60	H

12.2 Identified Impacts

The following potential were identified and further assessed for the following project phases:

- Construction Phase;
- Operational Phase, and the
- Post-closure Phase.

12.2.1 Construction Phase

There are no anticipated surface water impacts to the proposed Matla Stooping Project (Phase 1) during the construction phase as the existing facilities on the adjacent site will be used and no surface activities are planned to take place.

12.2.2 Operational Phase

The following section describes the potential impacts associated with the operational phase of the proposed project, as summarised in **Error! Reference source not found.** below.

- The proposed operations proposed within the Matla Stooping Project (Phase 1) will marginally reduce the runoff volume reporting to the local streams. The maximum anticipated subsidence of 1.53m will result in surface depressions capable of collecting surface water runoff, therefore reducing the catchment area contributing runoff to the streams. Streamflow reduction will be a consequence of the reduction in catchment area. The impact of catchment reduction depends on the percentage of a particular area to be isolated and the consequence of isolating the area. Catchments with an isolated area in excess of 10% can be considered to have an influence on the flow patterns and volumes in the receiving catchment. A review of the current catchment showed that the catchment flow would be reduced by up to 5%. A reduction in catchment flow of less than 10% can be deemed fairly small, and these values are therefore not likely to be significant. The project's influence on downstream catchment flows, however, should be monitored and investigated at a later stage once the infrastructure footprint develops. The impact was ranked as **medium** due to the loss of contributing catchment area. With the mitigation measures in place the impact ranking is reduced to **low**.
- The maximum anticipated subsidence of 1.53m will result in steep slopes being generated on the perimeter of the proposed stooping areas, and, owing to the tendency of steep slopes to erode, it is likely that soils could be regularly mobilised with extreme rainfall events. This could result in a deterioration of land capability, as well as the accumulation of sediment in the various water resources. The ranking will be reduced from **medium** to **low** if correct storm water management measures are installed.

Table 12.3 Significance rating results of the identified risks for the operational phase

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION							ACTION PLAN	PHASE	PERSON	ANNUAL MANAGEMENT COST
		M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP				
OPERATIONAL ACTIVITIES																				
HYDROLOGY																				
Catchment reduction	The stooping operations will result in subsidence which will isolate portions of the stream catchments. Ultimately this will reduce the catchment area that feeds the adjacent streams. The surface water runoff that reports to the local streams will be reduced.	6	3	3	3	36	-	M	Effective diversion of clean storm water, by implementation of the proposed storm water management plan should reduce the impacts of reduced catchment runoff.	6	2	2	2	20	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Operational	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in operational costs
Erosion and sediment accumulation in the surface depressions (subsided areas)	The maximum anticipated subsidence of 1.53m will result in steep slopes being generated on the perimeter of the proposed stooping areas, and, owing to the tendency of steep slopes to erode, it is likely that soils could be regularly mobilised with extreme rainfall events.	6	2	3	3	33	-	M	Rehabilitate open areas as soon as practically possible. Vegetate open areas as soon as practically possible. Manager storm water systems and runoff.	4	2	1	2	14	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Operational	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in operational costs

12.2.3 Closure Phase

The following section describes the potential impacts associated with the closure phase of the proposed project, as summarised in **Error! Reference source not found.** below.

- All aspects of potential operational phase water quality modifications discussed are equally applicable to works associated with the decommissioning of Matla Stooping Project (Phase 1).

Table 12.4 Significance rating results of the identified risks for the closure phase

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION							ACTION PLAN	PHASE	PERSON	ANNUAL MANAGEMENT COST
		M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP				
CLOSURE ACTIVITIES																				
HYDROLOGY																				
Catchment reduction	The stooping operations will result in subsidence which will isolate portions of the stream catchments. Ultimately this will reduce the catchment area that feeds the adjacent streams. The surface water runoff that reports to the local streams will be reduced.	6	3	3	3	36	-	M	Effective diversion of clean storm water, by implementation of the proposed storm water management plan should reduce the impacts of reduced catchment runoff.	6	2	2	2	20	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Closure	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in closure costs
Erosion and sediment accumulation in the surface depressions (subsided areas)	The maximum anticipated subsidence of 1.53m will result in steep slopes being generated on the perimeter of the proposed stooping areas, and, owing to the tendency of steep slopes to erode, it is likely that soils could be regularly mobilised with extreme rainfall events.	6	2	3	3	33	-	M	Rehabilitate open areas as soon as practically possible. Vegetate open areas as soon as practically possible. Manager storm water systems and runoff.	4	2	1	2	14	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Closure	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in closure costs

12.3 Mitigation Measures

Table 12.5 describes the mitigation measures that have been identified for the operational phase and decommissioning and closure phase of the Matla Stooping Project (Phase 1), in response to the potential risks identified.

Table 12.5 Environmental Management Programme - Operational Phase

Project Activity: Operational and Closure Phase activities.

Impact: The stooping operations will result in subsidence which will isolate portions of the stream catchments. Ultimately this will reduce the catchment area that feeds the adjacent streams. The surface water runoff that reports to the local streams will be reduced.

Management objective: To minimize the impact on the local streams.

Mitigation measures: The following measure should be implemented:

- Effective diversion of clean storm water, by implementation of the proposed storm water management plan, should reduce the impacts of reduced catchment runoff.

Responsibility: Environmental Manager

Key Performance Indicators (KPIs): Evidence of clean water cut-off trenches and diversion channels.

Project activity: Operational and Closure Phase activities.

Impact: The maximum anticipated subsidence of 1.53m will result in steep slopes being generated on the perimeter of the proposed stooping areas and the tendency of steep slopes to erode, it is likely that soils could be regularly mobilised with extreme rainfall events.

Management objective: To prevent sediment build up in surface depressions (subsided areas) and conveyance infrastructure.

Mitigation measures: The following measures should be implemented:

- The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate. Where possible, earthwork activities should be undertaken during dry periods;
- Progressive rehabilitation of disturbed land should be carried out to minimize the amount of time that bare soils are exposed to the erosive effects of rain and subsequent runoff;
- Traffic and movement over stabilised areas will be restricted and controlled, and damage to stabilised areas shall be repaired and maintained to the satisfaction of the Environmental Manager; and
- Maintenance should be carried out by removing sediment regularly from surface depressions (subsidence areas) and conveyance infrastructure.

Responsibility: Environmental Manager

Key Performance Indicators (KPIs): Evidence of erosion protection measures and maintenance of storage and conveyance infrastructure capacities thereof.

13 CONCLUSIONS

The following conclusions were derived based on the findings of this study:

13.1 Hydrology

The Mean Annual Precipitation (MAP) in the vicinity of the site was calculated to be 655 mm, based on the Strehla Station dataset. About 86% of the annual rainfall falls in summer (October to March), in the form of thundershowers, with the maximum amount of precipitation falling in January. The WR2012 dataset (WRC, 2012) shows annual evaporation for the site to be 1638mm (S-Pan estimate). The mean monthly evaporation data show that the evaporation significantly exceeds precipitation.

The hydrology data (extracted design rainfall depths) were used as input into the calculations of the flood peaks. The calculated peak flows used in the flood line analysis were based on the Rational Alt 3 method.

13.2 Baseline Water Quality

Focus of the water quality analysis was placed on pH, SO_4, Mn and Fe as these constituents are commonly associated with AMD and pollution at coal mines. The following baseline water quality chemistry trends were observed:

- All monitoring points exhibit neutral pH conditions. There has been no historic indications of AMD occurring at any of these monitoring points.
- On average the Mn and Fe concentrations for the selected points have remained fairly low and below the SANS 241-1 2011 maximum aesthetical limits. Seasonal fluctuations in these concentrations are evident. These could have been due to laboratory or sampling errors.
- All monitoring points have historically shown seasonal fluctuations in EC (a reflection of the TDS) and SO_4 concentrations. 2 Mine U/S has historically shown the most elevated SO_4 concentrations. 2 Mine D/S, however, has shown lower concentrations, which suggests that dilution is taking place between these points or from other water inflow near 2 Mine D/S.
- The EC for 3 Mine settling pond and 2 mine U/S have historically been elevated. The latest data available (June 2014) indicated that the surface water was saline and above the SANS 241-1:2011 drinking water limits. The elevated EC readings could have been due to sampling of stagnated water.

13.3 Flood Lines

The flood levels for the 1:50-year and 1:100-year flood peaks were determined and plotted, as were the local stream 100m buffers and the site Exclusion Zone. The results indicate that the proposed stooping does not encroach on the non-perennial streams within the study area.

13.4 Storm Water Management Plan

The Matla Stooping Project (Phase 1) will have no surface related activities as the mining will be underground. There will be no dirty water generating areas as a result of this. The impacts to the surface will be in the form of subsidence of approximately 1.53m, therefore the site-wide framework is to allow the subsided areas to be free-draining while at the same time limiting the amount of surface water runoff infiltrating into the underground workings. The clean water runoff being generated from the upslope clean water catchments should be diverted away from the subsided areas via perimeter berms. The water runoff generated from the subsided areas will be diverted to flow out via channels. The SWMP will be comprised of approximately 26 kilometres of diversion channels.

13.5 Water and Salt Balance

Owing to time limitations on the part of the client, it was agreed that that this document would be provided, in its current, draft form, without a completed water balance, in 2015. A final version of this document will be produced, with a completed water balance section, in 2016. To date the hydrological inputs to the water balance have been calculated, the subsidence catchment areas have also been delineated. The outstanding information is the groundwater inputs to the water balance.

13.6 Risk Assessment

It appears that that no current regional water conservation or management plans will impact directly on the proposed mining development.

Potential impacts of the Matla Stooping Project (Phase 1) expected to arise from the mining activities include mostly catchment reduction and erosion.

14 RECOMMENDATIONS

The following recommendations were made based on the findings of this study:

14.1 Water Quality Monitoring Plan

Water quality monitoring is recommended to occur on a monthly basis. Regular reviews of the management plans should be undertaken to establish that they are functioning as intended to avoid unnecessary impacts to the environment, provide a safe work place, and work to maintain the quality of the surface water.

14.2 Risk Assessment

Proposed mitigation measures thus include the use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction and silt ponds where appropriate.

15 REFERENCES

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